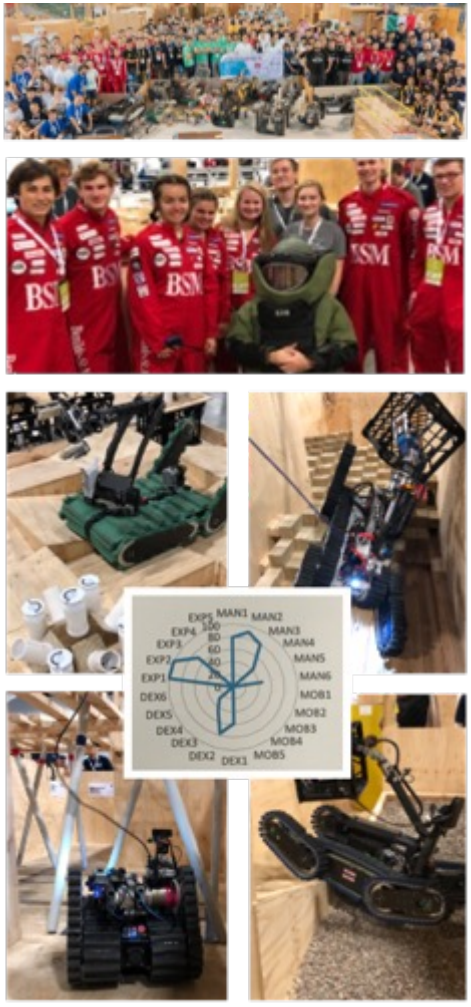
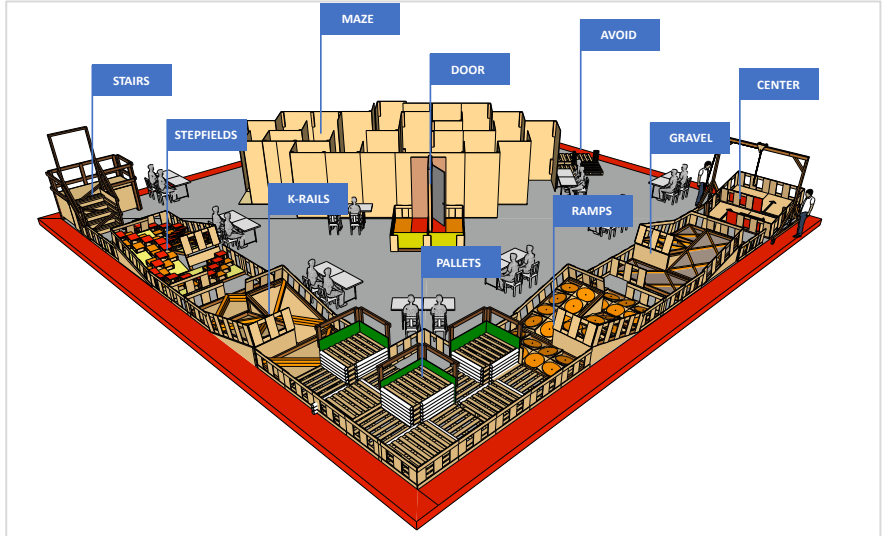
RoboCupRescue Robot League

Arena Fabrication Guide for Salvador, Brazil (2025)





RoboCupRescue Championships

2025 Salvador, Brazil
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

Adam Jacoff, Ann Virts
Emergency Response Robots Project
National Inst. of Standards and Technology (NIST)
U.S. Department of Commerce

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

Science and Technology

Contact
Email: RobotTestMethods@nist.gov
Website: RobotTestMethods.nist.gov
Phone/Text: +1 301-704-2323

Table of Contents

RoboCupRescue Robot League

RoboCupRescue Championships

2025 Salvador, Brazil
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

Adam Jacoff, Ann Virts
Emergency Response Robots Project
National Inst. of Standards and Technology (NIST)
U.S. Department of Commerce

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

Science and Technology

Contact
Email: RobotTestMethods@nist.gov
Website: RobotTestMethods.nist.gov
Phone/Text: +1 301-704-2323

Revisions to this Document

RoboCupRescue Robot League

New in Version 2025B

- MISSION: Added mission statement from workshop (page 4)
- PURCHASES: Added more examples (page 17)
- CENTER: Added test method (page 53)
- DOORS: Added test method (page 56)
- DEXTERITY – ALIGN/INSPECT: Added pipe lengths (page 68)

Adam Jacoff, Ann Virts
Emergency Response Robots Project
National Inst. of Standards and Technology (NIST)
U.S. Department of Commerce

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

Science and Technology

Contact
Email: RobotTestMethods@nist.gov
Website: RobotTestMethods.nist.gov
Phone/Text: +1 301-704-2323

Mission

RoboCupRescue Robot League

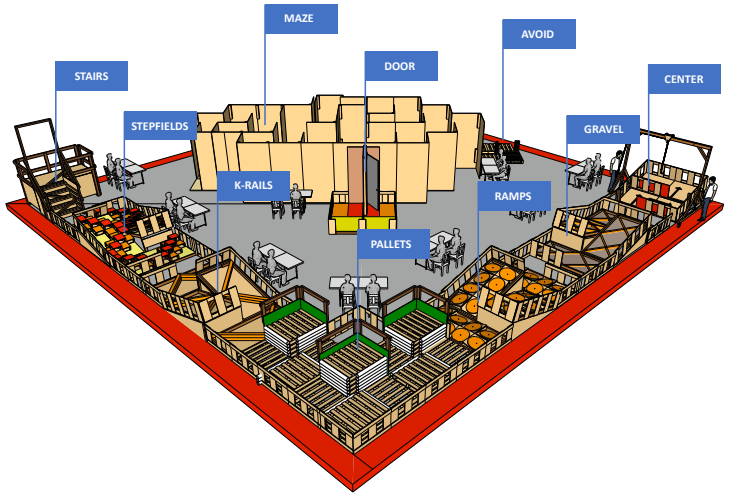
Gather international researchers working on innovative smart robotics technologies to assist emergency responders operating in complex, hazardous environments.

Inspire innovations addressing the needs of emergency responders in a wide spectrum of mission requirements involving mobility, sensory perception, planning, mapping, manipulation, assistive behaviors and operator interfaces and their integration in a holistic manner.

Host Annual competitions and additional activities to foster exchange, cooperation, demonstration and evaluation of novel and best-in-class robotic solutions.

Emergency Responders ← ***RoboCupRescue*** → ***Robotics Researchers***

20 standard test methods replicated around the world to support development, procurement, and training.

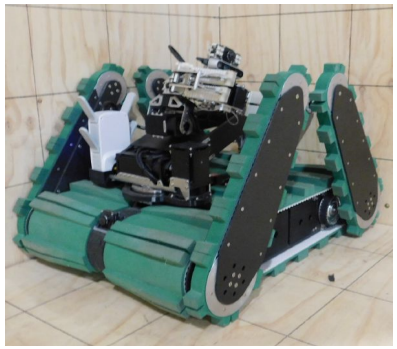
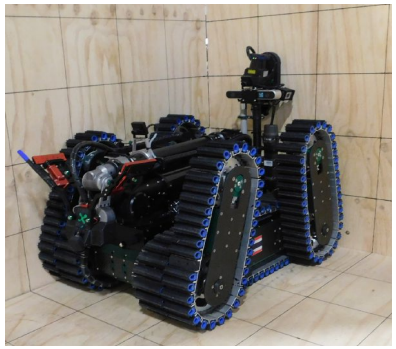
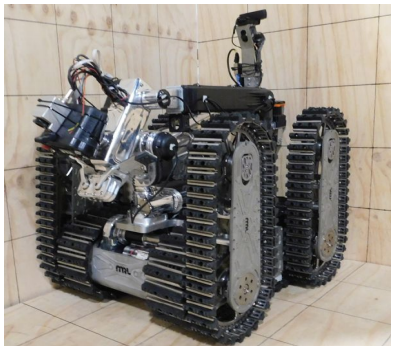


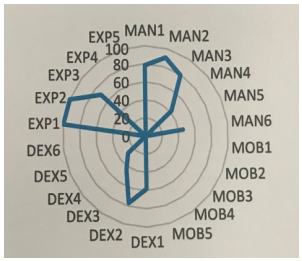
- Established just before the World Trade Center collapse in New York City more than 20 years ago, where robots were deployed but didn't do so well (understandably, because it was a horrific collapse). But there are partial structural collapses and many other missions where robots need to deploy.
- Gather 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 standard test methods that 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.

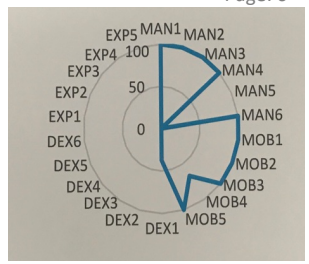
MISSION SUCCESS = MOBILITY + DEXTERITY + MAPPING

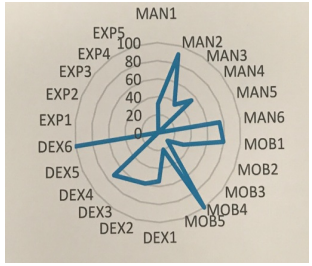
Evaluate Robots in 20 Standard Test Methods

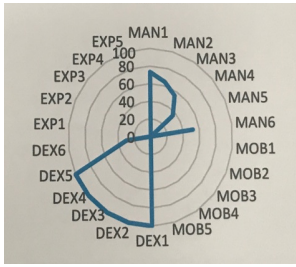
RoboCupRescue Robot League

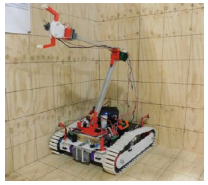
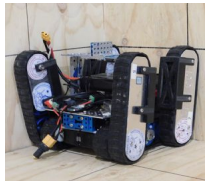
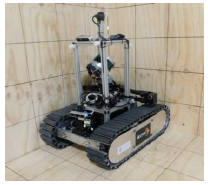
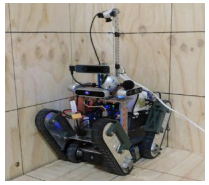













RAMPS

STEPFIELDS

PALLETS & PIPES

K-RAILS

GRAVEL

STAIRS w/DEBRIS

PUSH/PULL DOORS

CENTER

AVOID

LABYRINTH/MAZE

Autonomous Behaviors Enable Measurably Better Remote Operator Proficiency

THE ORIGINAL ”STEPFIELDS”

Standard Test Lanes Used Around the World

RoboCupRescue Robot League

Same test lanes used in the IEEE/RAS Quadruped Robot Challenges.
Incremental complexity settings enable a wide variety of robots to be evaluated.

ICRA–2024, Yokohama, Japan

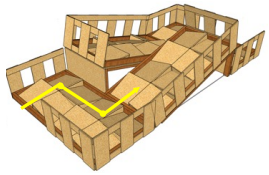
”OPEN” CONFIGURATION – FLAT (EASIER)

“OPEN” = STRAIGHT PATHS FROM HALLWAYS TO SQUARE ROOM IN THE MIDDLE

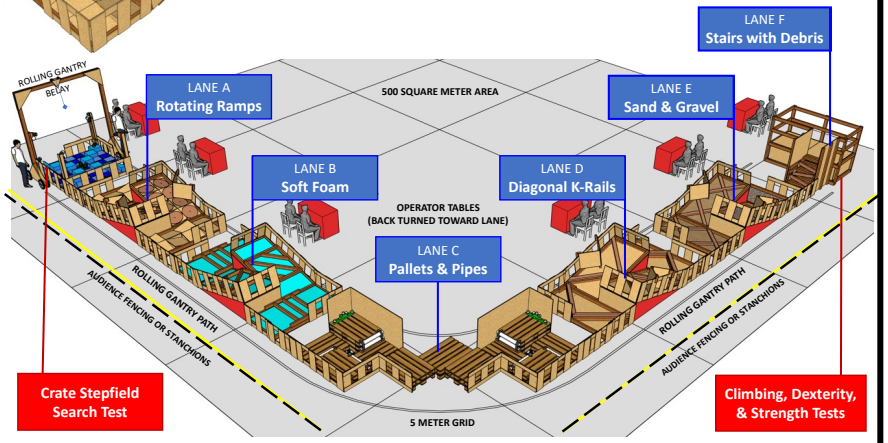
”OPEN” CONFIGURATION – SLOPED (HARDER)

IROS–2024, Abu Dhabi, UAE

”CONFINED” CONFIGURATION (MORE TURNS)

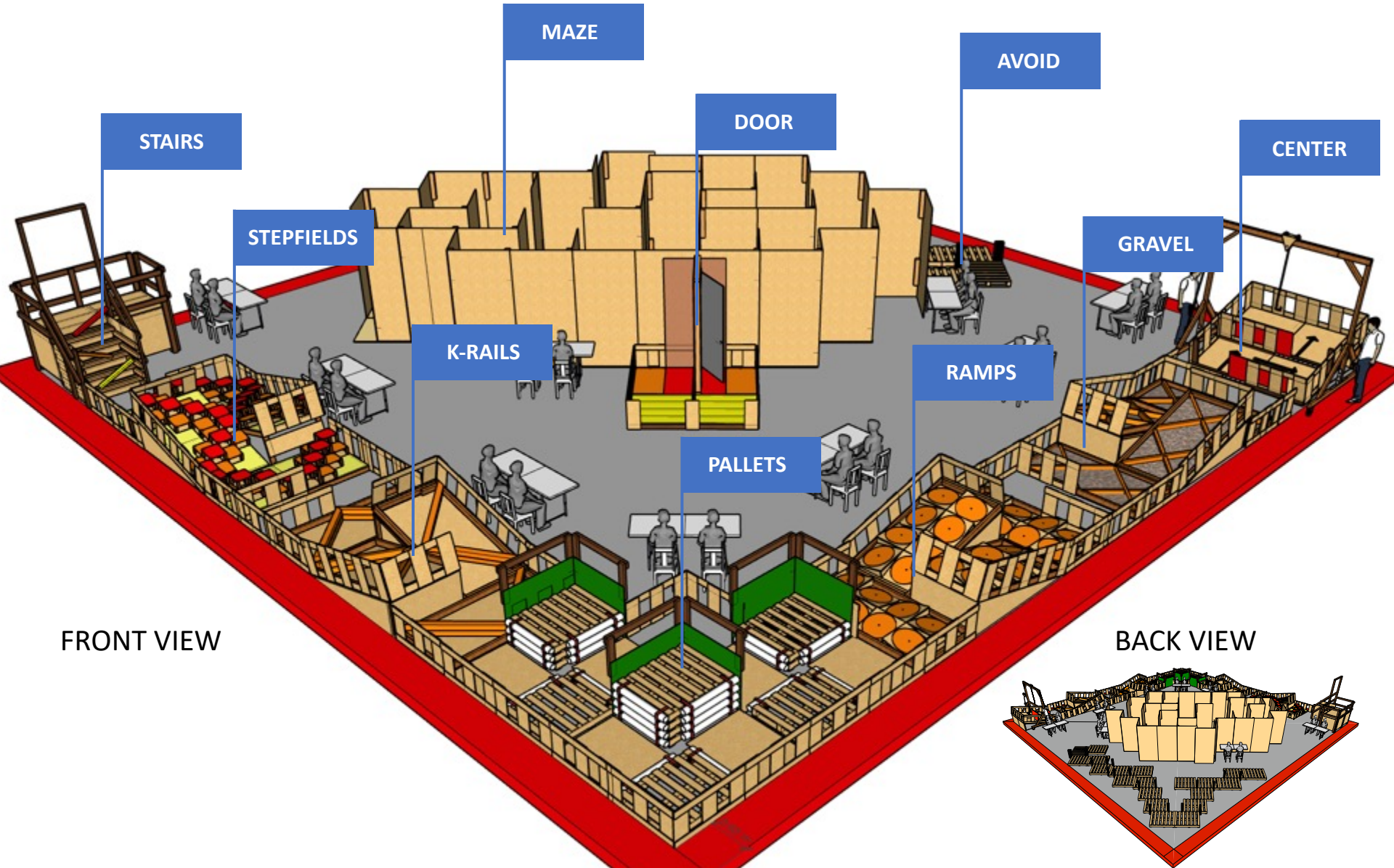


- Requires 90° turns in the hallways to enter the square middle room. Search tasks are more confined as well.
- Applies to both FLAT and SLOPED settings.



Arena Front View

RoboCupRescue Robot League

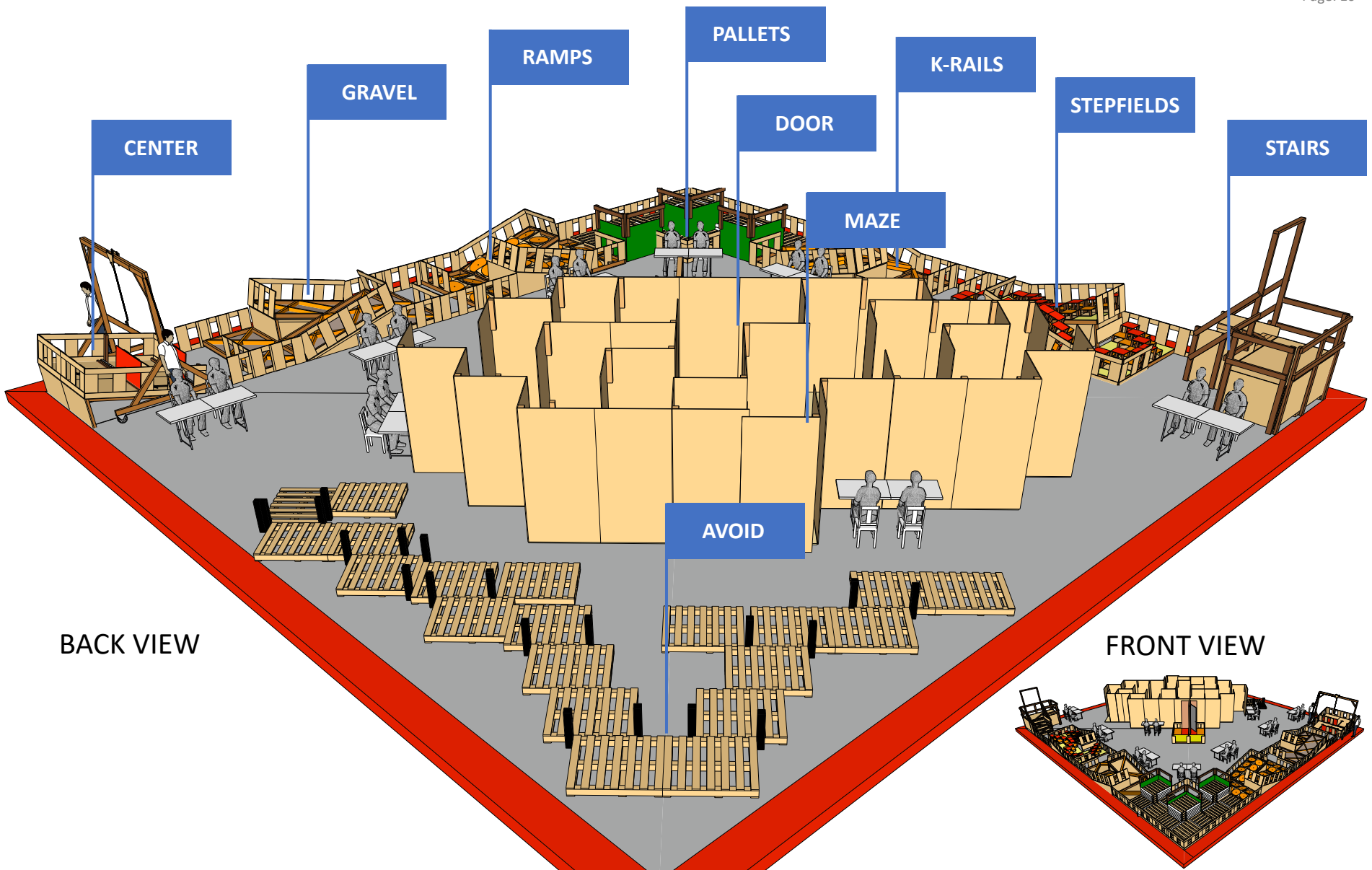


FRONT VIEW

BACK VIEW

Arena Back View

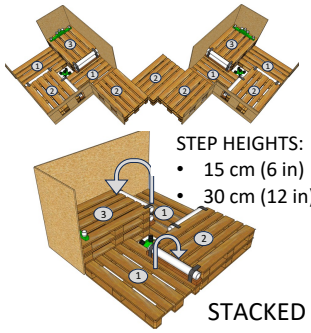
RoboCupRescue Robot League



Standard Terrains and Obstacles

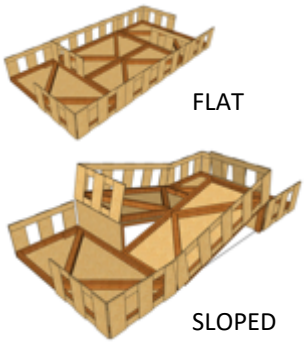
RoboCupRescue Robot League

Pallets



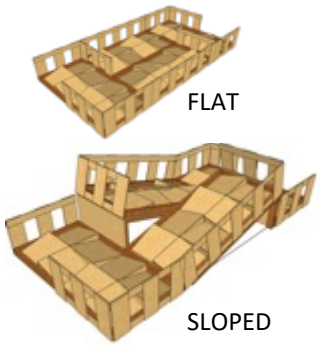
Stacked pallets provide Incremental elevation changes with rolling pipes on the leading edges to encourage autonomous behaviors for articulated front and rear flippers or even dynamic jumping.

K-Rails



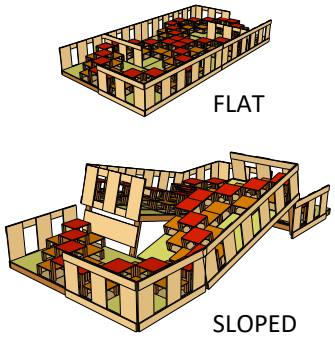
Diagonal step-over obstacles at incremental heights require precise steering or even climbing behaviors for smaller robots within otherwise slippery floors.

Ramps



Square ramps of 60cm (24 in) with 15° surfaces provide constant changes in ground contact orientation. Added slip disks can rotate to reduce friction even further like dust covered concrete after a building collapse.

Stepfields



Stepfields are the most complex terrain with square footfalls 30 cm (12 in) square with 15 cm (6 in) step elevations. They ensure that robots interact with three different elevations at all times.

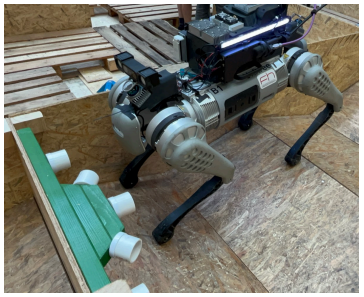
Stairs

Stairs with variable inclines from 35°-45° have angled debris rails to steer around while ascending and descending. This requires fine control and encourages autonomous behaviors.

Standard Dexterity Tasks

RoboCupRescue Robot League

Dexterity tasks are placed throughout the terrains and obstacles to score Dexterity points. So-called Linear and Omni tasks provide increasing difficulty. Tasks are placed along the walls, on the ground, or below the ground plane. They include non-contact Align/Inspect, Touch/Insert, Press E-Stops, Turn Valves, and Push/Pull Doors. The Carry Crate tasks evaluate strength of the manipulator and stowing capabilities within complex terrains.

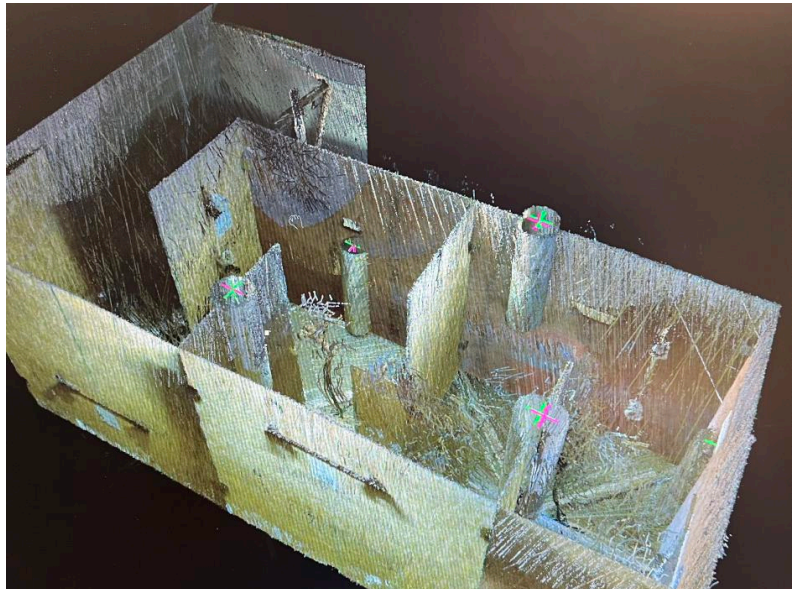


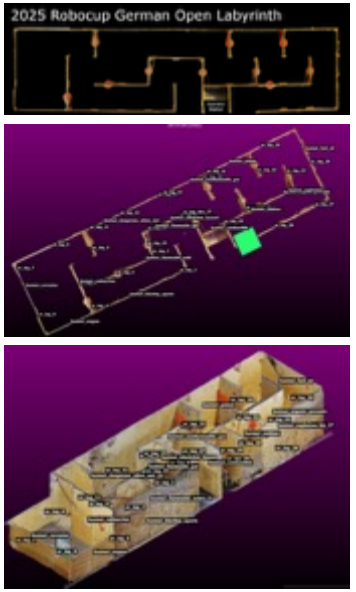
Align/Inspect	Touch/Insert	Press E-Stops	Turn Valves	Open Doors	Carry Crates
 Acuity & Color					
 Gauges to Read					
 QR Codes					
 Partial Hazmat					

Mapping tasks focus on 2D and 3D representations of the explored environment that can be used by emergency responders to identify the shortest route to victims, the location of potential hazards, etc.

Some key features include:

- Known lexicon of 2D and 3D objects of interest to find, identify, and locate on a map.
- Modest terrain elements challenge SLAM techniques while maneuvering.
- Split cylinder mapping fiducials and point cloud comparisons enable quantitative evaluation of maps and comparison of results with other teams and in other locations.



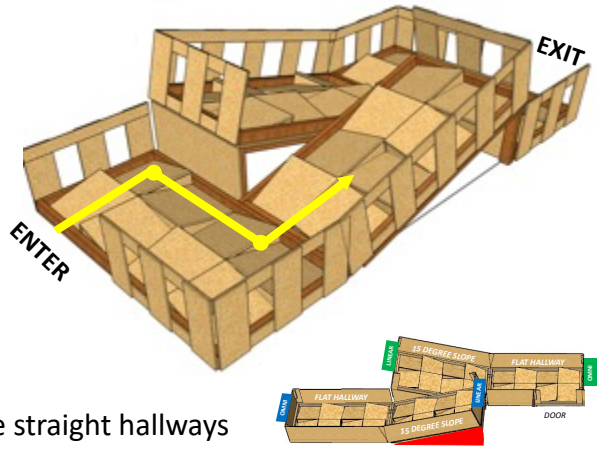


Arena Design Features

Balancing Needs of Robots, Teams, and Audience

"CONFINED" LANE CONFIGURATION

"Confined" lanes have 90° turns in the hallways to enter the square room in the middle.

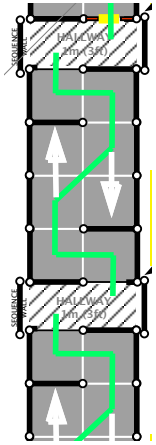


"Open" lanes have straight hallways

AUDIENCE SAFETY STANDOFF

- This is important to keep children and adults away from a robot potentially falling out of the test lane. The walls are 60cm (24in) tall to contain most robots but some may be taller.
- The standoff also enables ALL the spectators to see all the way down the test lane sequence and to capture good images and videos.
- The teams typically deploy their robots from the interior area opposite the audience, so nothing is blocking the audience view.

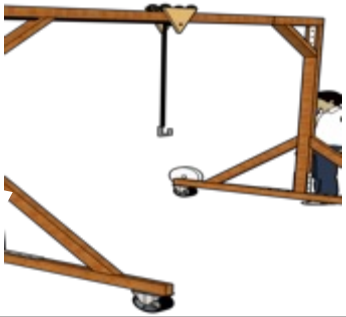
GAPS BETWEEN LANES PROVIDE ACCESS



- Gaps of 90cm (36in) between lanes enable access to BOTH lanes with doors on their ends.
- This maintains the overall width of the lanes at 2.4m (8ft) to enable the rolling gantry crane.
- Typical 120cm (48in) wall panels can be used to block the doorways for autonomous teams.
- The same removable lane walls can then be used to block the audience side and team side of the gaps for sequences.

ROLLING GANTRY SAFETY BELAY

- Enables humanoids and other robots to safely try more advanced terrains and obstacles.
- Fabricated using the same wood as all the rest of the test lanes (inexpensive and easy).
- Rolls along with a person on both sides to maintain position over the robot.
- One of them manages the belay rope too.



Compact Arena Layout

20 x 20 m (65 x 65 ft)

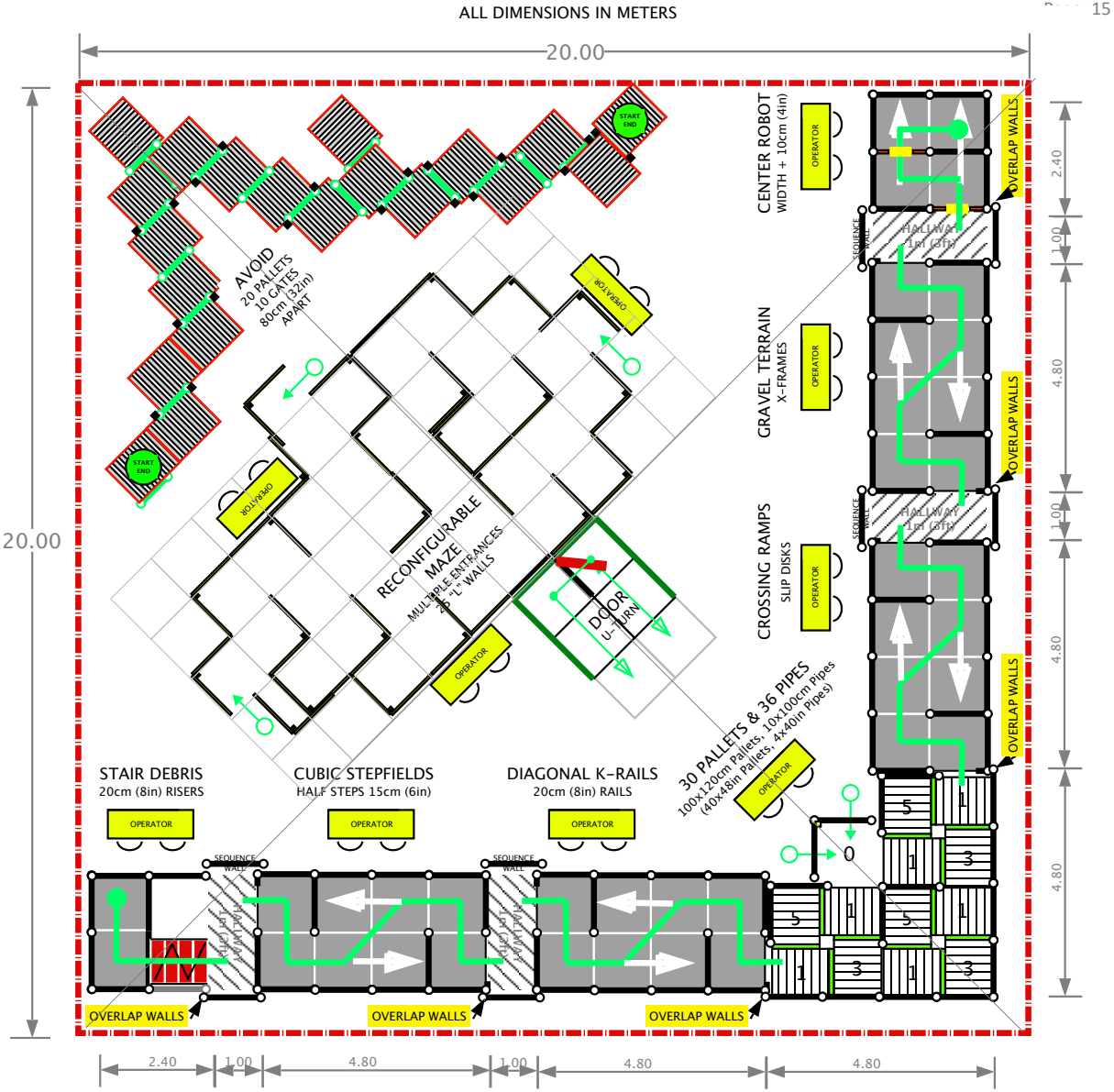
1. Tape the intended 20 x 20 meter perimeter on the floor. Add a 1m (3ft) buffer if possible to separate from the line of stantions and rope that keep the audience away from the walls. This ensures safety from a robot falling over the 60cm (24in) wall and improves sight lines for all the audience along the ropeline.

2. Find the center of the square with two long tape measures or string. Tape lines on the floor for 6m (20ft) from the intersection to align the LABYRINTH and DOOR apparatuses.

3. Orient the layout so the corner of the perimeter sequence is pointing toward the audience approach.

4. Start with the PALLETS & PIPES then abut the nearest terrains. Make the HALLWAYS between terrains 1m (3ft) as shown so typical 1.2m (4ft) walls can span the gap.

5. Place OPERATOR tables **with an affixed power strip and two chairs** facing away from the lanes.



Purchases

Materials and Screws

Key Items to Purchase Locally

See Associated Pointers to Examples

"2x2" LUMBER
6 cm x 6 cm x 3 m

"THIN WALL OSB"
9.5 mm x 120 cm x 240 cm

https://www.mercadolivre.com.br/forma-de-papelao-lisa-300mmx3m-tubominas/up/MLBU1429838140

"MAPPING" – 30 CM (12 IN)
MAZE/LABYRINTH

https://a.co/d/9qpx6kA

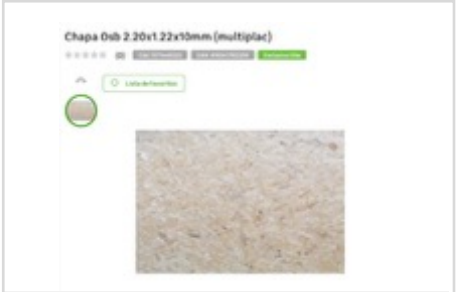
"SLIP DISKS" – 50 CM (20 IN)
RAMP TERRAIN

"2x4" LUMBER
5 cm x 11 cm x 3 m

"THICK FLOOR OSB"
18 mm x 120 cm x 240 cm

PIPES (PVC) – 10 cm (4 in) OD
PALLETS & PIPES

"PALLET"
100 cm x 120 cm (40 x 48 in)



"MAZE WALLS ONLY"
MAZE/LABYRINTH

https://a.co/d/71D7jzt

HAND TIGHT STAPS
PALLETS & PIPES

WORKING

Key Items to Purchase Locally

See Associated Pointers to Examples

https://a.co/d/0UJbKy7

HANDLES
INCLINED LANES

https://a.co/d/iGPAvJ2

CIRCULAR PUNCH 5 CM (2 IN)
DEXTERITY TASKS

https://a.co/d/hy28aQi

“E-STOP” BUTTONS
DEXTERITY TASK

https://a.co/d/gzLlpON

https://a.co/d/bhYANVh

RAIL (1.5 m) with TROLLEY
ROLLING SAFETY BELAY

https://a.co/d/d8rBjh0

HINGES
INCLINED LANES

https://a.co/d/6NlbXev

TOOL SHAFTS — 6 MM (1/4IN)
DEXTERITY TASKS

https://a.co/d/a2CrT4Z

SHUT OFF VALVES (90DEG)
DEXTERITY TASK

15 cm (6 in)
- (2) SWIVEL
- (2) FIXED

https://a.co/d/f4Lp85s

CASTERS
ROLLING SAFETY BELAY

SAFETY GREEN

SAFETY BLUE

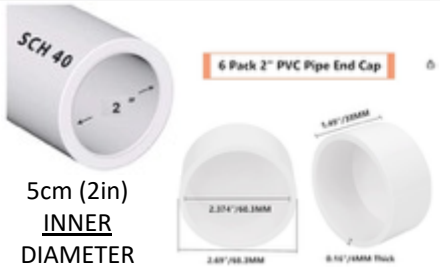
SAFETY RED

MATTE BLACK

SPRAY PAINT
DEXTERITY TASKS

https://a.co/d/26pAK06

THREADED INSERTS
8mm (5/16 in) x 25 mm (1 in)



5cm (2in)
INNER
DIAMETER

PIPES and CAPS
DEXTERITY TASKS

https://a.co/d/3aVigTE

ROPE (10 mm x 10 m)
ROLLING SAFETY BELAY

Key Items to Purchase Locally

Different Types of Scews

Fabrication of Lumber Elements

- For fabrication of elements that will never come apart.
- Burying the head into lumber is okay.
- Use any TORX SCREWS to facilitate one-handed power tool use.

TORX GENERAL DECKING SCREWS

[800] 5mm (#10in) x 40 mm (1-1/2 in) long
[300] 5mm (#10in) x 65 mm (2-1/2 in) long
[100] 5mm (#10in) x 75 mm (3 in) long

TYPICAL FLAT-HEAD TORX SCREWS

OR

SPAX WAFER-HEAD TORX SCREWS

Fabrication of OSB Panels

- For assembly of OSB panels to any lumber.
- Washer heads prevent penetration into the OSB.
- Use WASHER-HEAD TORX SCREWS or WAFER-HEAD SPAX SCREWS, to facilitate one-handed power tool use

SPAX WAFER HEAD SCREWS

[800] 5mm (#10in) x 40 mm (1-1/2 in) long
[300] 5mm (#10in) x 65 mm (2-1/2 in) long
[100] 5mm (#10in) x 75 mm (3 in) long

SCREWS: https://a.co/d/2So1bOh
BITS: https://a.co/d/aG4VE6l

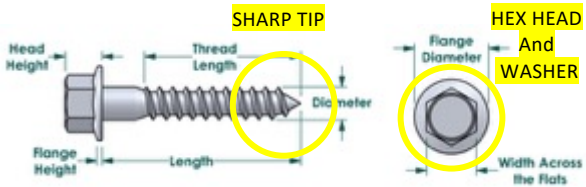
Set-Up / Tear-Down Hex Head to be Different

- For final attachment of walls on site and other elements that get disassembled.
- CANNOT BURY TO BE EASY TO FIND AND REMOVE. Also different so volunteers do not disassembly anything else!
- Use #10 ROOFING SCREWS with WASHERS, HEX HEADS, and MAGNETIZED SOCKET BITS to facilitate one-handed power tool use.

HEX HEAD ROOFING SCREWS

[800] 5mm (#10in) x 40 mm (1-1/2 in) long
[300] 5mm (#10in) x 65 mm (2-1/2 in) long
[100] 5mm (#10in) x 75 mm (3 in) long

EXAMPLE: https://a.co/d/51dEgnJ
BITS: https://a.co/d/0g1KPAb



Lane Walls

Fabrication

Lane Walls (Cheaper/Easier)

Short and Long OSB Panel Walls

QTY: [50] Short , [20] Long

PURCHASE LIST:

[23] **"THIN WALL OSB" PANELS**
120 x 240 cm (48 x 96 in)

[11] **"2x2" LUMBER**
240 cm (96 in)

CUT LIST:

A **[50]** **"THIN WALL OSB" SHORT WALLS**
60 x 120 cm (24 x 48 in)

B **[20]** **"THIN WALL OSB" LONG WALLS**
60 x 240 cm (24 x 96 in)

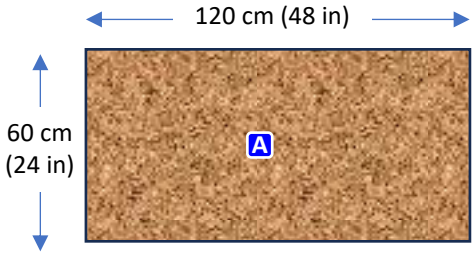
C **[40]** **"2x2" CORNER CONNECTORS**
30 cm (12 in)

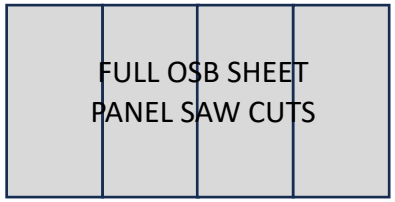
D **[20]** **"2x2" HORIZONTAL SUPPORTS**
100 cm (32 in)

FABRICATION TIPS:

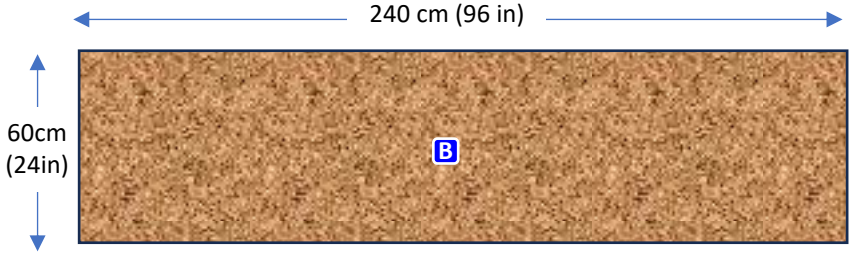
- Use a panel saw to make easy straight cuts of full OSB panels.

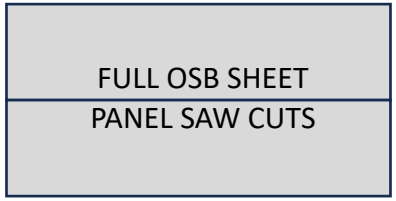
SHORT THIN OSB WALLS
60 cm x 120 cm (24 in x 48 in)
CUT 50



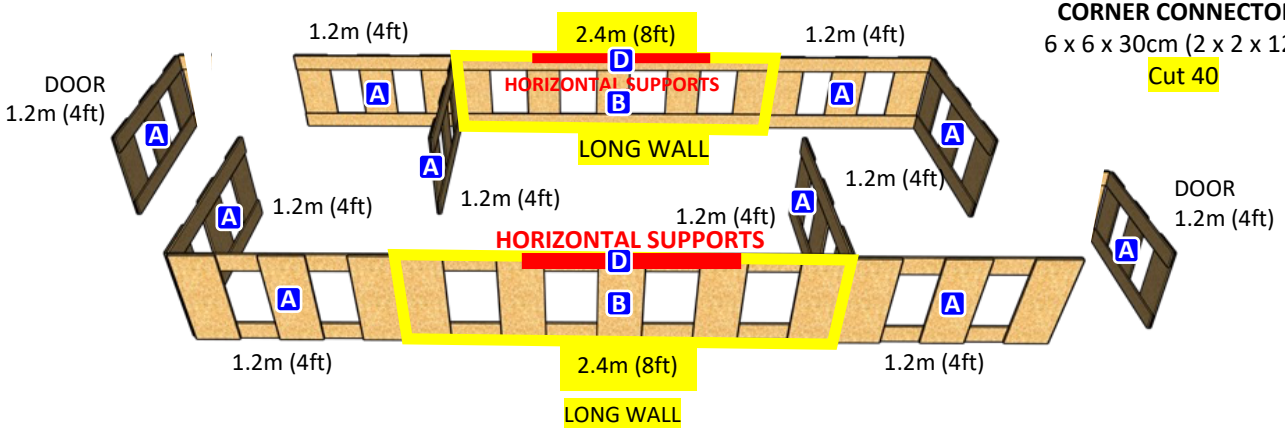


LONG OSB WALLS
60 cm x 240 cm (24 in x 96 in)
CUT 20





CORNER CONNECTORS
6 x 6 x 30cm (2 x 2 x 12in)
Cut 40



NOTE: Your dimensions may vary slightly depending on the your purchasable materials. The goal is to minimize purchase costs and cuts while maintaining the rough dimensions shown.

Subfloors

Fabrication

Subfloors

Fabricate All the Same Initially

QTY: [19] SUBFLOORS

PURCHASE LIST:

[19] **"THICK FLOOR OSB" PANELS**
120 x 240 cm (48 x 96 in)

[16] **"2x4" LUMBER**
240 cm (96 in) long

[20] **DOOR HINGES TO ATTACH FLOORS**
7.5 cm (3 in) or less

[20] **GRIP HANDLES TO LIFT FLOORS**
Strong and easy to grip type

CUT LIST:

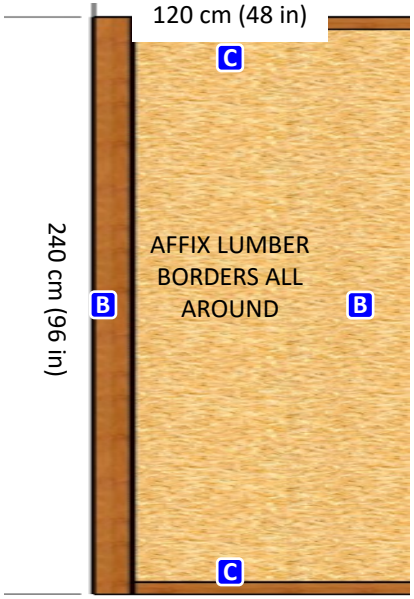
A **[19] "THICK FLOOR OSB" FULL PANEL**
NO CUTS

B **[38] "2x4" LONG BORDERS**
240 cm (96 in)
SHOULD BE SAME AS OSB PANEL

C **[76] "2x4" SHORT BORDERS**
110 cm (45 in)
CUT TO FIT BETWEEN LONG BORDERS

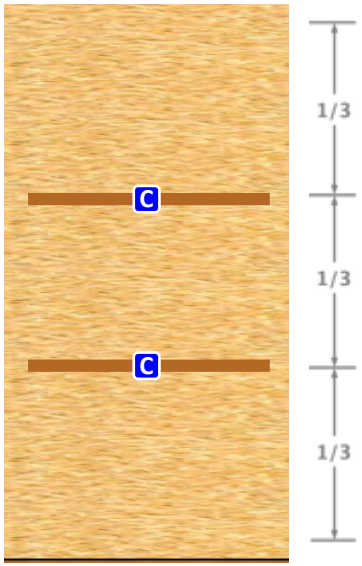
FULL OSB PANEL

ADD LONG BORDERS



ADD SHORT BORDERS

AND (2) MORE
CROSS SUPPORTS



[2] HANDLES ON [10] SUBFLOORS
INTENDED FOR SOPED TERRAINS
https://a.co/d/0UJbKy7

NOTE: Your dimensions may vary slightly depending on the your purchasable materials. The goal is to minimize purchase costs and cuts while maintaining the rough dimensions shown.

Tilt-Up Legs (15°)

Add to Only 10 of the Subfloors Fabricated

QTY: [10] TILT-UP LEGS

PURCHASE LIST:

[1] **"THIN WALL OSB" PANELS**
120 cm x 240 cm (48 in x 96 in)

[16] **"2x4" LUMBER**
240 cm (96 in)

[20] **DOOR HINGES**
7.5 cm (3 in) or less

[60m] **ROPE**
12 mm (1/2 in)

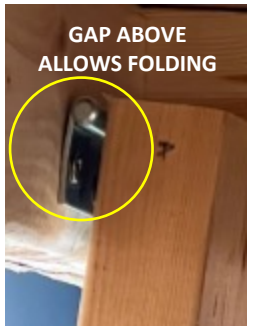
CUT LIST:

A **[10] "THIN WALL OSB" PANELS**
30 x 100 cm (12 x 40 in)

B **[20] "2x4" LEGS**
68.5 cm (27 in)
TO MAKE !5° INCLINE WHEN ASSEMBLED WITH THE HINGE

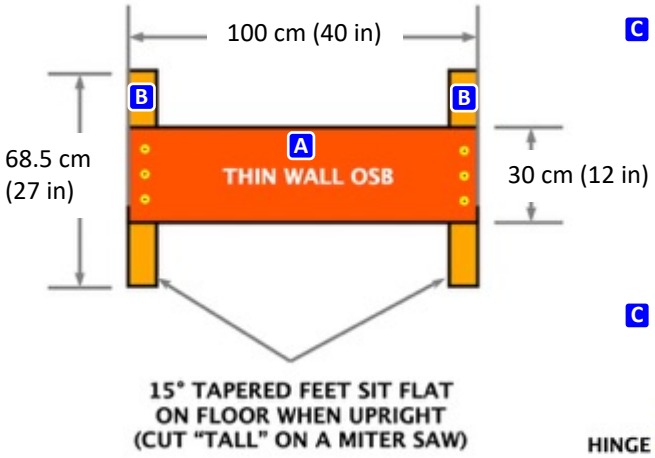
FABRICATION TIPS:

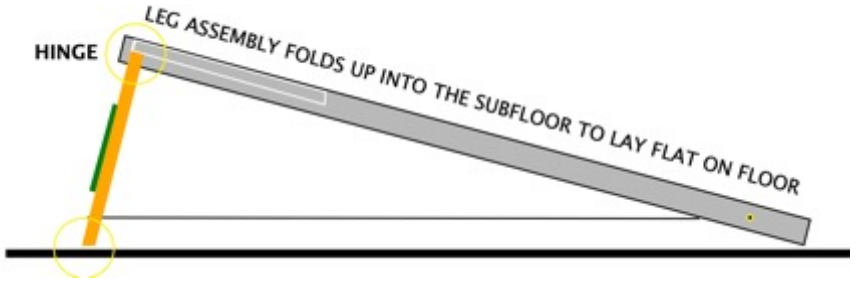
- Be certain the folded legs completely recess up into the frame of the floor. So be careful how the hinge is attached.
- Make one assembly and measure the resulting angle before making more. The incline should be 15°.



ROPES KEEP LEGS FROM ENTENDING TOO FAR

**HINGES ALLOW LEG ASSEMBLY TO FOLD FLAT UNDER FLOOR.
THE SUBFLOOR FRAME LIMITS THE LEGS FROM EXTENDING TOO FAR.**

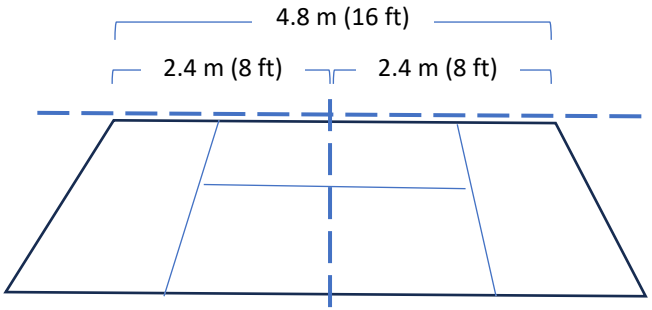


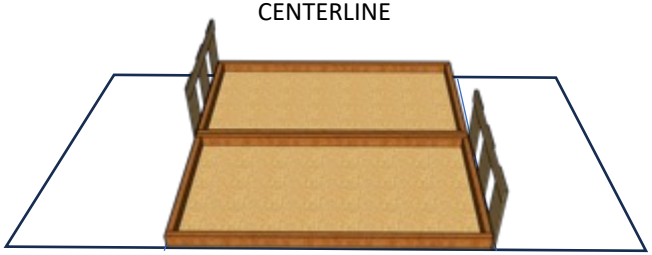


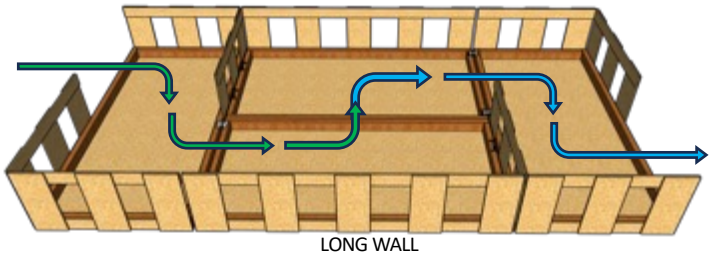
NOTE: Your dimensions may vary slightly depending on the your purchasable materials. The goal is to minimize purchase costs and cuts while maintaining the rough dimensions shown.c

Lane Set Up Procedure - 3D View

Hallways (Flat) and Room (Flat or Sloped)







STEP 1

A. Measure and mark one side edge and the centerline of the intended lane location.

B. Remember to leave 90 cm (36 in) spaces between each lane for access to lanes doors. That allows short walls to span the gap, overlap, and binder clip to both lanes for sequences.

STEP 2

C. Place both center room floors WITH TILT LEGS aligned and touching a long edge.

D. Attach (2) short walls and (2) handles to intended uphill ends.

STEP 3

F. Place both 90° hallways leaving a slight 1cm (1/2in) gap with the uphill walls so they can incline and lay flat without interacting.

G. Attach hinges across downhill connections with the hallways to maintain the spacing.

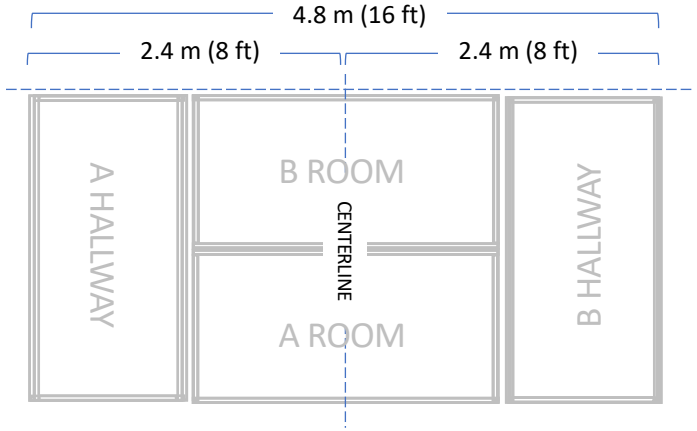
STEP 4

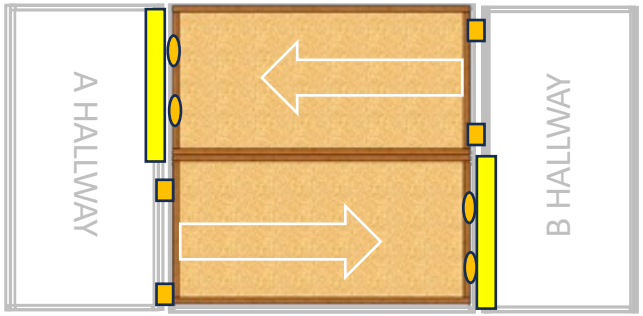
H. Attached (6) more short walls.

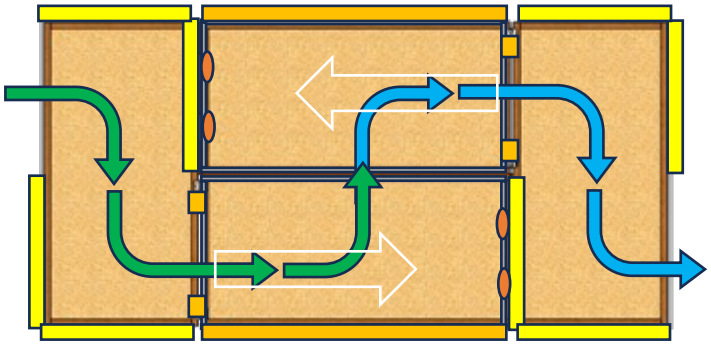
I. Attached (2) long walls along the rooms

Lane Set Up Procedure - 2D View

Hallways (Flat) and Room (Flat or Sloped)







STEP 1

A. Measure and mark one side edge and the centerline of the intended lane location.

B. Remember to leave 90 cm (36 in) spaces between each lane for access to lanes doors. That allows short walls to span the gap, overlap, and binder clip to both lanes for sequences.

STEP 2

C. Place both center room floors WITH TILT LEGS aligned and touching a long edge.

D. Attach (2) short walls and (2) handles to intended uphill ends.

STEP 3

F. Place both 90° hallways leaving a slight 1cm (1/2in) gap with the uphill walls so they can incline and lay flat without interacting.

G. Attach hinges across downhill connections with the hallways to maintain the spacing.

STEP 4

H. Attached (6) more short walls.

I. Attached (2) long walls along the rooms

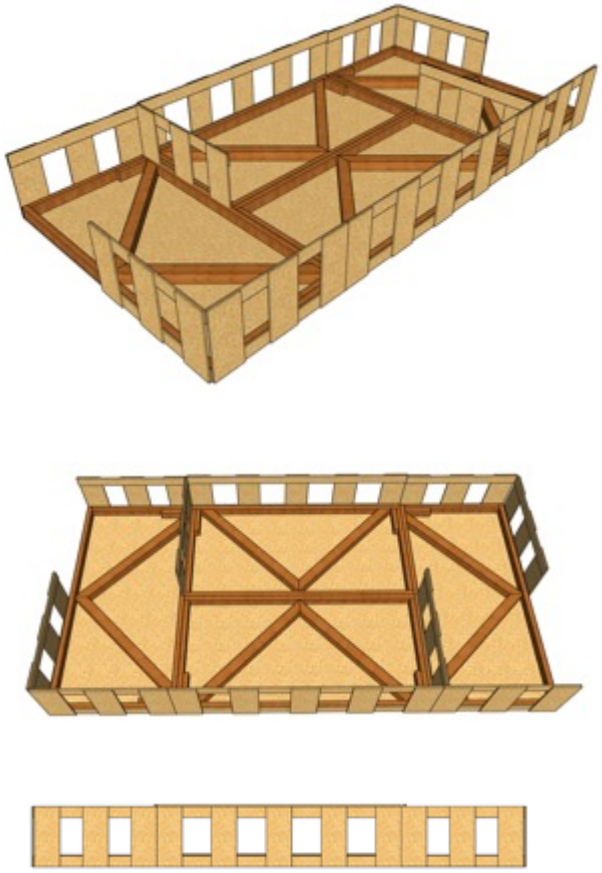
K-Rails

Fabrication

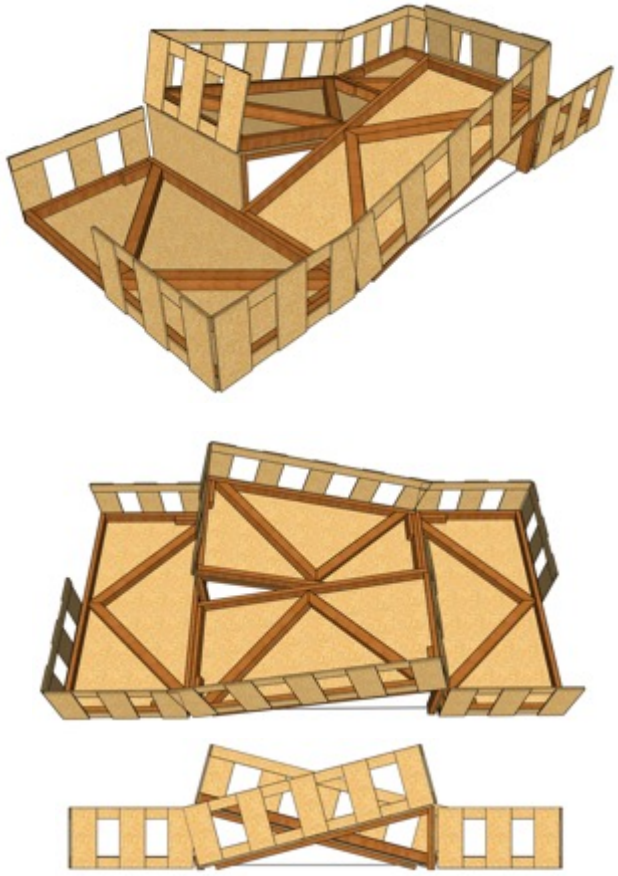
K-Rails

Difficulty Levels

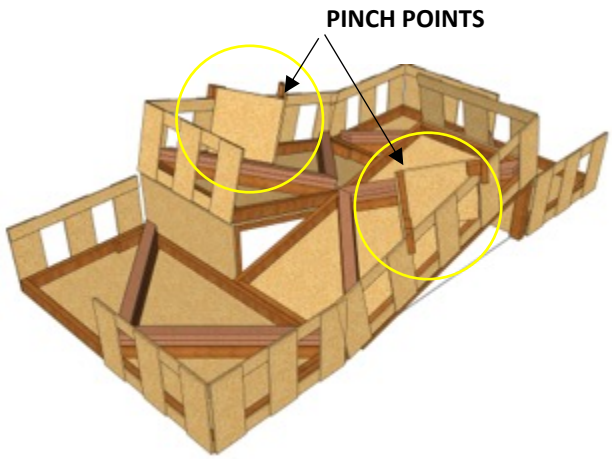
CONFINED FLAT
Prelims



OPPOSING SLOPES (15°)
Prelims/Semis



ADDITIONAL OBSTACLES
Semis/Finals



Layered K-Rails Elevations:
- Base K-Rails: 10cm (4in)
- Additional Layers: 5cm (2in) each
- Stack to challenge the maximum capability of the robot.

Pinch Points:
- Add precise steering within the terrain.
- Inconvenient approaches to the obstacles.

QTY: [4] "2x4" K-RAIL LAYERS

PURCHASE LIST:

[32] "2x4" LUMBER
240 cm (96 in)

CUT LIST:

A [32] "2x4" DIAGONAL K-RAILS
169 cm (67.5 in) – 45° BOTH ENDS
MUST FIT CORNER TO WALL
CUT FLAT, BOTH ENDS OPPOSING

B [8] HINGES
7.5 cm (3 in) DOOR HINGES
MAKES THE ADDITIONAL LAYERS
DROP IN AND STOW EASIER

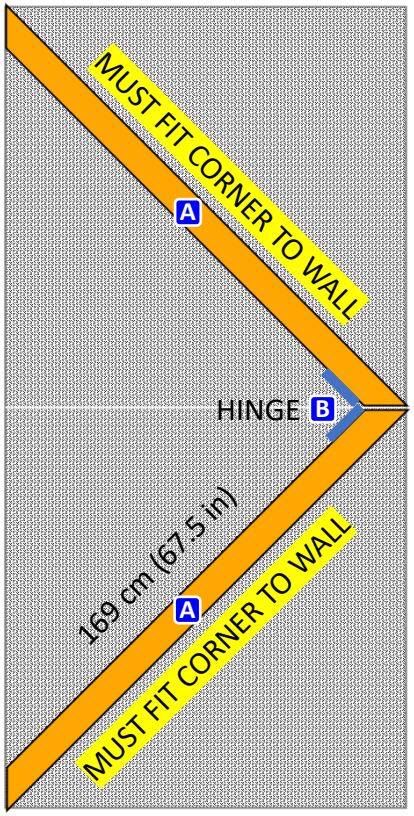
FABRICATION TIPS:

- Double thick DIAGONAL K-RAILS get screwed together in flat layers.
- ADD A SPACER to make the combined 2 layers total 10cm (4in) tall.
- Screw the BASE LAYER to the SUBFLOOR from the underside to support the OSB.
- Additional layers can be HINGED at the apex to fold and stow. This helps to carry and drop into place as well.
- The second hinged layer can be affixed to the base layer either with screws, holes with dowels between layers, or added constraints.

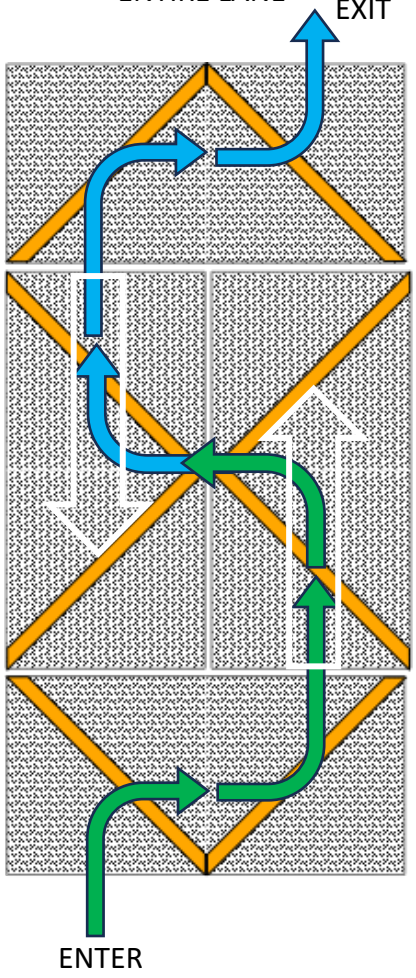
DOUBLE BASE LAYER
10 cm TALL (4 in TALL)
(ADD THIN OSB SPACERS AS NEEDED)

ADDITIONAL LAYERS SCREWED TO BASE LAYER FOR LARGER ROBOTS
20cm (8in)
(ADD THIN OSB SPACERS)

PAIRS OF DIAGONAL "2x4s"
45° ENDS CUT FLAT (OPPOSING)



PATTERN FOR
ENTIRE LANE



NOTE: Your dimensions may vary slightly depending on the your purchasable materials. The goal is to minimize purchase costs and cuts while maintaining the rough dimensions shown.

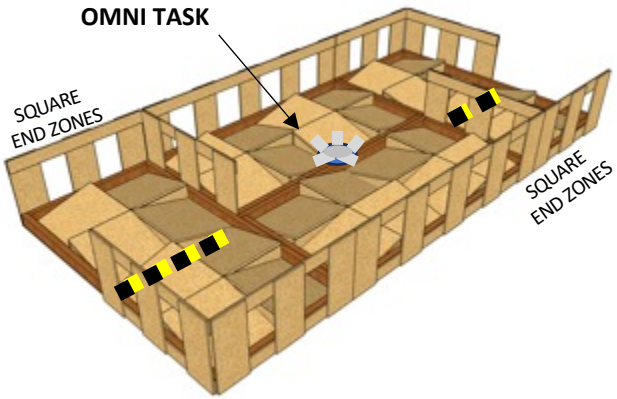
Ramps

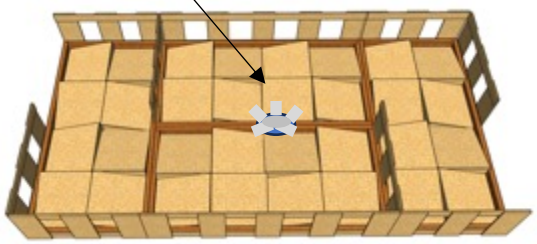
Fabrication

Ramps (15°)

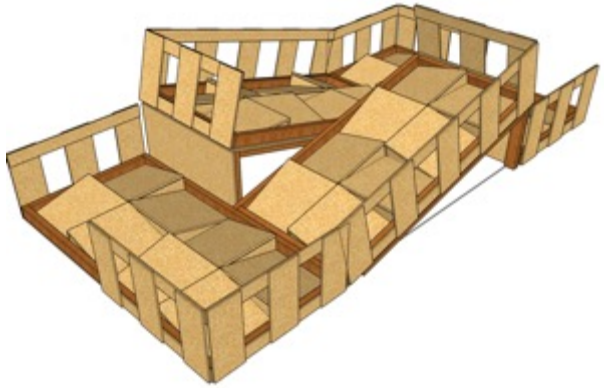
Lane Difficulty Settings

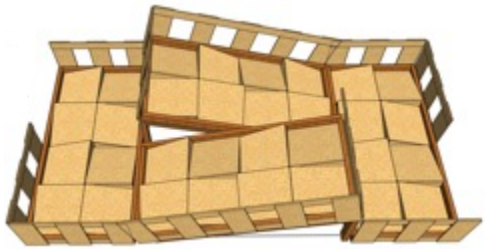
CONFINED FLAT
Prelims



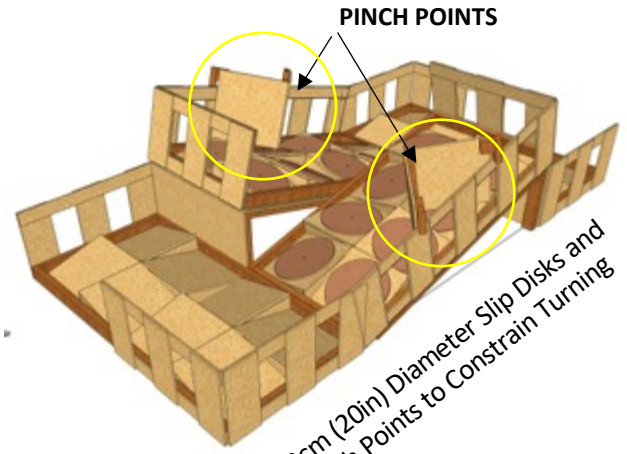


OPPOSING SLOPES (15°)
Prelims/Semis





ADDITIONAL OBSTACLES
Semis/Finals



THIN WOOD DISKS
50 cm (20 in) DIAMETER
4mm (1/8in) THICK OR MORE

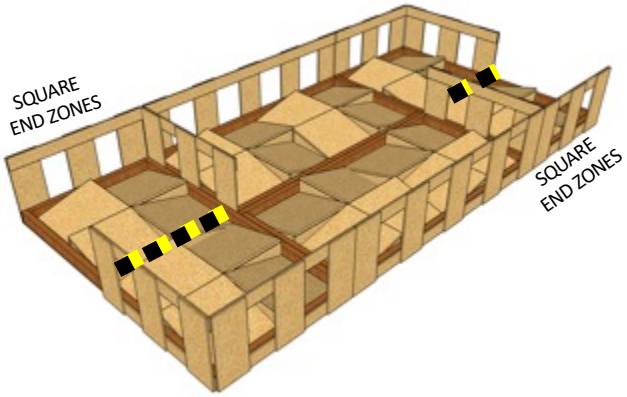
THREADED INSERTS
8mm (5/16in) THREADS
25mm (1in) LONG
PINCH POINTS

HEX HEAD BOLTS AND WASHERS
8mm (5-16in) THREAD
50 cm (20 in) DIAMETERj
FLANGE WASHERS

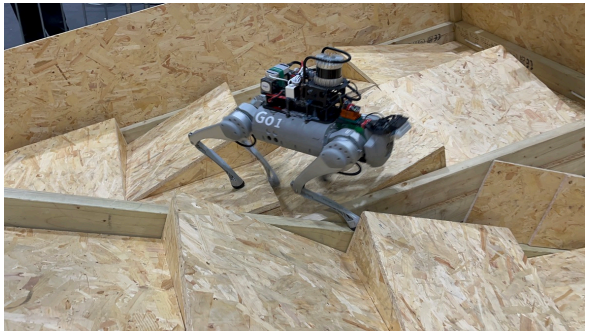
Ramps (15°)

Lane Difficulty Settings

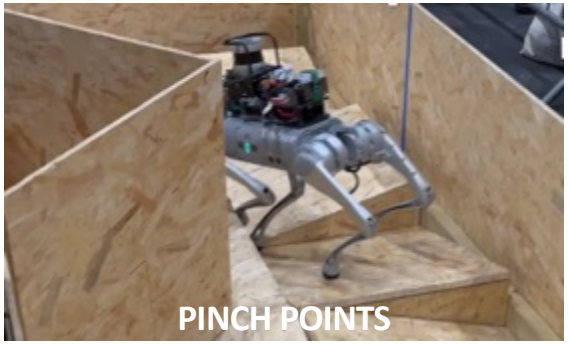
CONFINED FLAT
Prelims



OPPOSING SLOPES (15°)
Prelims/Semis



ADDITIONAL OBSTACLES
Semis/Finals



Ramps (15°)

Fabrication

QTY: [40] RAMPS

PURCHASE LIST:

[5] **"THICK FLOOR OSB" PANELS**
120 x 240 cm (48 in x 96 in)

[5] **"THIN WALL OSB" PANELS**
120 x 240 cm (48 in x 96 in)

[10] **"2x4" LUMBER**
240 cm (96 in)

CUT LIST:

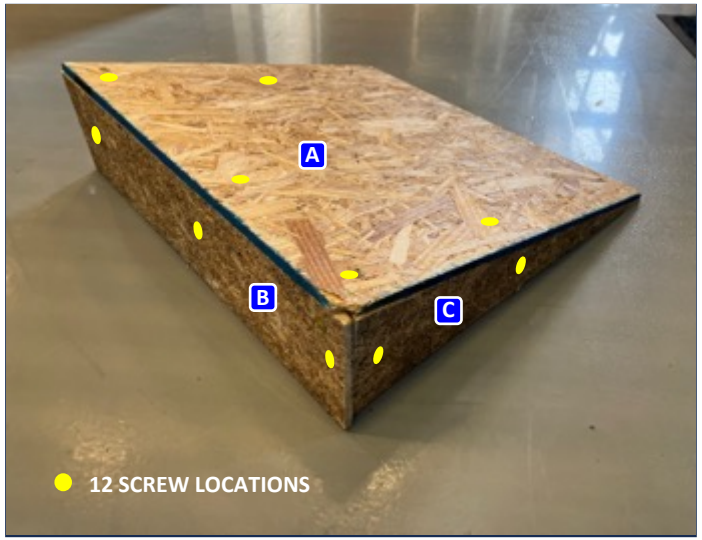
A [40] "THICK FLOOR OSB" TOPS
594 mm (23-3/4 in) SQUARE
MUST BE LESS THAN HALF YOUR FLOOR WIDTH TO FIT 2 ACROSS

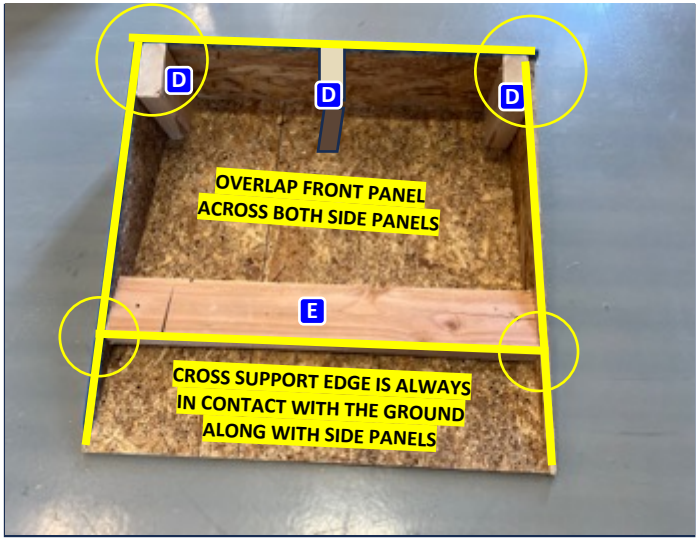
B [40] "THIN FLOOR OSB" FRONTS
15 cm (6 in) TALL
MATCH SQUARE TOP DIMENSION
SUPPORTS THE ENTIRE TOP EDGE

C [80] "THIN FLOOR OSB" SIDES
MATCH SQUARE TOP DIMENSION
15 cm (6 in) TALL
TAPERS AT 15°
SUPPORTS THE ENTIRE TOP EDGE

D [120] "2x4" LEGS
15 cm (6 in) – 15° CUT ONE END
CUT FLAT ON SAW

E [40] "2x4" CROSS SUPPORTS
CUT TO WIDTH BETWEEN WALLS
LESS THAN TOP BECAUSE SIDES ARE RECEESSED UNDER THE TOP





- TIP: ASSEMBLE TWO RAMPS FIRST TO ENSURE YOUR DIMENSIONS FIT BETWEEN THE LANE WALLS WHEN ATTACHED TO A SUBFLOOR.
- Two ramps must fit EASILY within the space BETWEEN THE WALLS so they can be rotated in place.
- To ensure all the OSB pieces are the same size, cut the FRONTS and SIDES from the extra TOPS all cut at the same time.
- STEP 1: Attach [2] CORNER LEGS to [2] SIDE PANELS upside down on the floor so that when inverted the top edges are coincident.
- STEP 2: Attach the two SIDE panels to the FRONT panel upside down on the floor so that the FRONT overlaps the SIDES.
- STEP 3: Attach the 3rd LEG to the center of the FRONT panel while still upside down on the floor.
- STEP 4: Attach the CROSS SUPPORT to the [2] SIDES so that the near edge is coincident with both SIDES.
- STEP 3: Flip the assembly and attach the square TOP to the three LEGS and the CROSS SUPPORT.

NOTE: [32] RAMPS fill a lane, but we need extras elsewhere.

NOTE: Your dimensions may vary slightly depending on the your purchasable materials. The goal is to minimize purchase costs and cuts while maintaining the rough dimensions shown.

Ramps (15°)

Slip Disks

QTY: [40] SLIP DISKS

PURCHASE LIST:

[40] THIN ROUND DISKS
3 mm thick x 50 cm diameter
(0.12 in thick x 20 in diameter)
Example: https://a.co/d/bZNhpLu

[40] THREADED INSERTS
8 mm thread x 25 mm long
(5/16 in thread x 1 in long)
Example: https://a.co/d/3lhbJ5J

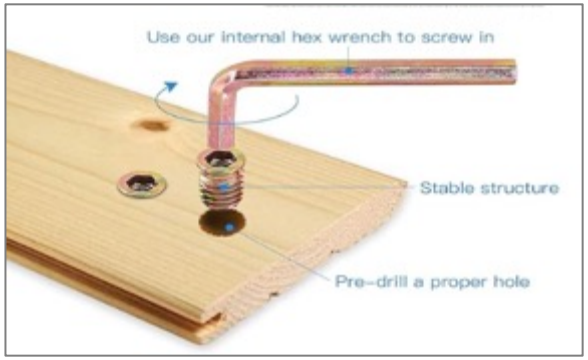
[40] HEX BOLTS
8 mm thread x 40 mm long
(5/16 in thread x 1-1/2 in long)
Example: https://a.co/d/at3Zsu3

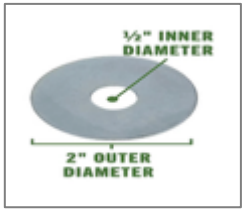
[40] FENDER WASHERS
8 mm thread x 40 mm diameter
5/16 in bolt x 1-1/2 in diameter
Example: https://a.co/d/0V6FOMf

[1] THICK MARKER
Magnum black marker
Example: https://a.co/d/9YNsxQu

FABRICATION TIPS:

- Find the center of each ramp by drawing lines from corner to corner. Drill in center using a bit appropriate for the threaded insert being used.
- Find the center of the disks by measuring in multiple angles from the edge. Clamp several of them together and drill all at once.





THIN ROUND DISKS
- Any thin disk with big enough diameter may do. It doesn't need to be wood.
- Could also be plastic or even metal (pizza pan liners)
- Need to drill oversized center holes for the hex bolts.

THREADED INSERTS
- Placed in the CENTER of each RAMP.
- Be sure to drill the correct size hole for the the external threads to bite.

HEX BOLTS
- Must match the threaded inserts internal thread and be at least 25mm (1in) long.
- Thread in by hand and stays loose so the disk rotates freely.
- Add a FENDER WASHER to protect the holes in the THIN ROUND DISKS

FENDER WASHERS
- Big enough for the HEX BOLTS.
- Any outer diameter will work.

THICK MARKER
- Straight lines from the center out shows when the ROUND DISK is rotated by the robot's actions.

NOTE: Your dimensions may vary slightly depending on the your purchasable materials. The goal is to minimize purchase costs and cuts while maintaining the rough dimensions shown.

Stepfields

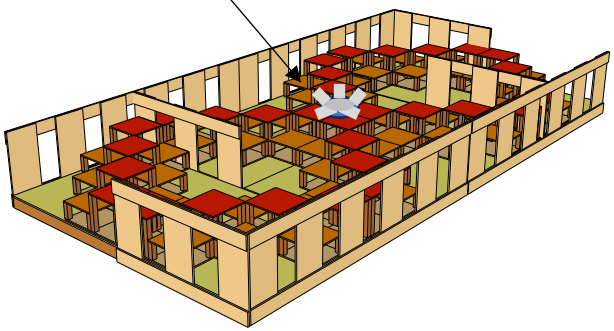
Fabrication

Stepfields

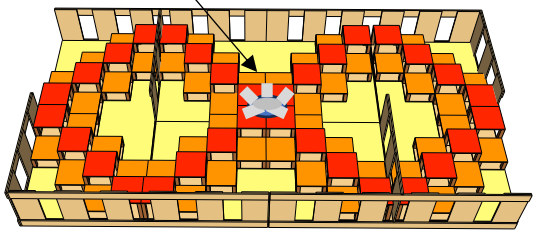
Lane Difficulty Settings

CONFINED FLAT
Prelims

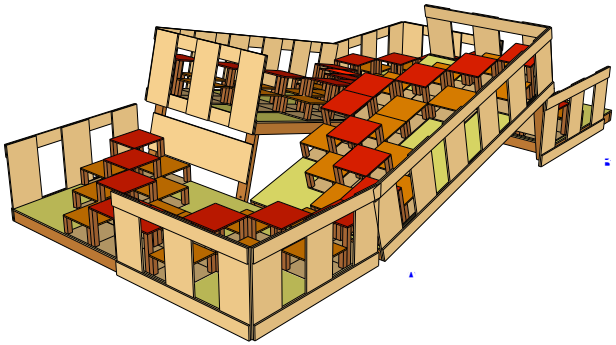
OMNI TASK

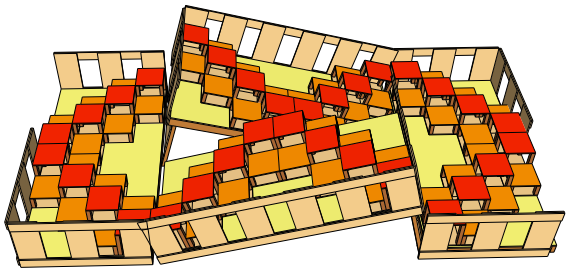


OMNI TASK



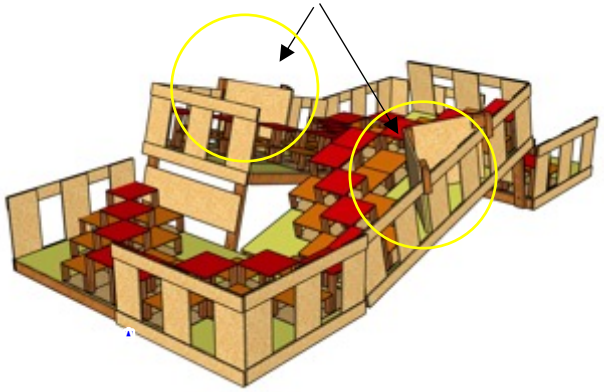
OPPOSING SLOPES (15°)
Prelims/Semis





ADDITIONAL OBSTACLES
Semis/Finals

PINCH POINTS



PINCH POINTS HANG ON WALLS

QTY: [16] DOUBLE, [16] TRIPLE

NOTE: CAN USE SHELVING WOOD BOARDS IF WIDTH IS JUST UNDER 30cm (12in) SO THEY FIT 4 ACROSS FLOOR WIDTH.

PURCHASE LIST:

[5] **"THICK FLOOR OSB" PANELS**
120 cm x 240 cm (48 in x 96 in)

[25] **"2x2" LUMBER**
240 cm (96 in)

CUT LIST:

A **[80] "THICK FLOOR OSB" SINGLES**
MUIST FIT 4 ACROSS FLOOR WIDTH
WIDTH: 297 mm (11-7/8 in)
LENTTH: 297 mm (11-7/8 in)

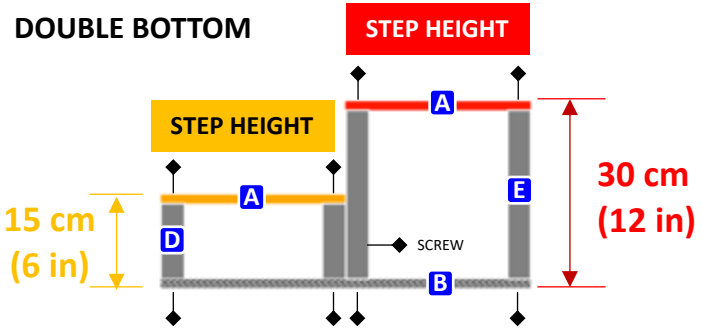
B **[16] "THICK FLOOR OSB" DOUBLES**
MUIST FIT 4 ACROSS FLOOR WIDTH
WIDTH: 297 mm (11-7/8 in)
LENTTH: 594 mm (23-3/4 in)

C **[16] "THICK FLOOR OSB" TRIPLES**
MUIST FIT 4 ACROSS FLOOR WIDTH
WIDTH: 297 mm (11-7/8 in)
LENTTH: 891 mm (35-5/8 in)

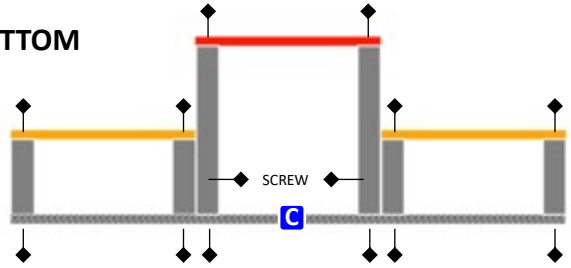
D **[200] "2x2" SHORT LEGS**
SUBTRACT TOP/BOTTOM THICKNESS
114 mm = 15 cm STEP – 2(18 mm)
4-3/4 in = 6 in STEP – 2(19/32 in)

E **[130] "2x2" LONG LEGS**
SUBTRACT TOP/BOTTOM THICKNESS
264 mm = 30 cm STEP – 2(18 mm)
10-3/4 in = 12 in STEP – 2(19/32)

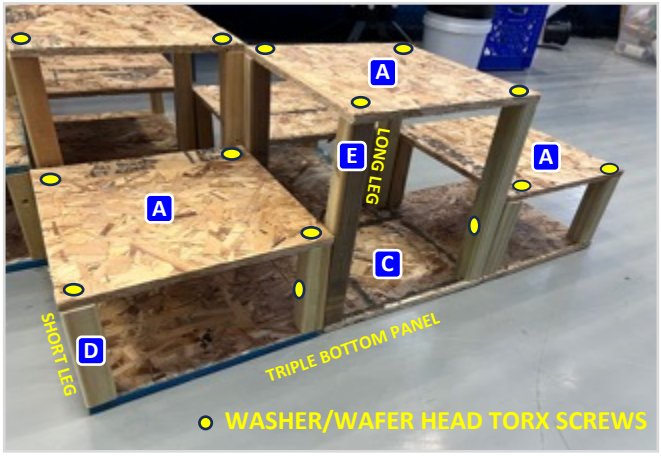
DOUBLE BOTTOM

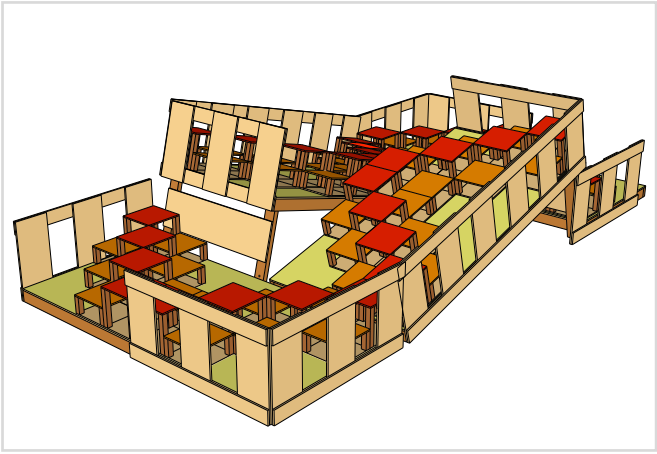


TRIPLE BOTTOM



WASHER/WAFER HEADTORX SCREWS





NOTE: Your dimensions may vary slightly depending on the your purchasable materials. The goal is to minimize purchase costs and cuts while maintaining the rough dimensions shown.

Gravel

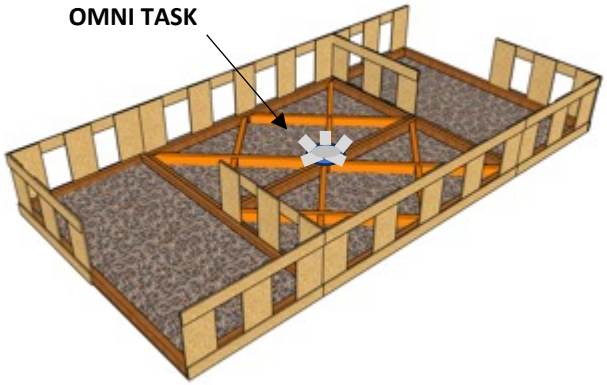
Fabrication

Gravel

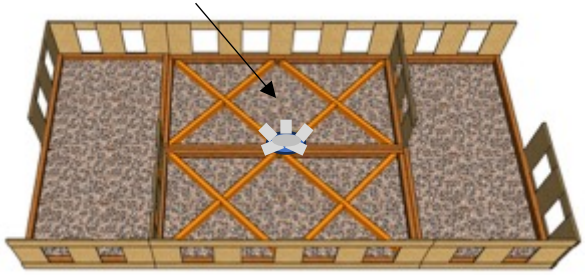
Lane Difficulty Settings

CONFINED FLAT
Prelims

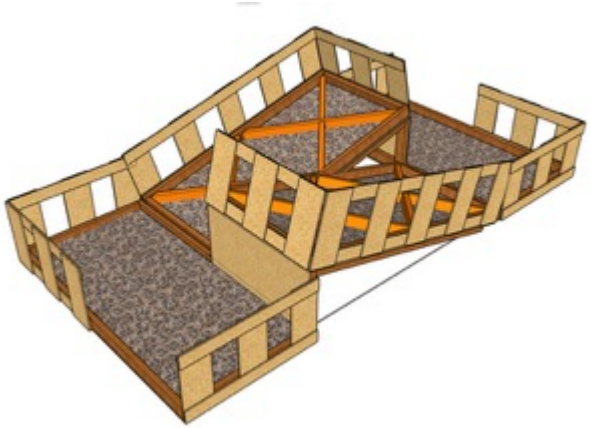
OMNI TASK

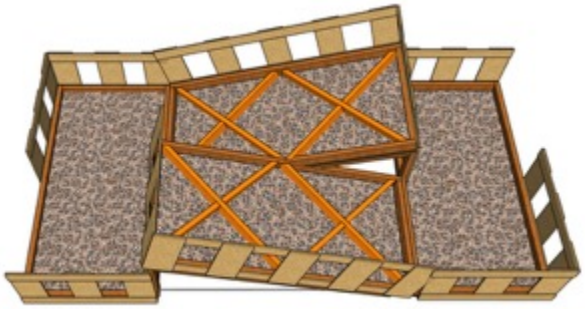


OMNI TASK



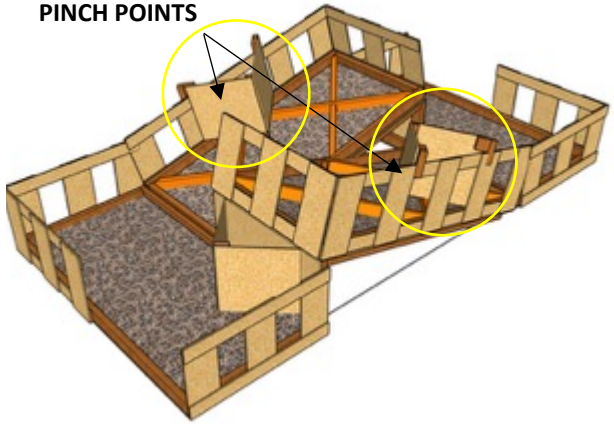
OPPOSING SLOPES (15°)
Prelims/Semis





ADDITIONAL OBSTACLES
Semis/Finals

PINCH POINTS



Pinch points constrain turns, can bury wheels and tracks.

QTY: [4] BORDERS, [4] X-RAILS

PURCHASE LIST:

[20] "2x4" LUMBER
240 cm (96 in)

CUT LIST:

A **[8] "2x4" LONG BORDERS**
240 cm (96 in)
SHOULD BE SAME AS OSB PANEL

B **[8] "2x4" SHORT BORDERS**
110 cm (45 in)
CUT TO FIT BETWEEN LONG BEAMS

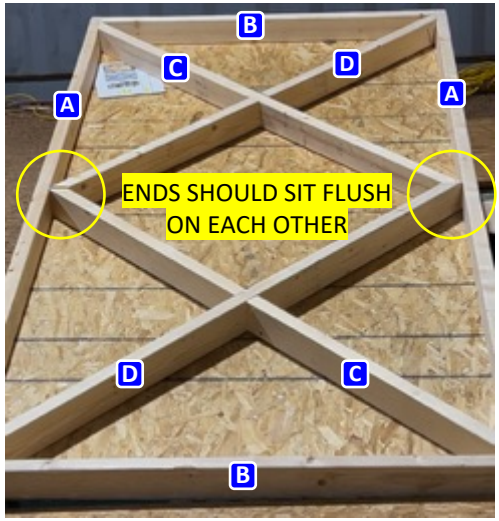
C **[4] "2x4" X-RAIL TOP NOTCH**
169 cm CORNER TO BORDER CENTER
67.5 in CORNER TO BORDER CENTER)
45° BOTH ENDS – CUT TALL OPPOSING

D **[4] "2x4"X-RAIL BOTTOM NOTCH**
169 cm CORNER TO BORDER CENTER
67.5 in CORNER TO BORDER CENTER)
45° BOTH ENDS – CUT TALL OPPOSING

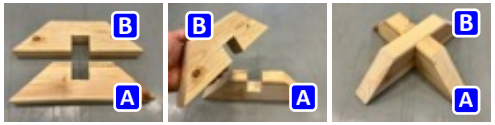
FABRICATION TIPS:

- Attach border frames together and to pre-fabricated SUBFLOORS with angled screws.
- Measure the diagonals that fit from a corner to the center of a long border.
- Notch the exact CENTER of each rail a bit wider than the beam's width, so the two notches can intersect easily.
- Screw the X-Rails to the SUBFLOOR from the underside to support the OSB.

TALL "2x4" X-RAILS CONTAIN GRAVEL ON SLOPED CETER ROOM

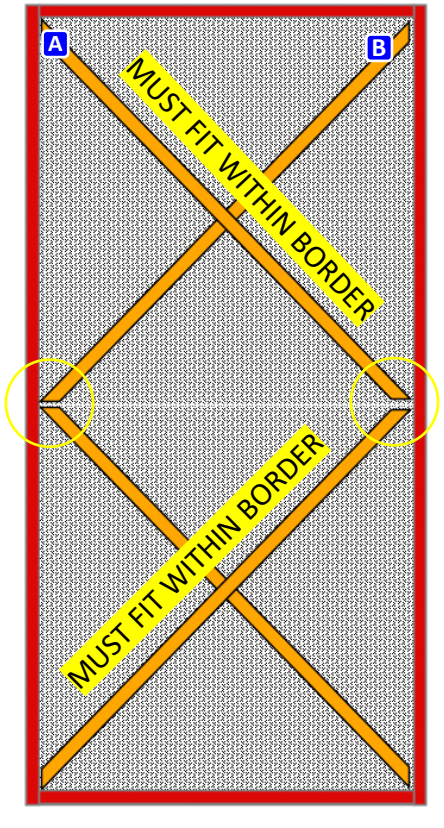


CENTER NOTCHES INTERSECT LIKE OMNIS



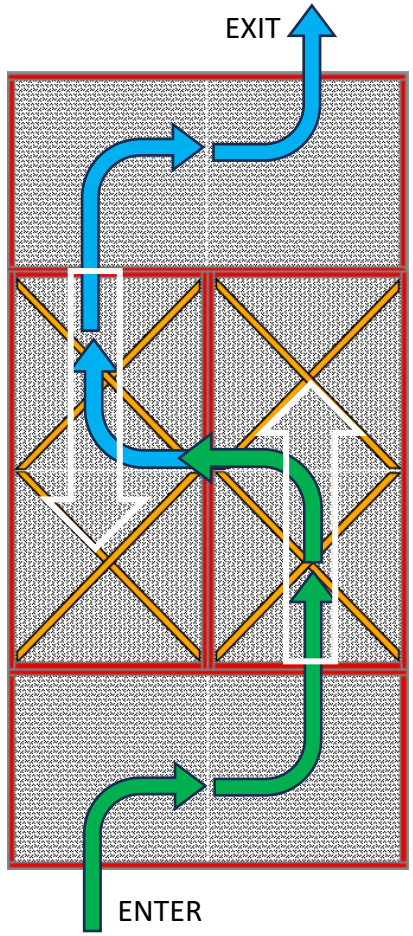
SINGLE SLOPED SUBFLOOR

DIAGONAL "2x4s"
45° ENDS CUT TALL (OPPOSING)
CENTER NOTCHES TO INTERSECT



SCREW X-RAILS TO SUBFLOOR
FROM UNDERSIDE TO STIFFEN OSB

LANE PATTERN



NOTE: Your dimensions may vary slightly depending on the your purchasable materials. The goal is to minimize purchase costs and cuts while maintaining the rough dimensions shown.

Pallets & Pipes

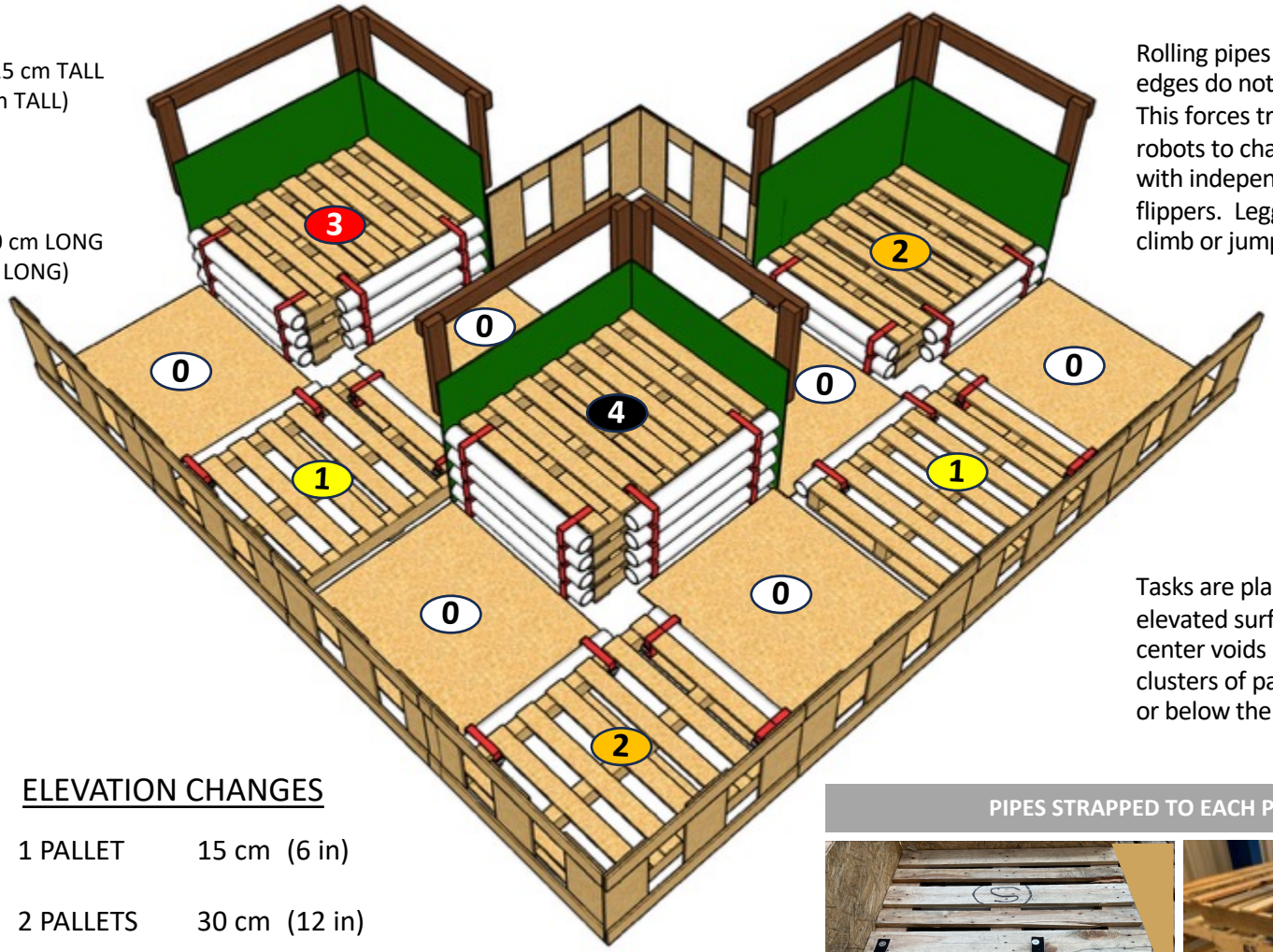
Fabrication

Pallets & Pipes (Purchased Pallets)

Purchased Pallet Stacks

13 PALLETS
100 WIDE x 120 LONG x 15 cm TALL
(40 WIDE x 48 LONG x 6 in TALL)

26 PIPES
10 cm OUTER DIAM x 100 cm LONG
(4 in OUTER DIAM x 40 in LONG)



Rolling pipes ensure the sharp edges do not help robot ascend. This forces tracked and wheeled robots to change their shape with independently controlled flippers. Legged robots need to climb or jump.

Tasks are placed on walls of elevated surfaces and in the center voids below between clusters of pallets either above or below the terrain plane.

ASCEND/DESCEND	ELEVATION CHANGES	
0 ↔ 1	1 PALLET	15 cm (6 in)
0 ↔ 2	2 PALLETS	30 cm (12 in)
0 ↔ 3	3 PALLETS	45 cm (18 in)
0 ↔ 4	4 PALLETS	60 cm (24 in)

PIPES STRAPPED TO EACH PALLET

Pallets & Pipes (Design A)

Purchased Pallet Stacks

QTY: 13 PALLETS w/ 2 PIPES

PURCHASE LIST:

[13] PALLETS
100 x 120 x 10-15 cm THICK
(40 x 48 x 4-6 in THICK)

[26] PVC PIPES (DRAIN PIPES)
10 cm OUTER DIAMETER x 120 cm
(4 in OUTER DIAMETER x 48 in)

[52] CARGO STRAPS W/LATCHES
WIDTH: 25 mm (1 in)
LENGTH: 60-120 cm (24-48 in)
EXAMPLE: https://a.co/d/irzBUva

[3] "THIN WALL OSB" PANELS
120 x 240 cm (48 x 96 in)

[6] "2x4" LUMBER
240 cm (96 in)

CUT LIST:

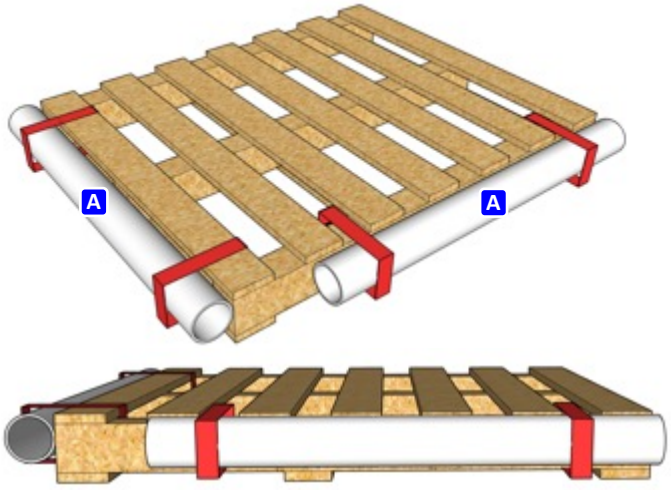
A [6] PVC PIPES
99 cm (47.5 in)
A BIT LESS THAN PALLET WIDTH

B [6] "THIN WALL OSB" LEVEL 0
100 x 120 cm (40 x 48 in)
SAME DIMENSIONS AS PALLETS

C [12] "2x4" PIPE BASE SPACER
100 cm (40 in)
SAME SHORT DIMENSION OF PALLETS

Rolling pipes remove the sharp edge forces tracked and wheeled robots use to ascend. They need to change their shape to surmount these obstacles with incremental elevations.

Porous pallet surfaces force legged robots to avoid cracks or enlarge feet.



OPTIONAL TASKS BELOW THE TERRAIN

STACKS FOR CLIMBING/DESCENDING

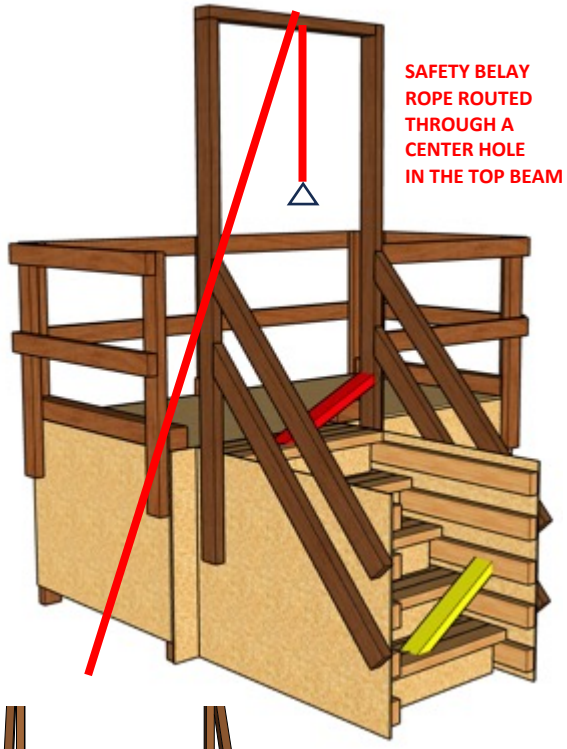
NOTE: Your dimensions may vary slightly depending on the your purchasable materials. The goal is to minimize purchase costs and cuts while maintaining the rough dimensions shown.

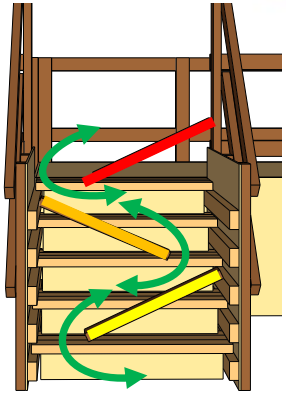
Stairs

Fabrication

Adjustable Incline 35-45° and Debris

20cm (8in) Steps with Debris

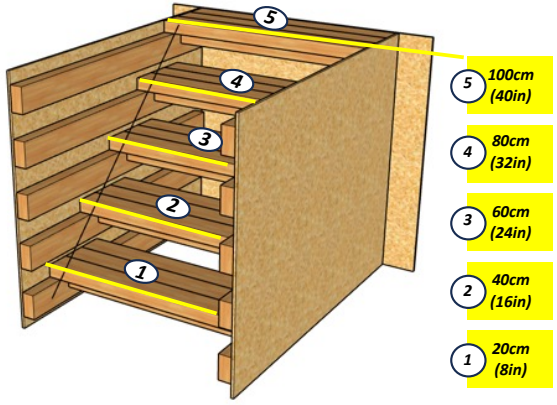




Optional stair DEBRIS can be placed incrementally as three levels of difficulty to require steering on the stair or climbing behaviors (color coded yellow-orange-red).

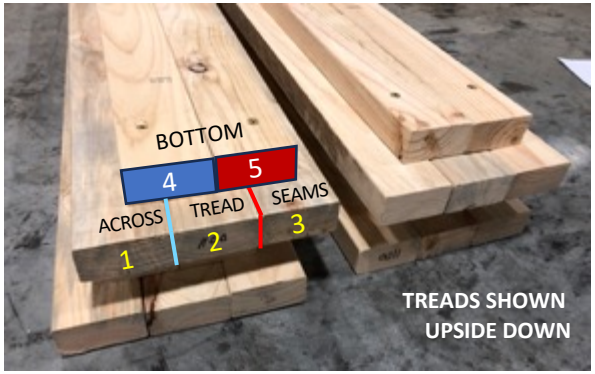
Adjustable Incline 35-45°

Treads slide like shelves



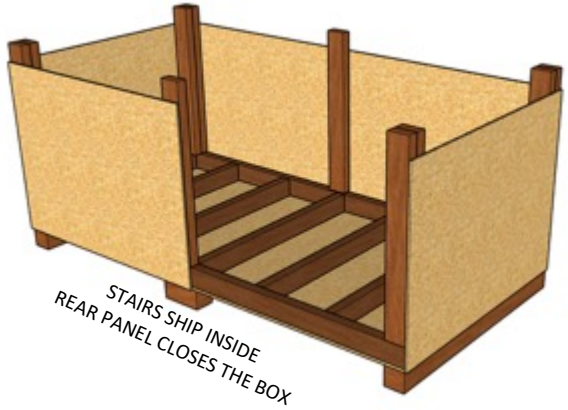
90 cm (36 in) wide treads are made of [5]“2x4s” screwed together.

They can be interchangeable with purchased metal treads.



Landing Inverted for Transport

Stair assembly fits inside



- The LANDING is a typical SUBFLOOR with added ”2x4” joists every 40cm (16in) so that multiple people can walk on it.
- The walking surface is “THICK FLOOR OSB.”
- The walls are “THIN WALL OSB” to provide the strength. They mount flush with the LANDING surface and do not touch the ground when inverted for use.
- The legs make the LANDING surface elevated 100cm (40in).
- Double “2x4” flat skids enable fork lifting from all sides.

Stairs

Sliding Treads = 20cm (8in) Steps

QTY: [1] STAIR ASSEMBLY

PURCHASE LIST:

[2] **"THIN WALL OSB" PANELS**
120 x 240 cm (48 x 96 in)

[20] **"2x4" LUMBER**
240 cm (96 in)

[3] **HINGES (FOR DEBRIS RAILS)**

CUT LIST:

A **[3] "THIN WALL OSB" SIDES & BACK**
100 cm TALL x 120 cm WIDE
(40 in TALL x 48 in) WIDE

C **[10] "2x4" HORIZONTAL SLIDE RAILS**
115 cm (46 in)

D **[15] "2x4" STAIR TREAD TOPS**
90 cm (36 in)

E **[10] "2x4" STAIR TREAD BOTTOMS**
75 cm (30 in)

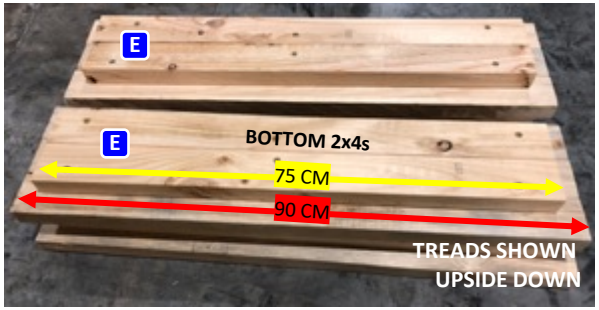
[3] "2x4" HINGED DEBRIS RAILS
75 cm (30 in)

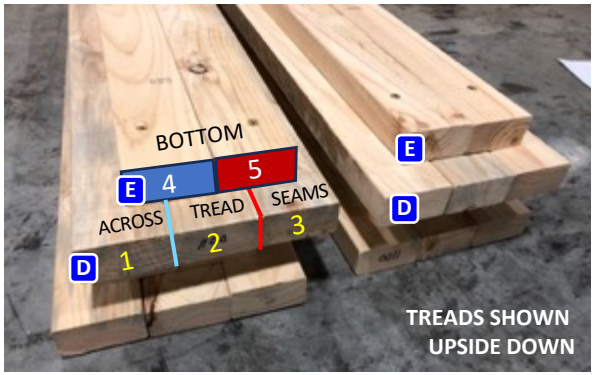
FABRICATION TIPS:

- MOUNT THE SUPPORT RAILS 1 TREAD THICKNESS LOWER THAN 20cm (8 in), 40 cm (16 in), 60 cm (24 in), 80 cm (32 in), 100 cm (40 in) above ground level.
- BACK PANEL extends EQUALLY beyond the SIDE WALLS to attach to the LANDING.

FABRICATED TREADS

Using [5] "2x4s" for each tread





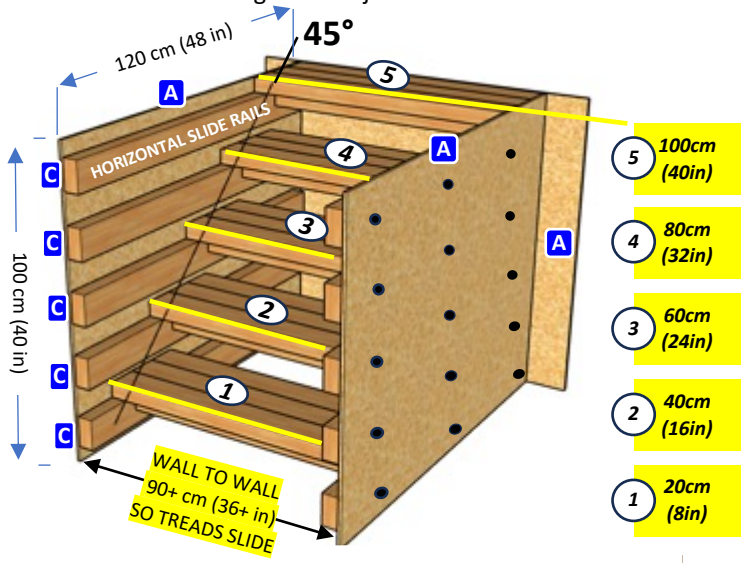
USE 40mm (1-1.2in) WASHER/WAFER HEAD TORX SCREWS THROUGH OSB PANELS

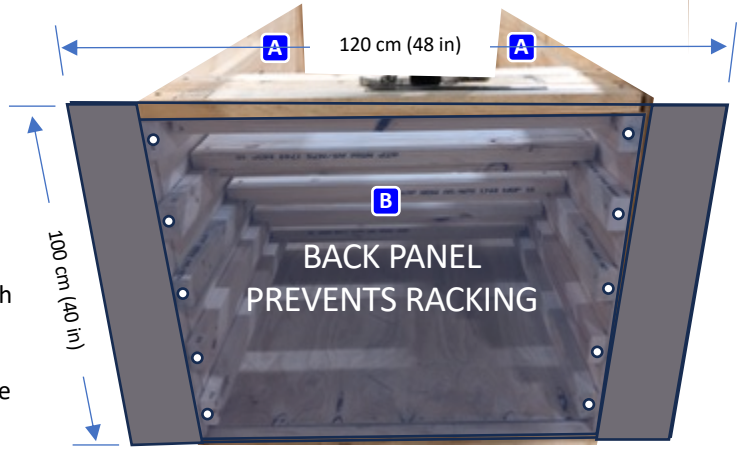
Both bottom "2x4s" are shorter than the treads so they easily slide BETWEEN the side wall support rails.

The bottom "2x4s" add a lot of strength for really heavy and dynamic robots. Their thickness also provides a way to attach a front recessed OSB panel piece as an optional riser

STEP ELEVATIONS = 20cm (8in)

Sliding tread adjust from 35° - 45°





NOTE: Your dimensions may vary slightly depending on the your purchasable materials. The goal is to minimize purchase costs and cuts while maintaining the rough dimensions shown.

Stairs

Landing Elevation = 100 cm (40 in)

QTY: [1] LANDING (shipping crate)

PURCHASE LIST:

[3] **"THIN WALL OSB" PANELS**
120 x 240 cm (48 x 96 in)

[7] **"2x4" LUMBER**
240 cm (96 in)

CUT LIST:

A **[1]** **USE PRE-FABRICATED SUBFLOOR**
ADD [3] MORE "2x4s" SUPPORTS

B **[6]** **"2x4" LEGS**
90 cm (36 in)
MUST ELEVATE LANDING SURFACE TO 100 cm (40 in) WHEN INVERTED

C **[1]** **"THIN WALL OSB" BACK**
90 x 240 cm (36 x 96 in)
ATTACH ALL OSB WALLS FLUSH WITH SUBFLOOR SURFACE

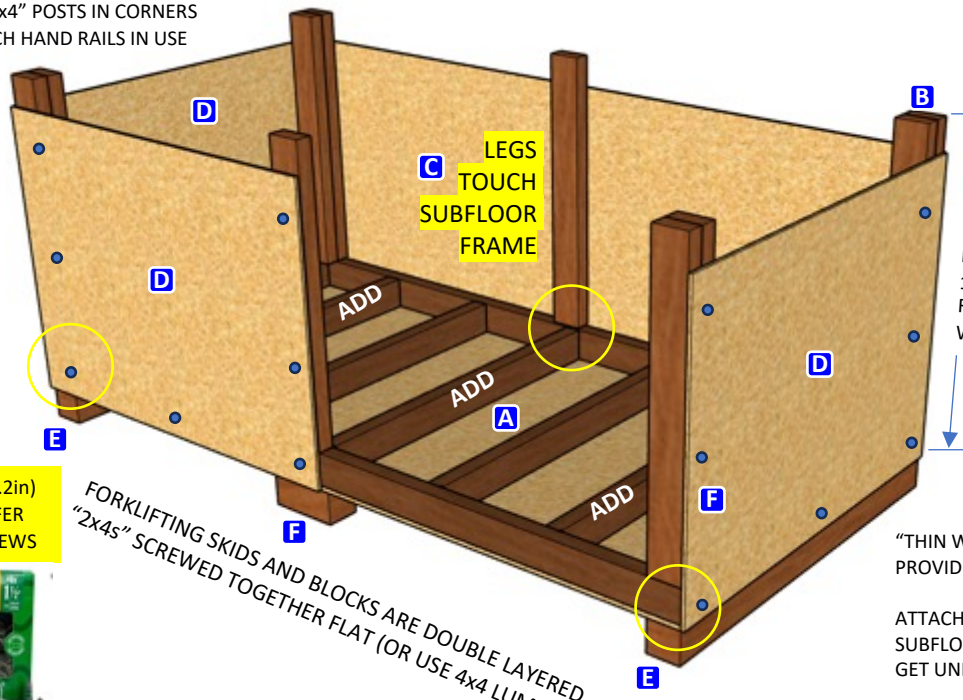
D **[3]** **"THIN WALL OSB" SIDES**
90 x 120 cm (36 x 48 in)
ATTACH ALL OSB WALLS FLUSH WITH SUBFLOOR SURFACE

E **[2]** **"2x4" FORKLIFT SKIDS**
120 cm (48 in)
LAST ADDITION TO ASSEMBLY. SCREW THROUGH THE SUBFLOOR TO ATTACH

F **[2]** **"2x4" FORKLIFT BLOCKS**
20 cm (8 in)
LAST ADDITION TO ASSEMBLY. SCREW THROUGH THE SUBFLOOR TO ATTACH

USE A **TYPICAL SUBFLOOR ALREADY FABRICATED** THEN ADD [3] MORE "2x4" JOISTS SPACED 40cm (16in).

DOUBLE "2x4" POSTS IN CORNERS TO ATTACH HAND RAILS IN USE



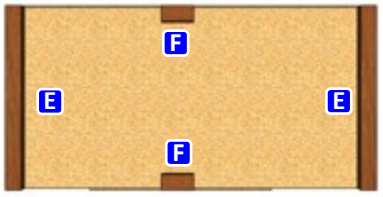
LANDING SURFACE MUST BE ELEVATED 100 cm (40 in) FROM THE FLOOR WHEN INVERTED FOR USE

USE 40mm (1-1.2in) WASHER/WAFER HEADTORX SCREWS

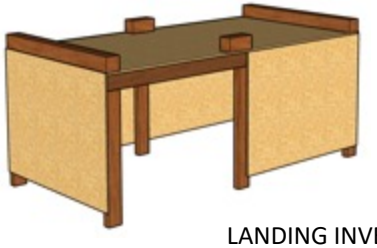
FORKLIFTING SKIDS AND BLOCKS ARE DOUBLE LAYERED "2x4s" SCREWED TOGETHER FLAT (OR USE 4x4 LUMBER)

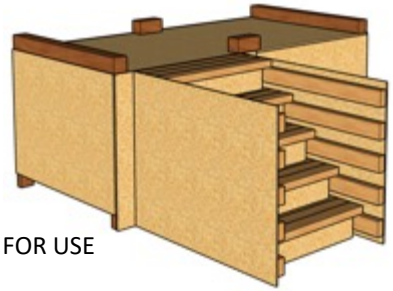
"THIN WALL OSB" SIDE PANELS PROVIDE STRENGTH

ATTACH FLUSH WITH SUBFLOOR SURFACE SO FORKLIFT CAN GET UNDER FROM ANY SIDE



BOTTOM





LANDING INVERTED FOR USE

NOTE: Your dimensions may vary slightly depending on the your purchasable materials. The goal is to minimize purchase costs and cuts while maintaining the rough dimensions shown.

Railings & Safety Belay

QTY: [5] RAILINGS & BELAY

PURCHASE LIST:

[15] **"2x4" LUMBER**
240 cm (96 in)

CUT LIST:

A **[15] "2x4" VERTICALS AND HORIZONTALS**
120 cm (48 in)

B **[2] "2x4" SAFETY BELAY VERTICALS**
240 cm (96 in)

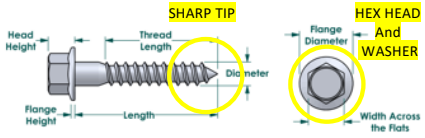
C **[1] "2x4" SAFETY BELAY TOP**
100 cm (40 in)

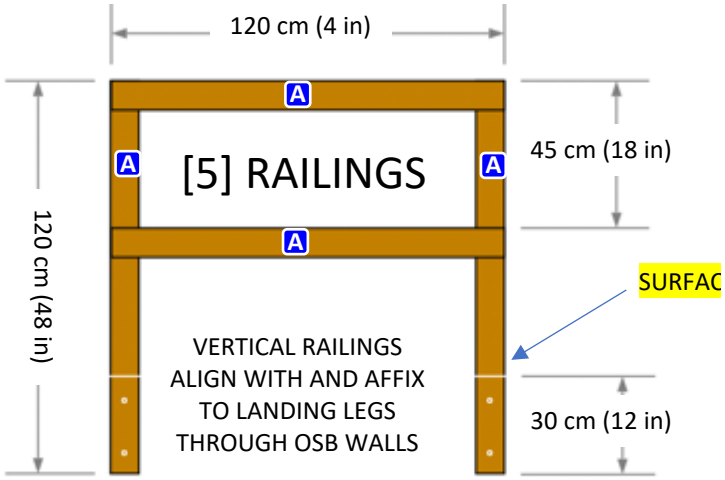
D **[4] "2x4" DIAGONAL STAIR RAILINGS**
120 cm (48 in)
45° BOTH ENDS PARALLEL
CUT FLAT ON THE MITER SAW
(WILL LOOK BETTER THAN SHOWN)

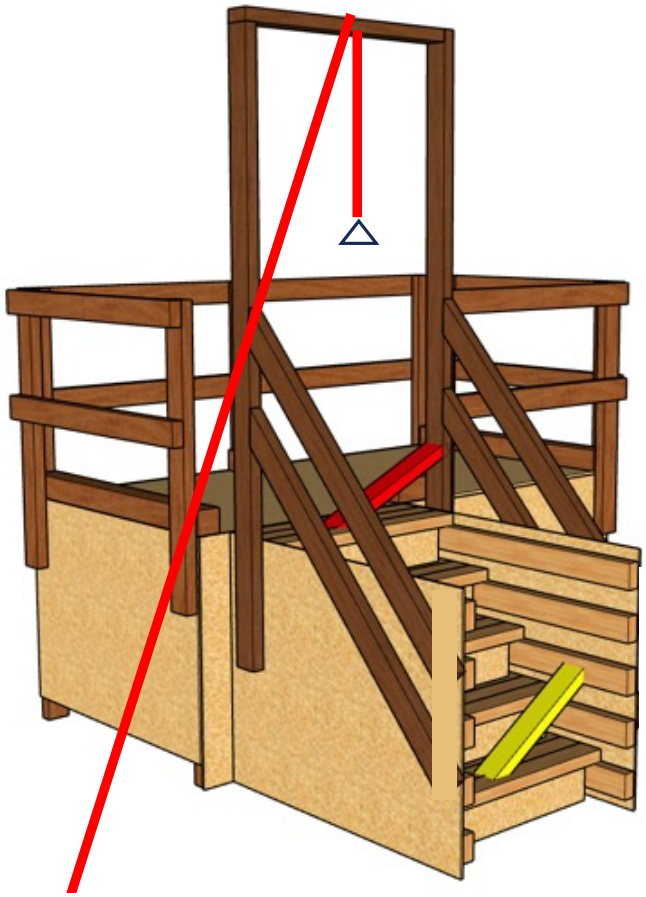
FABRICATION TIPS:

- Use HEX HEAD ROOFING SCREWS WITH WASHERS (and magnetized socket bits) to attach all railings so they can be removed easily on site.

  5 mm (#10 in) x 75 mm (3 in) long







NOTE: Your dimensions may vary slightly depending on the your purchasable materials. The goal is to minimize purchase costs and cuts while maintaining the rough dimensions shown.

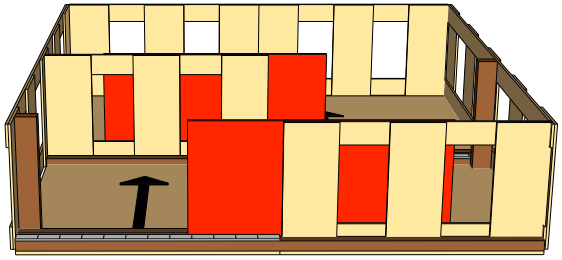
Center

Fabrication

Adjustable Doorways, Adjustable Incline

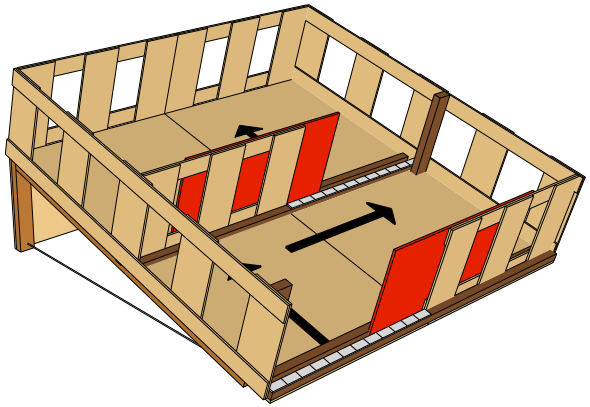
Square Room Dimensions
Flat or Sloped

FLAT



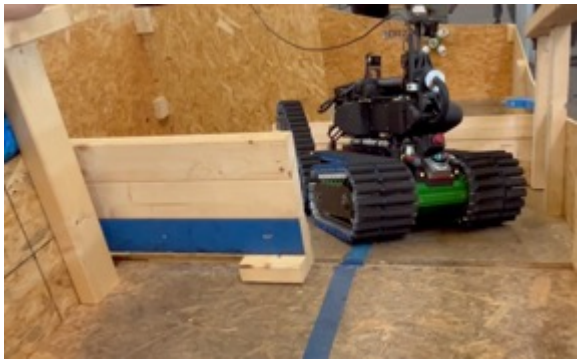
(2) SLIDING PANELS SHOWN IN RED

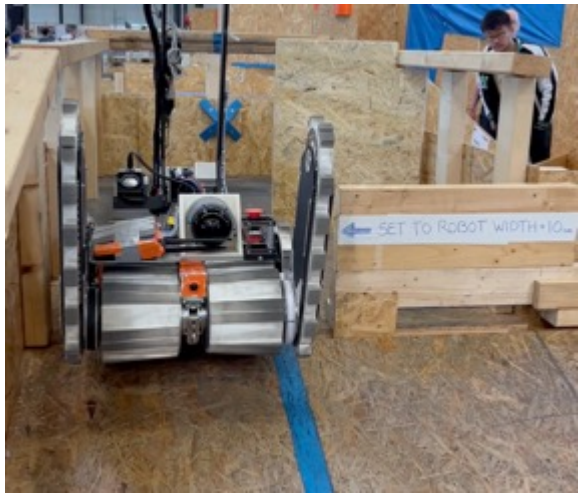
SLOPED 15°



Sliding Panels
Challenge All Robots Similarly

SET TO ROBOT WIDTH + 10 cm (4 in)





Flooring Complexity Options
Positioning Uncertainty

ADD SLIP DISKS

THIN WOOD DISKS
50 cm (20 in) DIAMETER
4mm (1/8in) THICK OR MORE

THREADED INSERTS
8mm (5/16in) THREADS
25mm (1in) LONG

PINCH POINTS

HEX HEAD BOLTS AND WASHERS
8mm (5-16in) THREAD
50 cm (20 in) DIAMETERj
FLANGE WASHERS

QTY: [2] SLIDING PANELS

PURCHASE LIST:

NOTE: USE ALREADY FABRICATED ELEMENTS
[2] SLOPED FLOORS
[3] LONG WALLS
[2] SHORT WALLS

[1] "THIN WALL OSB"
120 x 240 cm (48 x 96 in)

[2] "2x2" LUMBER
240 cm (96 in)

[1] "2x2" LUMBER
240 cm (96 in)

[10] LARGE METAL BINDER CLIPS
HOLD THE SLIDING PANEL ALONG THE TOP OF THE WALL FOR ADJUSTMENT.

CUT LIST:

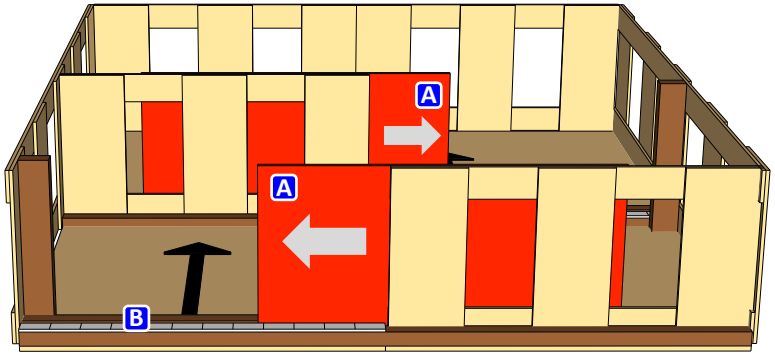
A [2] "THIN WALL OSB" PANELS
60cm x 120 cm (24 x 48 in)

B [4] "2x2" THRESHOLDS TRACKS
120 cm (48 in)

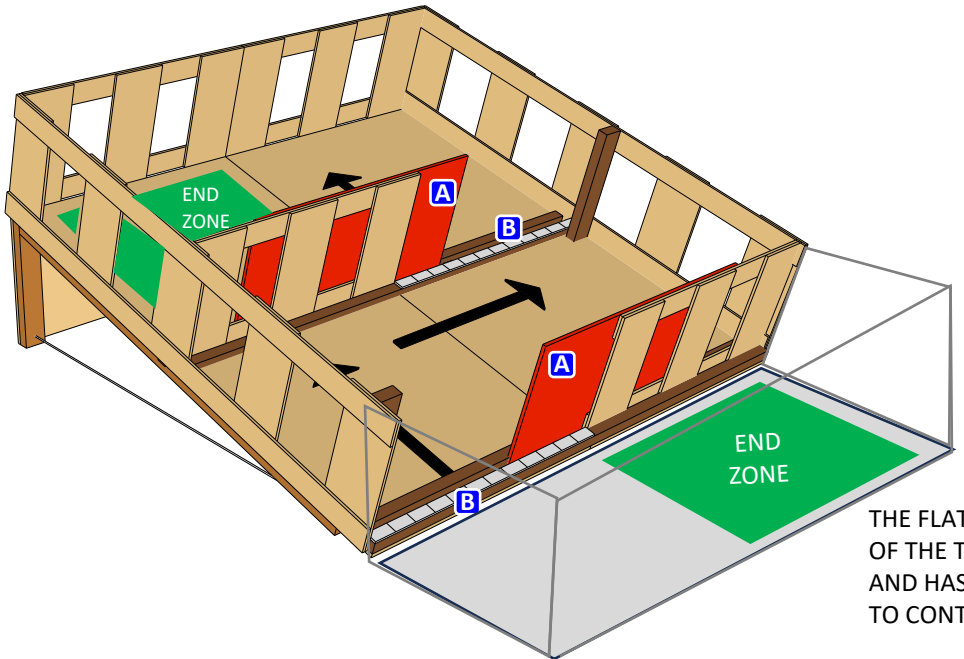
FABRICATION TIPS:

- Both sliding panels rest against the UPHILL side of the apparatus wall.
- Make a "2x2" threshold track to contain the sliding panel. The downhill "2x2" threshold should fill the doorway. Ensure the panel slides easily throughout before screwing them down to the subfloors.
- The thresholds should have a metric drawn on them with marks every 1 cm.
- Large metal binder clips attach over the top of the sliding panels and the apparatus wall.

FLAT



SLOPED



THE FLAT HALLWAY IS PART OF THE TEST APPARATUS AND HAS SURROUNDING WALLS TO CONTAIN AUTONOMOUS ROBOTS

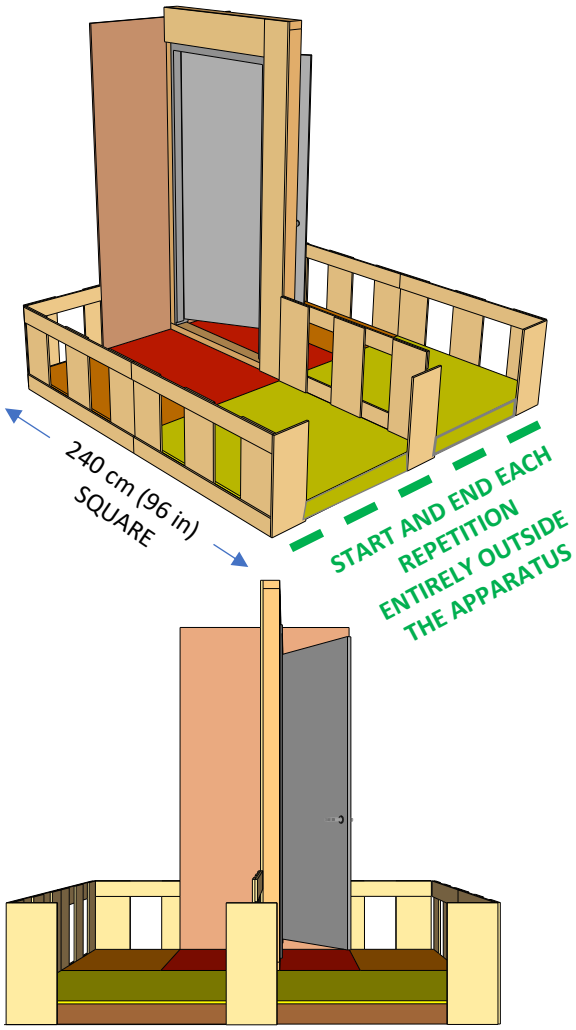
Door

Fabrication

Door

Push/Pull, Weighted Closure, Flooring Complexity

Square Apparatus
Push and Pull U-Turns

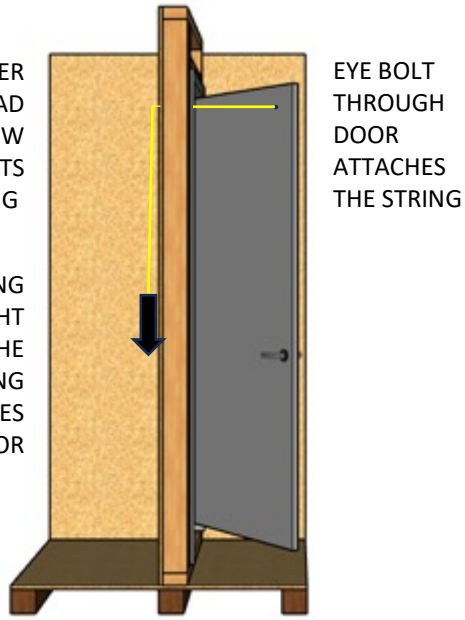


Weighted Closure Mechanism
Adjustable Force

WASHER HEAD SCREW RE-DIRECTS THE STRING

HANGING WEIGHT ON THE STRING CLOSES THE DOOR

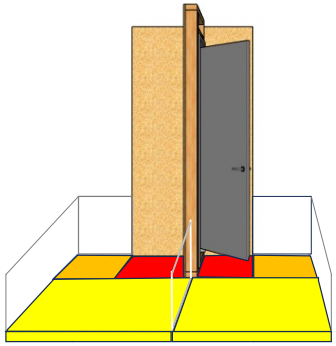
EYE BOLT THROUGH DOOR ATTACHES THE STRING



Flooring Complexity
Half and Full Stoops

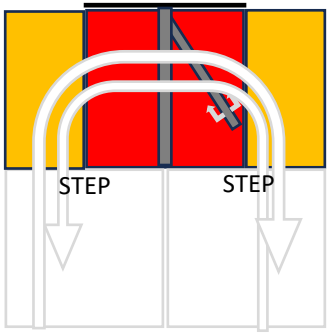
FLAT FLOOR
U-TURN PATH
240 x 240 cm
(96 x 96 in)

YELLOW, ORANGE, AND RED PALLETS FORM FLAT FLOOR



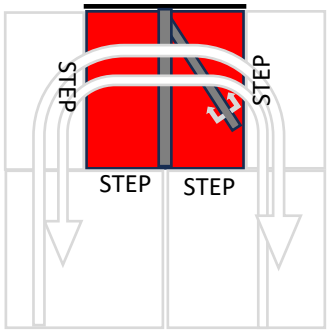
<u>TOP VIEW</u>
SQUARE STEPS
BOTH SIDES
120 cm (48 in)

REMOVE BOTH YELLOW PALLETS



<u>TOP VIEW</u>
SHORT STEPS
BOTH SIDES
60 cm (24 in)

REMOVE ORANGE HALF PALLETS TOO



Door

Door Element

QTY: [1] DOOR ELEMENT

PURCHASE LIST:

[2] **"THIN WALL OSB"**
120 x 240 cm (48 x 96 in)

[1] **"THICK FLOOR OSB"**
120 x 240 cm (48 x 96 in)

[8] **"2x4" LUMBER**
240 cm (96 in)

[1] **FRAMED DOOR with LEVER HANDLE**
90 cm (36 in) WIDE

CUT LIST:

A **[2] "2x4" TOP/BOTTOM THRESHOLD**
120 cm (48 in)

B **[3] "2x4" VERTICALS**
Approximately 230 cm (93 in)
MUST FIT FULL OSB PANEL

C **[1] "2x4" DOOR FRAME TOP**
MUST FIT YOUR DOOR WIDTH

D **[1] "THICK FLOOR OSB" FLOOR**
120 x 120 cm (48 x 48 in)

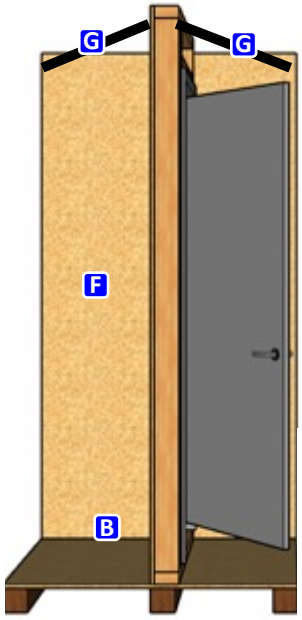
E **[6] "2X4" DOUBLE SKIDS FOR PALLET JACK**
120 cm (48 in)
ATTACH TALL UNDER FLOOR TO BE EVEN WITH REMOVABLE STEPS

F **[1] "THIN WALL OSB" FULL PANEL**
120 x 120 cm (48 x 48 in)

G **[2] "2x4" DIAGONAL TOP SUPORTS**
120 cm (48 in)
45° BOTH ENDS OPPOSING
CUT FLAT ON SAW

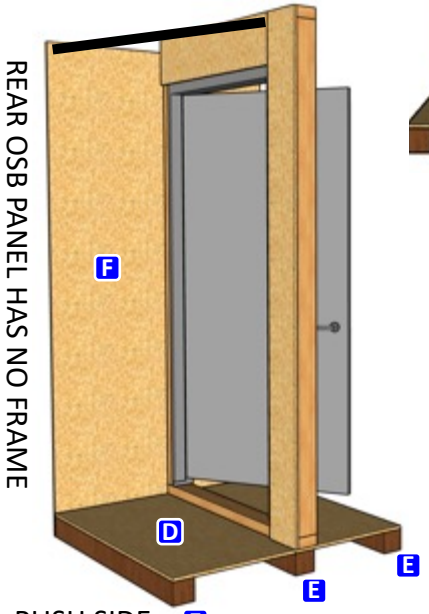
FABRICATION TIPS:

- Lay door on the floor so it can open upward to expose the inside of the door frame.
- Build a 120 x 240 cm (48 x 96 in) wall around the purchased door frame using all "2x4s" standing tall. Place the door hinge side against the frame.
- Cover the frame with "THIN WALL OSB" on both sides (one side is shown exposed).
- Screw through the PURCHASED DOOR FRAME all around to attach to the wall.
- Attach the upright door wall centered on the floor pallet.
- Attach the rear OSB panel touching the floor. Screw through to connect all 3 skids and the door wall.
- Add 2x4 DIAGONAL TOP SUPPORTS level with the top frame.
- Add an optional triangle on top to stiffen the entire door.



2x4 DIAGONAL TOP SUPPORTS
(TOP OSB TRIANGLE OPTIONAL)

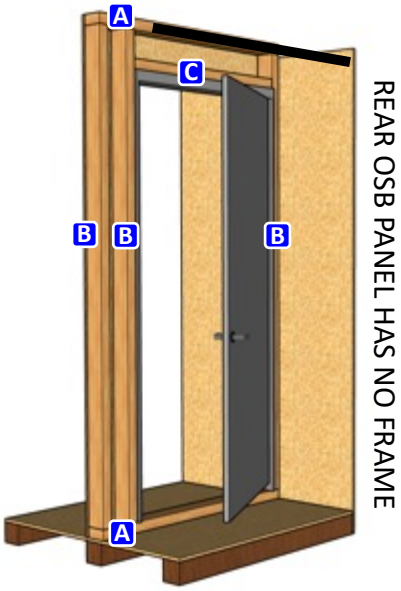
FRAMED WALL AROUND DOOR
120 x 240 cm
(48 x 96 in)



PUSH SIDE

SQUARE BASE CAN MOVE WITH A PALLET JACK
120 x 120 cm
(48 x 48 in)

FRAMED WALL AROUND DOOR
120 x 240 cm
(48 x 96 in)



PULL SIDE

NOTE: Your dimensions may vary slightly depending on the your purchasable materials. The goal is to minimize purchase costs and cuts while maintaining the rough dimensions shown.

Removable Floor Steps

QTY: [2] SQUARE, [2] HALF

PURCHASE LIST:

[2] **"THICK FLOOR OSB" PANELS**
120 x 240 cm (48 x 96 in)

[8] **"2x4" LUMBER**
240 cm (96 in)

CUT LIST:

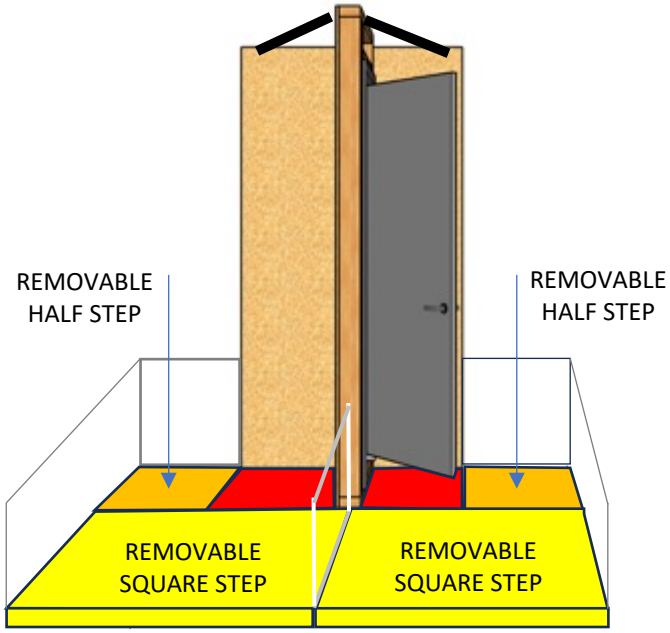
A **[4]** **"2x4" PANEL EDGES – SQUARE STEP**
120 cm (48 in)

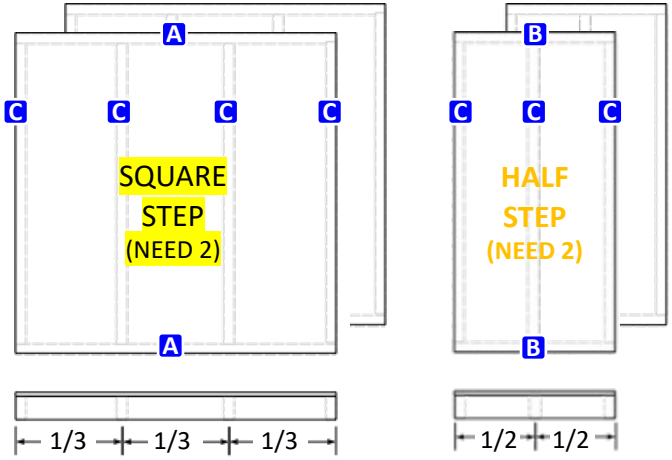
B **[4]** **"2x4 PANEL EDGES – HALF STEP**
60 cm (24 in)

C **[14]** **"2x4 CENTERS – ALL STEPS**
MEASURE TO FIT YOUR PANEL FRAME
Approximately 110 cm (45 in)

FABRICATION TIPS:

• These removable SQUARE STEPS and HALF STEPS have tall "2x4" lumber frames all the way around because tracked and wheeled robots use the edges to ascend.



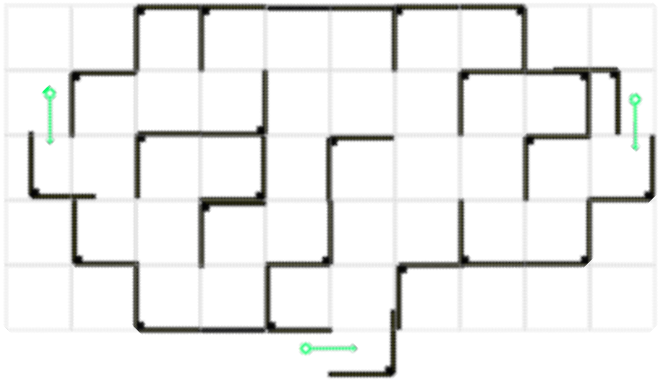


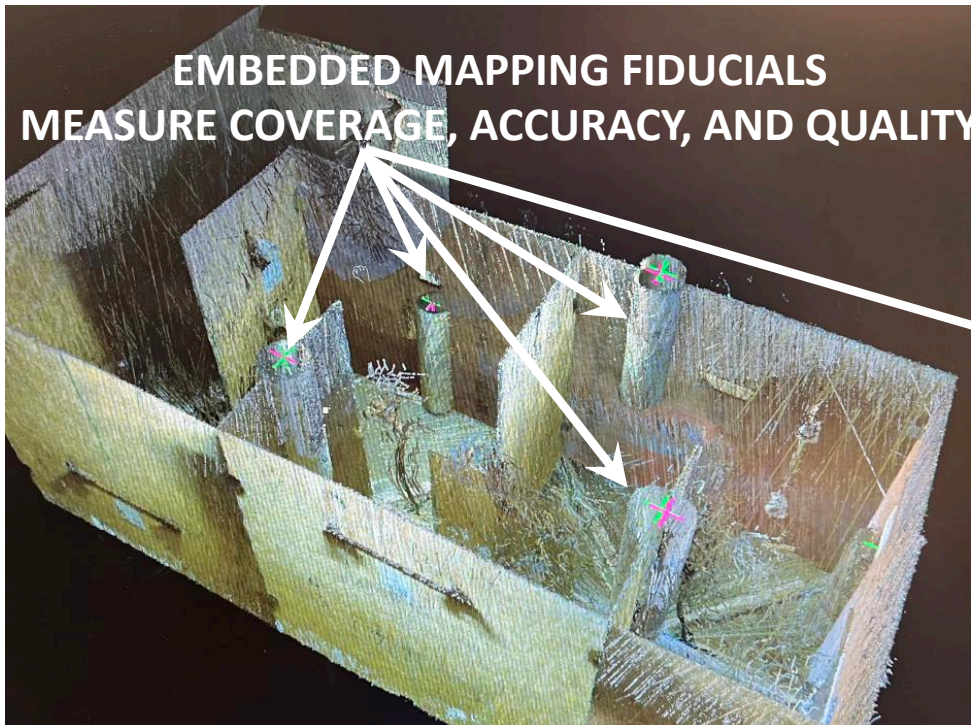
Labyrinth/Maze

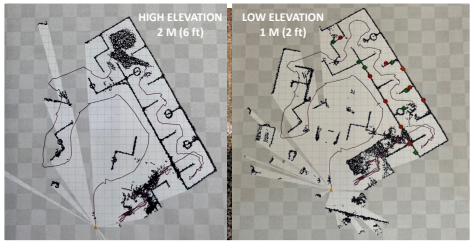
Fabrication

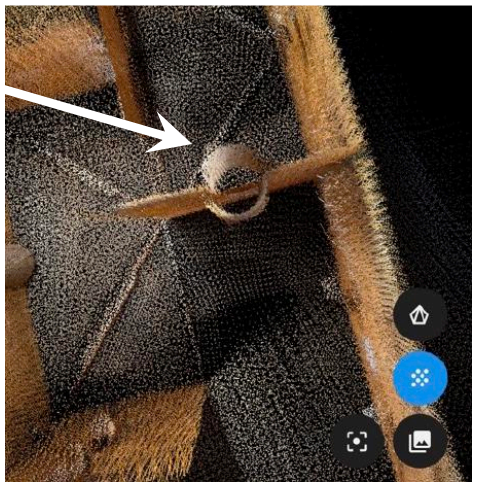
Maze

Tall “L” Walls









Maze

Tall “L” Walls

QTY: [25] TALL “L” WALLS

PURCHASE LIST:

[50] **“MAZE WALL OSB” PANELS (ODD DIMENSIONS/INEXPENSIVE)**
10 mm x 122 cm WIDE x 220 cm TALL
(7/16 in x 48 in x 96 in)
https://www.leroymerlin.com.br/chapa-osb-2-20x1-22x10mm--multiplac-_1571449323

[3] **“2x4” LUMBER**
240 cm (96 in)

[1] **BLACKOUT TARP TO COVER THE ENTIRETY OF THE MAZE**

CUT LIST:

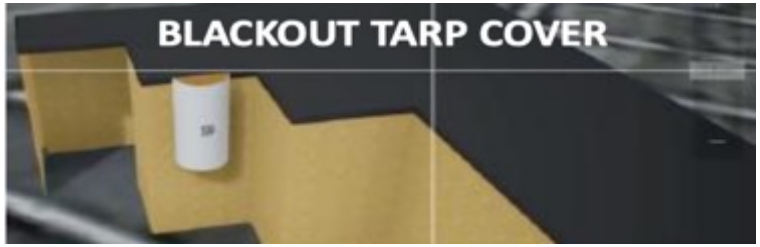
A **[75] ”2x4” JOINT BLOCKS**
6 x 12 m (20 x 40 ft)

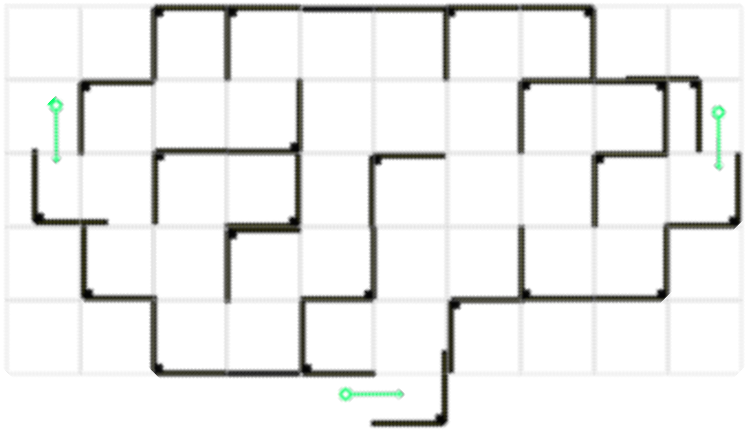
FABRICATION TIPS:

- “MAZE WALL OSB” are used as FULL PANELS (uncut) so can be recycled after the event for other uses.

- Cut JOINT BLOCKS and bring to the venue in a crate for final assembly in place.

USE 40mm (1.5in) WASHER/WAFER HEAD TORX SCREWS FOR SCREWING THROUGH OSB



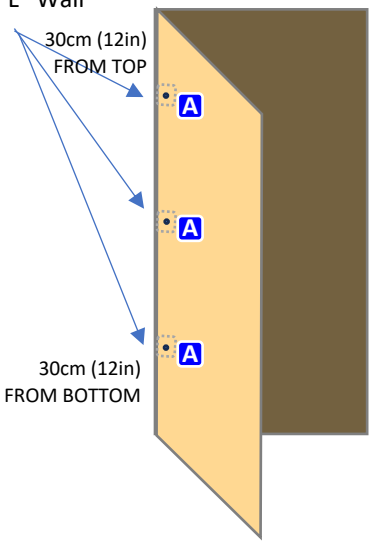


HIGH/LOW MAPPING FIDUCIALS

[3] “2x4” JOINT BLOCKS
10 cm (4 in)

TALL “L” WALL

[6] Screws per “L” Wall



NOTE: Your dimensions may vary slightly depending on the your purchasable materials. The goal is to minimize purchase costs and cuts while maintaining the rough dimensions shown.

QTY: [25] TALL "L" WALLS

PURCHASE LIST:

[50] **"MAZE WALL OSB" PANELS (ODD DIMENSIONS/INEXPENSIVE)**
10 mm x 122 cm WIDE x 220 cm TALL
(7/16 in x 48 in x 96 in)
https://www.leroymerlin.com.br/chapa-osb-2-20x1-22x10mm--multiplac-_1571449323

[3] **"2x4" LUMBER**
240 cm (96 in)

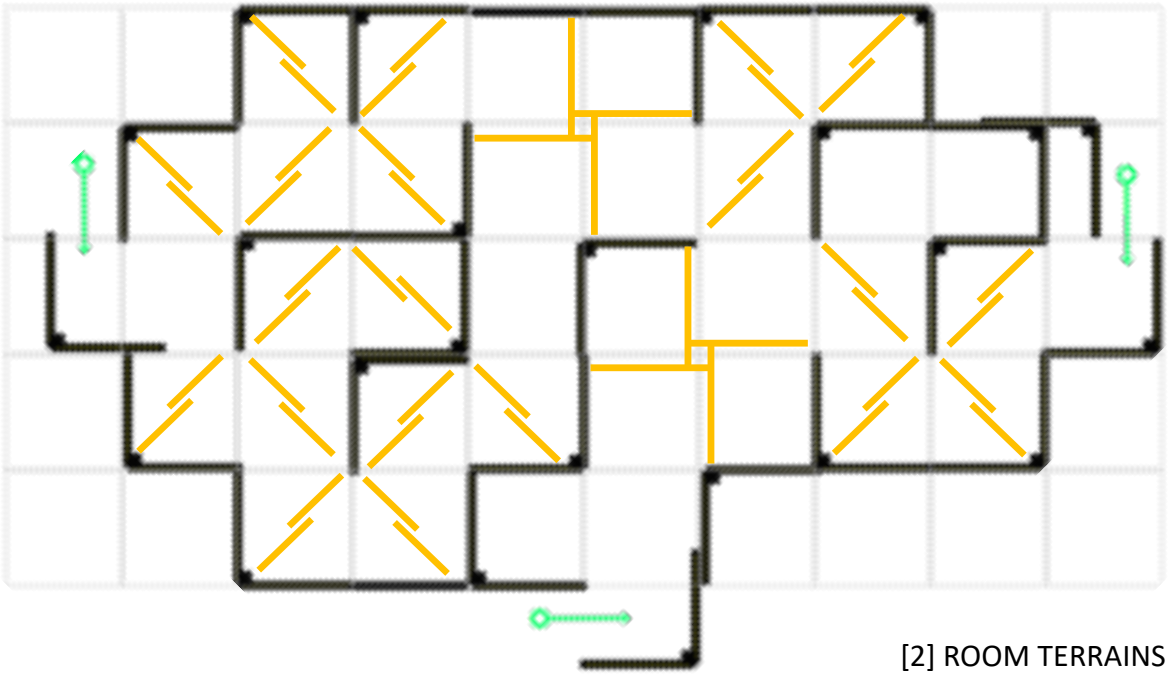
CUT LIST:

A **[75] "2x4" JOINT BLOCKS FOR "L" WALL**
5 x 10 x 10 cm (2 x 4 x 4 in)

FABRICATION TIPS:

- Cut JOINT BLOCKS and bring to the venue in a crate for final assembly in place.

USE 40mm (1.5in) WASHER/WAFER HEAD TORX SCREWS FOR SCREWING THROUGH OSB



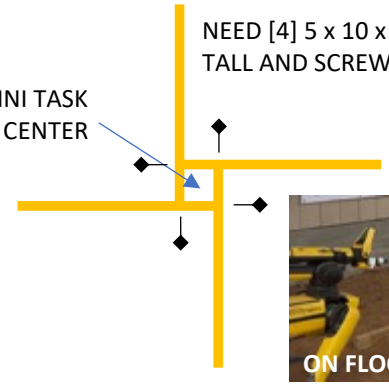
[20] HALLWAY DIAGONALS
NEED [2] 5 x 10 x 120 cm (2 x 4 x 48 in)
WITH 45° CUT TALL ON MITER SAW ON ONE END

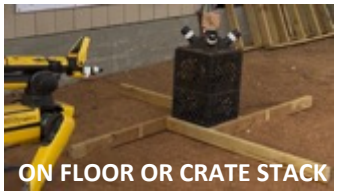
PLACED TALL DIAGONALLY IN THE HALLWAY CORNER TO CORNER THEN [2] SCREWS IN THE CENTER OVERLAP

[2] ROOM TERRAINS

NEED [4] 5 x 10 x 130 cm (2 x 4 x 52 in)
TALL AND SCREWED TO EACH OTHER

OMNI TASK IN CENTER





NOTE: Your dimensions may vary slightly depending on the your purchasable materials. The goal is to minimize purchase costs and cuts while maintaining the rough dimensions shown.

QTY: [10] SPLIT CLYINDERS

PURCHASE LIST:

[5] CONCRETE FORM TUBES
30 cm DIAM x 120 cm LONG
(12in DIAM x 48 in LONG)

[3] "2x2" LUMBER
240 cm (96 in)

[10] BOLTS (ANY DIAM/THREAD)
15 cm (6 in)

[10] WING NUTS (SAME DIAM/THREAD)

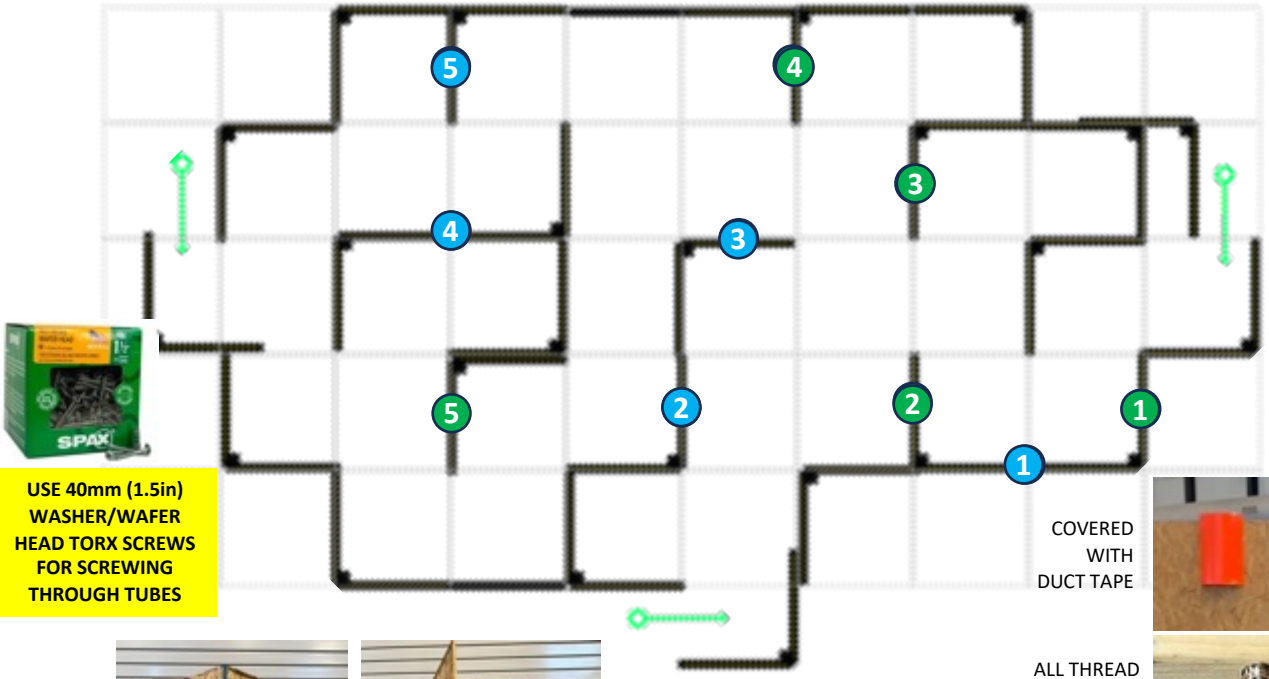
CUT LIST:

A [20] CONCRET FORM HALVES
30 cm DIAM x 60 cm LONG
(12 in DIAM x 24 in LONG)

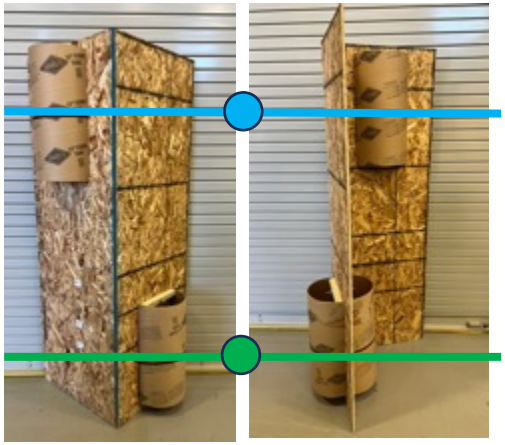
B [40] "2x2" HIGH/LOW SPINES
28 cm (11 in)

FABRICATION TIPS:

- Drill a center hole in the TOP SPINE to pass through a 15cm (6 in) long bolt for mounting with a nut.
- Use a single screw into both ends of the TOP and BOTTOM SPINES to hold the form and enable mounting to the walls.
- Cover the EXTERNAL/CONVEX side of the half cylinders with duct tape so no commercial logos are visible.
- Drill many mounting hole options in the MAZE walls at 210 cm (84 in) AGL and 130 cm (48 in)



USE 40mm (1.5in) WASHER/WAFER HEAD TORX SCREWS FOR SCREWING THROUGH TUBES



HIGH SLICE OF 3D MAP:
CENTERED VERTICALLY AT 2 m (6 ft)
WALL HOLES AT 210 cm (84 in)
ABOVE GROUND LEVEL (AGL)

LOW SLICE OF 3D MAP:
CENTERED VERTICALLY AT 1m (3 ft)
WALL HOLES AT 130 cm (48 in)
ABOVE GROUND LEVEL (AGL)

COVERED WITH DUCT TAPE

ALL THREAD & WING NUTS

"2x2s"HIGH AND LOW

ALWAYS BOTH SIDES OF THE WALL

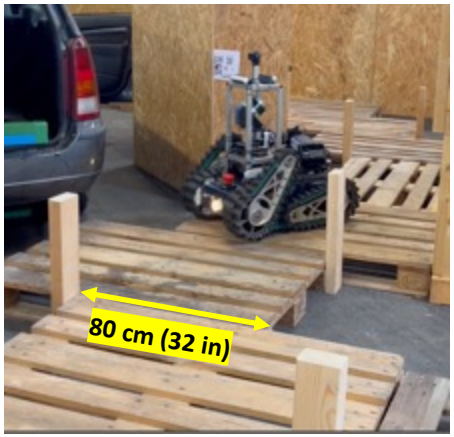
NOTE: Your dimensions may vary slightly depending on the your purchasable materials. The goal is to minimize purchase costs and cuts while maintaining the rough dimensions shown.

AVOID

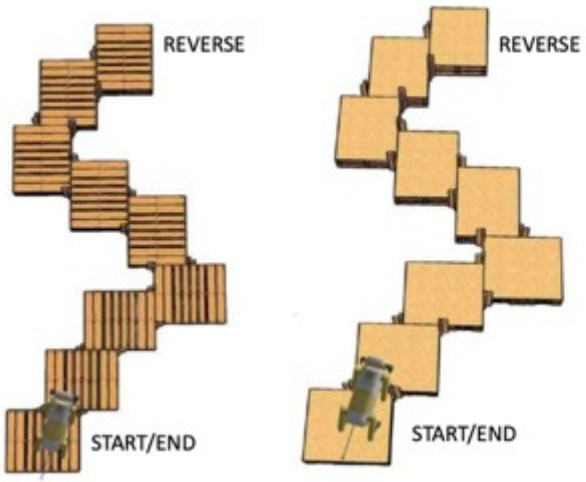
Fabrication

Avoid

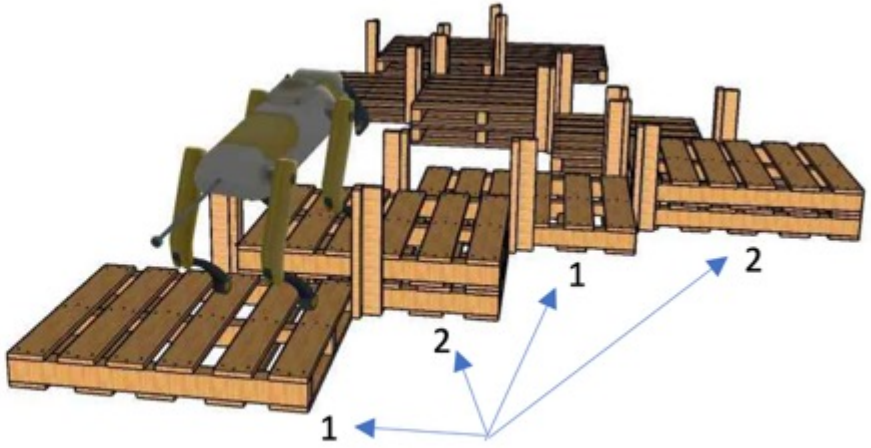
Levels of Difficulty



POROUS PALLETS OR SOLID SURFACES



SINGLE LEVEL OR WITH STEPS



Pallet stacks can also vary in height.

QTY: [20] PALLETS, [20] POSTS

PURCHASE LIST:

[20] PALLETS
100 x 120 x 10-15 cm THICK
(40 x 48 x 4-6 in THICK)

[20] "2x4" LUMBER
240 cm (96 in)

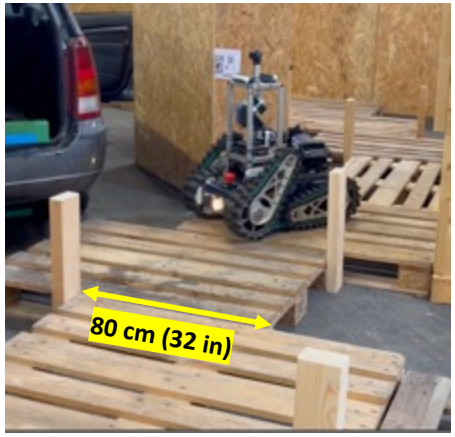
CUT LIST:

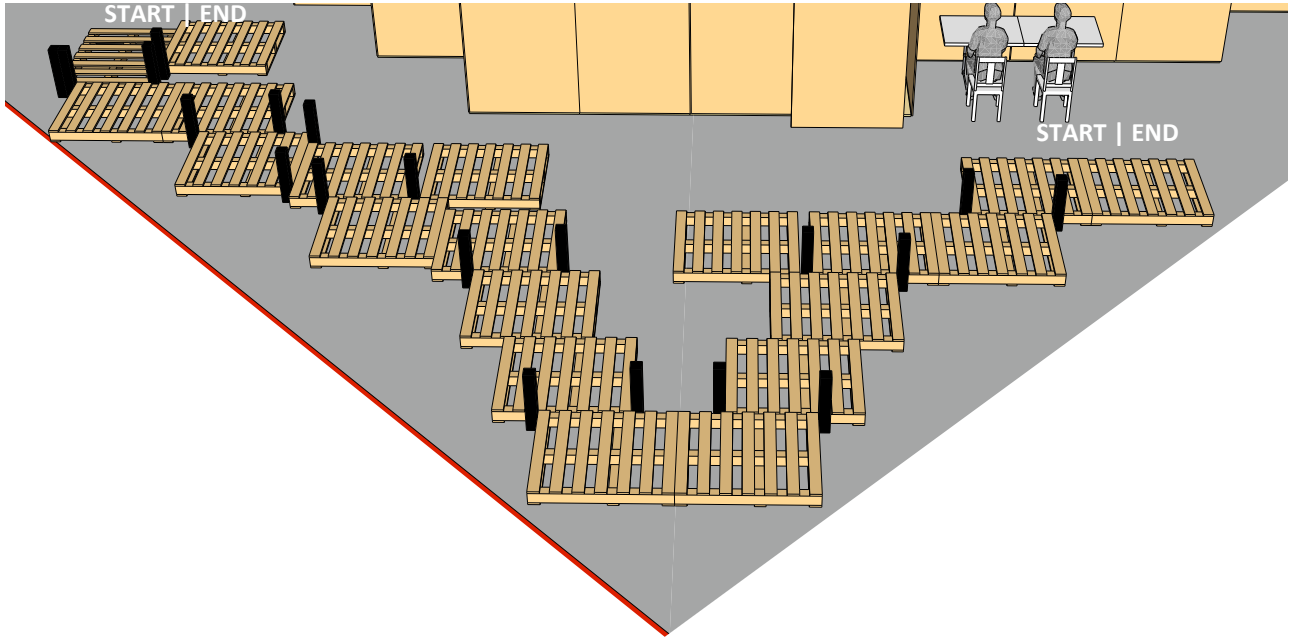
A [20] POSTS
45 cm (18 in)

FABRICATION TIPS:

- The design shown is just an example layout. Any meandering path can be made, and should change during the course of the competition.
- Add dead ends that move the robot directly closer to the goal point as a distraction.
- If a vehicle is provided, this path can circumnavigate the vehicle with a couple of doors, trunk, or windows open to inspect inside.

USE 65mm (2.5in) WASHER/WAFER HEAD TORX SCREWS FOR ATTACHING POSTS – EASY TO FIND AND REMOVE.





NOTE: Your dimensions may vary slightly depending on the your purchasable materials. The goal is to minimize purchase costs and cuts while maintaining the rough dimensions shown.

Dexterity Align/Inspect

Align/Inspect Tasks (Green)

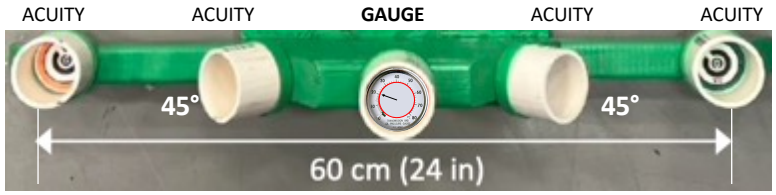
Levels of Difficulty

ALIGN/INSPECT TASKS

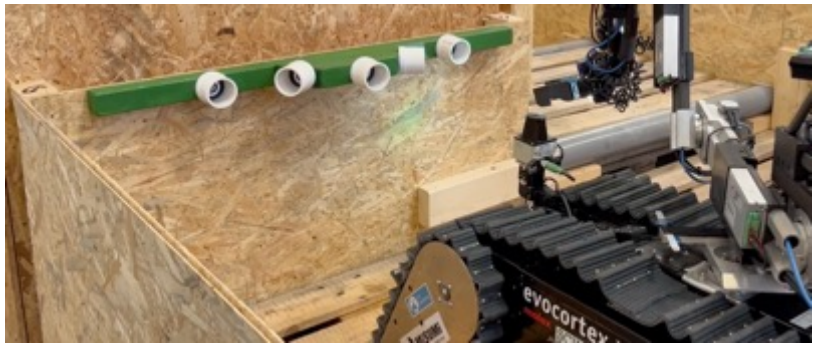
5 cm (2 in) INNER DIAMETER PIPES

Align/Inspect tasks are mounted on the walls at 60cm (24in) elevation or on the ground to reward robots moving throughout the terrains and obstacles with enough manipulator dexterity to perform the tasks. Zooming, exposure control, and image processing score more points.

OPERATOR SCORING



AUTOMATIC SCORING



TARGET OPTIONS

MANUAL AND AUTO TASKS

COLOR and ACUITY

Scored by the remote operator. Align with the pipe to see the entire colored ring as shown, then correctly identify the color, then read at least two concentric ring gap orientations – similar acuity to read the gauges. Zooming is generally encouraged to inspect details.

GAUGES

Scored by the remote operator. Align with the pipe to see the entire inscribed ring as shown, then correctly identify the pressure reading.

QR CODES

Scored by the robot using image processing, even when teleop driving. The robot must PAUSE with the UNIQUE CODE displayed prominently on the operator interface for the Proctor to confirm. The operator may then press one button to continue the search.

PARTIAL HAZMAT LABELS

Scored by the robot using image processing, even when teleop driving. The robot must to PAUSE with the WORD and NUMBER prominently displayed on the operator interface for the Proctor to confirm. The operator may then press one button to continue the search.

Linear Align/Inspect Tasks (Green)

Fabrication

QTY: [12] LINEAR INSPECT

PURCHASE LIST:

[6] **"2x2" LUMBER**
240 cm (96 in)

[2] **"2x4" LUMBER**
240 cm (96 in)

[2] **PVC PIPES (DRAIN PIPES)**
5 cm INNER DIAMETER x 240 cm
(2 in INNER DIAMETER x 96 in)

[60] **PVC CAPS**
MATCH THE PIPES

[1] **CIRCLE PAPER PUNCH**
5 cm (2 in) DIAMETER
https://a.co/d/i0A5hg8

CUT LIST:

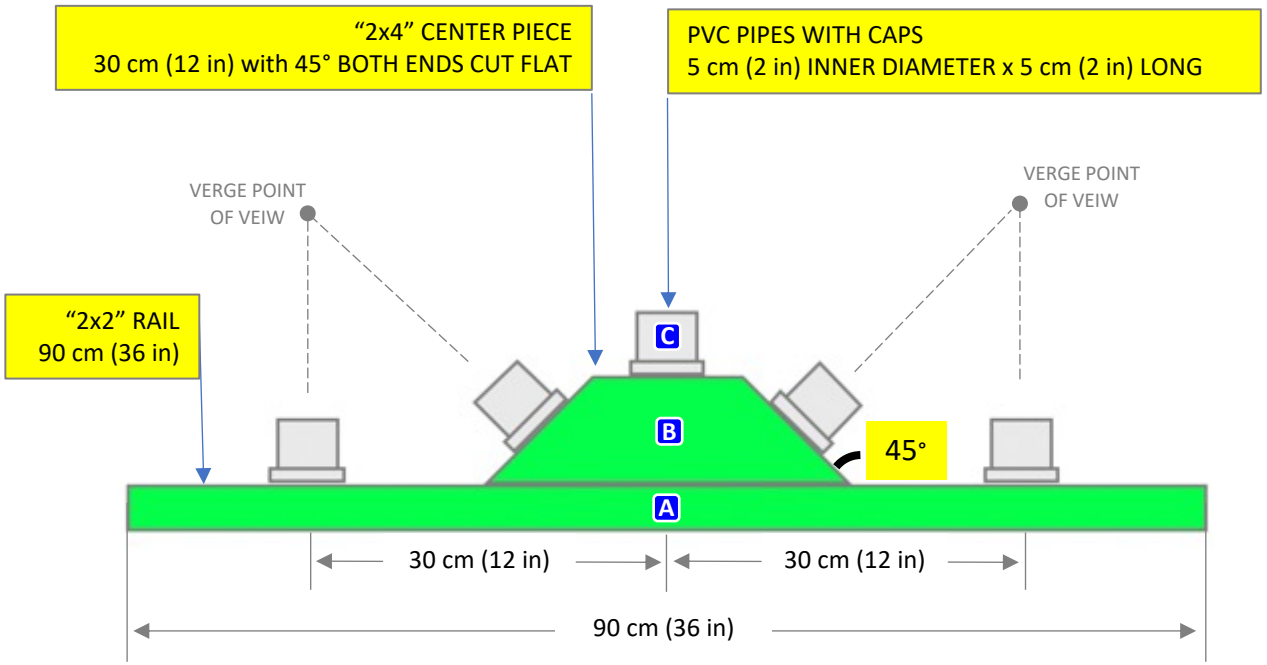
A **[12] "2X2" RAILS**
90 cm (36 in)

B **[12] "2X4" CENTERS**
30 cm (12 in)
45° BOTH ENDS CUT FLAT OPPOSING

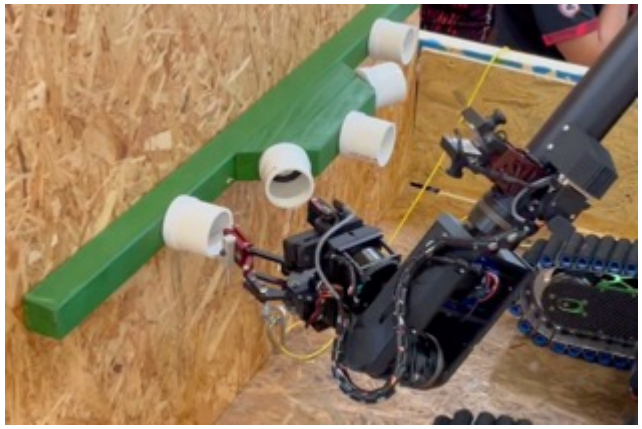
C **[60] PVC PIPES**
5 cm (2 in)

FABRICATION TIPS:

- Center and screw both pieces of lumber together lying flat their sides. Push up against as clamped beam or wall.
- Attach the pipe caps with ONE CENTER SCREW so they can rotate from HORIZONTAL to VERTICAL placements



USE 40mm (1.5in) WASHER/WAFER HEAD TORX SCREWS FOR SCREWING THROUGH PIPES



NOTE: Your dimensions may vary slightly depending on the your purchasable materials. The goal is to minimize purchase costs and cuts while maintaining the rough dimensions shown.

OMNI Align/Inspect Tasks (Green)

Fabrication

QTY: [12] OMNI INSPECT

PURCHASE LIST:

[3] **"2x4" LUMBER**
240 cm (96 in)

[1] **"THIN WALL OSB" PANEL**
120 x 240 cm (48 x 96 in)

[2] **PVC PIPES (DRAIN PIPES)**
5 cm INNER DIAMETER x 240 cm
(2 in INNER DIAMETER x 96 in)

[60] **PVC CAPS**
MATCH THE PIPES

[1] **CIRCLE PAPER PUNCH**
5 cm (2 in) DIAMETER
https://a.co/d/i0A5hg8

CUT LIST:

A **[24] "2X4" CENTERS**
30 cm (12 in)
45° BOTH ENDS CUT FLAT ON SAW

B **[12] "THIN WALL OSB" BASES**
30 cm (12 in) SQUARE

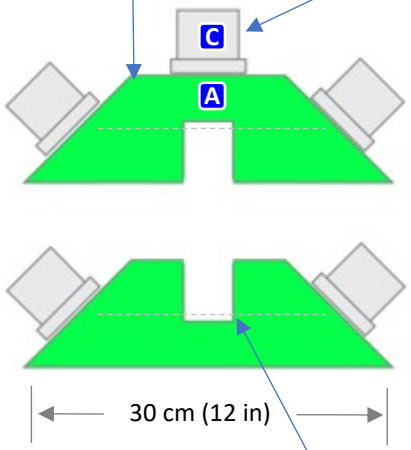
C **[60] PVC PIPES**
5 cm (2 in)

FABRICATION TIPS:

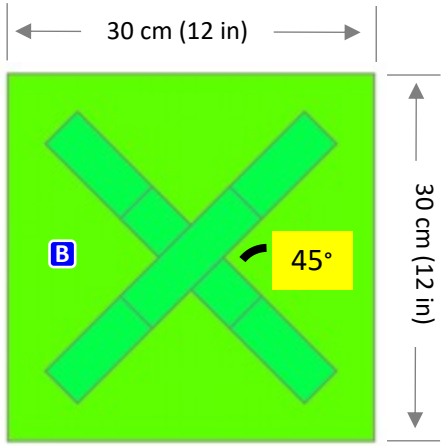
- Notch half the CENTER PIECES on the TOP and on the BOTTOM in pairs.
- A single long screw from the bottom can attach the two elements together.
- The OSB base makes Omnis easier to mount on walls from the front.

"2x4" CENTER PIECE
30 cm (12 in) with 45° BOTH ENDS CUT FLAT

PVC PIPES WITH CAPS
5 cm (2 in) INNER DIAMETER x 5 cm (2 in) LONG



NOTCHES MUST BE WIDE ENOUGH TO ACCOMMODATE THE "2x4" USED AND JUST PAST HALF THE DEPTH



SCREW OMNI TO BASE FROM UNDERSIDE

USE 40mm (1.5in) WASHER/WAFER HEAD TORX SCREWS FOR SCREWING THROUGH PIPES

NOTE: Your dimensions may vary slightly depending on the your purchasable materials. The goal is to minimize purchase costs and cuts while maintaining the rough dimensions shown.

Visual/Color Acuity

Inspect Tasks for Remote Operators to Read

Print this page an cut or punch 5cm (2in) diameter circles

LEFT 90 DEGREE

LEFT 45 DEGREE

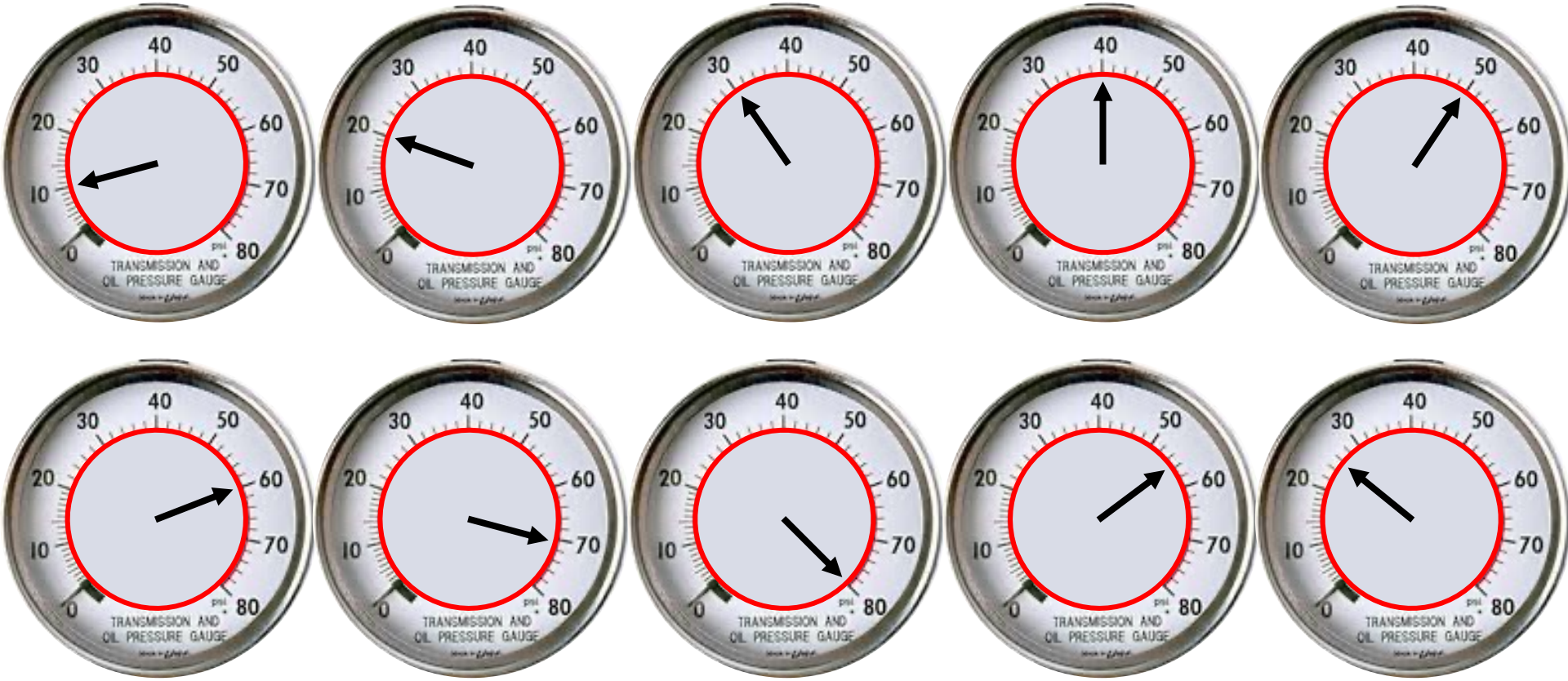
CENTER

RIGHT 45 DEGREE

RIGHT 90 DEGREE

Inspect Tasks for Remote Operators to Read

Print this page an cut or punch 5cm (2in) diameter circles



QR Codes

Inspect Tasks for Image Processing

Print this page and cut or punch 5cm (2in) diameter circles

LINEAR 1-A
LINEAR 2-A

LINEAR 1-B
LINEAR 2-B

LINEAR 1 (CENTER)
LINEAR 2 (CENTER)

LINEAR 1-C
LINEAR 2-C

LINEAR 1-D
LINEAR 2-D

Print this page and cut or punch 5cm (2in) diameter circles
Representing selected sections of an actual label.

Hazmat Label Lexicon

Complete Set of Hazmat Labels to Learn

These images are not intended for printing
They are not actual size labels, only examples of the variety of options.

Dexterity Touch/Insert

Linear Touch/Insert Tasks (Blue)

Fabrication

QTY: [12] LINEAR TASKS

PURCHASE LIST:

[6] **"2x2" LUMBER**
240 cm (96 in)

[2] **"2x4" LUMBER**
240 cm (96 in)

[60] **THREADED INSERTS**
8 mm (5/16 in) THREADS
EXAMPLE: https://a.co/d/c2r2Vi9

[20] **SANDER TOOLS WITH SHAFTS**
FITS EASILY IN THREADED INSERTS
EXAMPLE: https://a.co/d/9i8XJJO

[1] **DRILL BITS FOR PILOT HOLES**
8.7 mm 11/32 in)
EXAMPLE: https://a.co/d/1ToPFud

CUT LIST:

A **[12] "2X2" RAILS**
90 cm (36 in)

B **[12] "2X4" CENTERS**
30 cm (12 in)
45° BOTH ENDS CUT FLAT OPPOSING

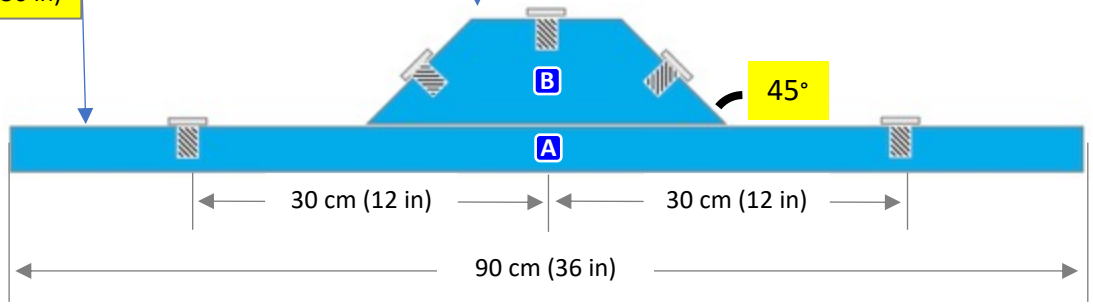
FABRICATION TIPS:

- Center and screw both pieces of lumber together lying flat their sides. Push up against as clamped beam or wall.
- Use the appropriate pilot hole drill so the threaded inserts can be installed by hand easily. Be sure the hole isn't too large.

"2x4" CENTER PIECE
30 cm (12 in) with 45° BOTH ENDS CUT FLAT

THREADED INSERTS 8 mm (5/16 in)
TO EASILY FIT TOOL SHAFTS 7 mm (1/4 in)

"2x2" RAIL
90 cm (36 in)



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

NOTE: Your dimensions may vary slightly depending on the your purchasable materials. The goal is to minimize purchase costs and cuts while maintaining the rough dimensions shown.

Omni Touch/Insert Tasks (Blue)

Fabrication

QTY: [12] OMMI TASKS

PURCHASE LIST:

[3] **"2x4" LUMBER**
240 cm (96 in)

[1] **"THIN WALL OSB" PANEL**
120 x 240 cm (48 x 96 in)

60] **THREADED INSERTS**
8 mm (5/16 in) THREADS
EXAMPLE: https://a.co/d/c2r2Vi9

[20] **SANDER TOOLS WITH SHAFTS**
FITS EASILY IN THREADED INSERTS
EXAMPLE: https://a.co/d/9i8XJJO

[1] **DRILL BITS FOR PILOT HOLES**
8.7 mm 11/32 in)
EXAMPLE: https://a.co/d/1ToPFud

CUT LIST:

A **[24] "2X4" CENTERS**
30 cm (12 in)
45° BOTH ENDS CUT FLAT ON SAW

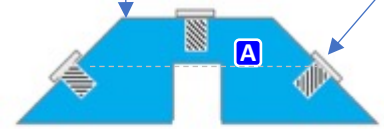
B **[12] "THIN WALL OSB" BASES**
30 cm (12 in) SQUARE

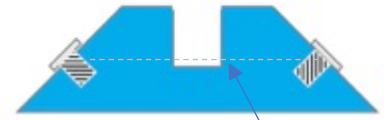
FABRICATION TIPS:

- Notch half the CENTER PIECES on the TOP and on the BOTTOM in pairs.
- A single long screw from the bottom can attach the two elements together.
- The OSB base makes Omnis easier to mount on walls from the front.

"2x4" CENTER PIECE
30 cm (12 in) with 45° BOTH ENDS CUT FLAT

THREADED INSERTS 8 mm (5/16 in)
TO EASILY FIT TOOL SHAFTS 7 mm (1/4 in)





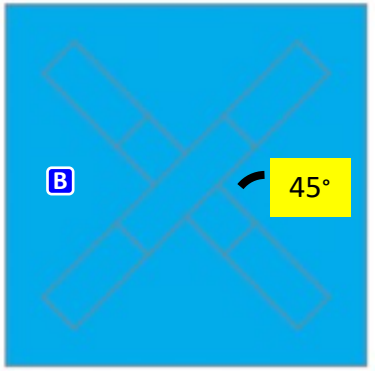
30 cm (12 in)

NOTCHES MUST BE WIDE ENOUGH TO ACCOMMODATE THE "2x4" USED AND JUST PAST HALF THE DEPTH

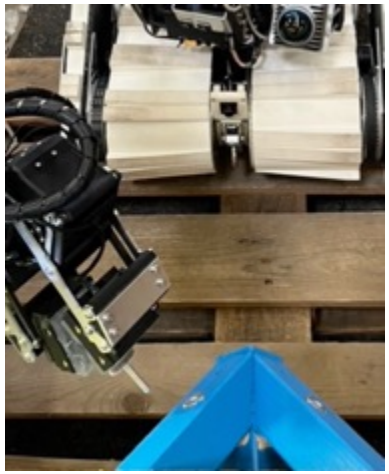
THREADED INSERTS
8 mm (5/16 in) THREADS
INSIDE FOR SHAFT TO FIT

TOOL SHAFT FITS EASILY
7 mm (1/4 in) DIAMETER
25 mm (1 in) LONG

30 cm (12 in)



SCREW OMNI TO BASE
FROM UNDERSIDE



NOTE: Your dimensions may vary slightly depending on the your purchasable materials. The goal is to minimize purchase costs and cuts while maintaining the rough dimensions shown.

Dexterity
E-Stops & Valves

Omni E-Stop Tasks (Black)

Fabrication

QTY: [6] OMNI E-STOPS

PURCHASE LIST:

[2] **"2x4" LUMBER**
240 cm (96 in)

[1] **"THIN WALL OSB" PANEL**
120 x 240 cm (48 x 96 in)

[30] **E-STOP BUTTONS**
Example: https://a.co/d/hy28aQi

CUT LIST:

A **[12] "2X4" CENTERS**
30 cm (12 in)
45° BOTH ENDS CUT FLAT ON SAW

B **[6] "THIN WALL OSB" BASES**
30 cm (12 in) SQUARE

FABRICATION TIPS:

- See the detailed OMNI fabrication instructions for ALIGN/INSPECT.
- Notch half the CENTER PIECES on the TOP and on the BOTTOM in pairs.
- A single long screw from the bottom can attach the two elements together.
- The OSB base makes Omnis easier to mount on walls from the front.

APPROXIMATELY
7 cm (3 in) SQUARE

4 cm (1.6 in)
DIAMETER

https://a.co/d/hy28aQi

NOTE: Your dimensions may vary slightly depending on the your purchasable materials. The goal is to minimize purchase costs and cuts while maintaining the rough dimensions shown.

Omni Valve Tasks (Black)

Fabrication

QTY: [6] OMNI VALVES

PURCHASE LIST:

[2] **"2x4" LUMBER**
240 cm (96 in)

[1] **"THIN WALL OSB" PANEL**
120 x 240 cm (48 x 96 in)

[30] **SHUT-OFF VALVES (90 DEGREE)**
Example: https://a.co/d/a2CrT4Z

CUT LIST:

A **[12] "2X4" CENTERS**
30 cm (12 in)
45° BOTH ENDS CUT FLAT ON SAW

B **[6] "THIN WALL OSB" BASES**
30 cm (12 in) SQUARE

FABRICATION TIPS:

- See the detailed OMNI fabrication instructions for ALIGN/INSPECT.
- Notch half the CENTER PIECES on the TOP and on the BOTTOM in pairs.
- A single long screw from the bottom can attach the two elements together.
- The OSB base makes Omnis easier to mount on walls from the front.

https://a.co/d/a2CrT4Z

NOTE: Your dimensions may vary slightly depending on the your purchasable materials. The goal is to minimize purchase costs and cuts while maintaining the rough dimensions shown.

Victim Crates

Fabrication

QTY: 12

PURCHASE LIST:

[12] **CUBIC CRATES**
30 cm (12 in)
APPROXIMATELY CUBIC SHAPE

EXAMPLE: https://a.co/d/ce5T3fO

NIST WILL BRING ALL THE CONTENTS

NOTE: Your dimensions may vary slightly depending on the your purchasable materials. The goal is to minimize purchase costs and cuts while maintaining the rough dimensions shown.

Complexity

Fabrication

Pinch Points and Angled Obstacles

Optional Complexity

PINCH POINT TRIANGLES TO HANG ON WALLS

- Forces more steering within terrains.
- Can be used on opposite side walls to form serpentine paths.
- Useful as mapping fiducials as well when distributed throughout a sequence of test lanes. Known locations of mapping fiducials can be used to evaluate map accuracy and consistency.

ANGLED OBSTACLES WITH MAGNETS

- Forces larger robots with advantages in the terrains and step-over obstacles to steer precisely and crouch at times. Small robots simply steer clear.
- All bars are magnetized in place so that any touched bar falls. Hitting the walls hard can also do it, so precise control is rewarded.
- Fallen bars act as debris so are not removed until the robot has moved past them to the next repetition or terrain. Extra points can be given for the number of bars left intact for each repetition (reset at the start).

QTY: 20 PINCH POINTS

PURCHASE LIST:

[5] **"THIN WALL OSB" PANELS**
120 x 240 cm (48 x 96 in)

[3] **"2x4" LUMBER**
240 cm (96 in)

[7] **"2x2" LUMBER**
240 cm (96 in)

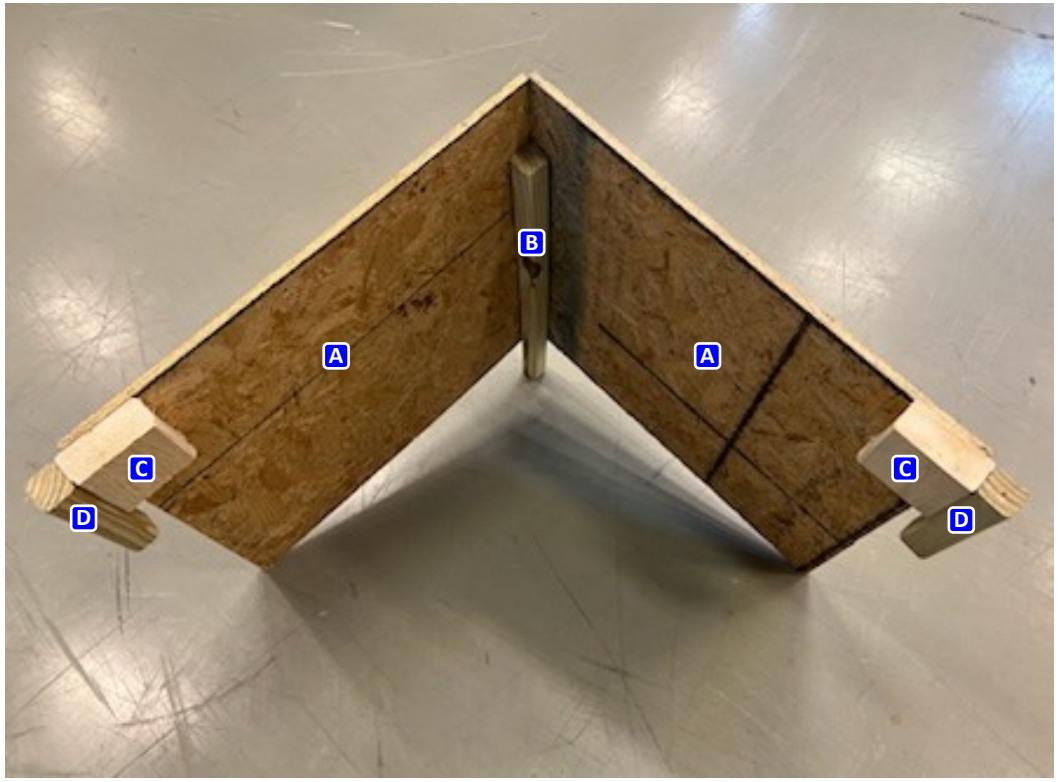
CUT LIST:

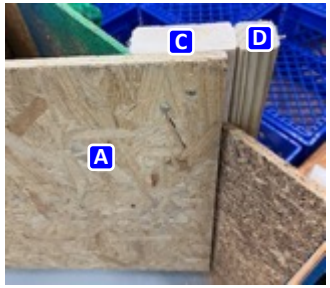
A [40] **PINCH POINT PANELS**
60 x 60 cm (24 x 24 in)

B [20] **"2x2" CENTER SPINE/LEG**
60 cm (24 in)

C [40] **WALL HANGING BLOCKS**
15 cm (6 in)

D [40] **WALL HANGING POSTS**
15 cm (6 in)





NOTE: Your dimensions may vary slightly depending on the your purchasable materials. The goal is to minimize purchase costs and cuts while maintaining the rough dimensions shown.

Negotiate Angled Obstacles

Optional Complexity

QTY: 20 ARCHES

PURCHASE LIST:

[40] **"2x2" LUMBER**
240 cm (96 in)

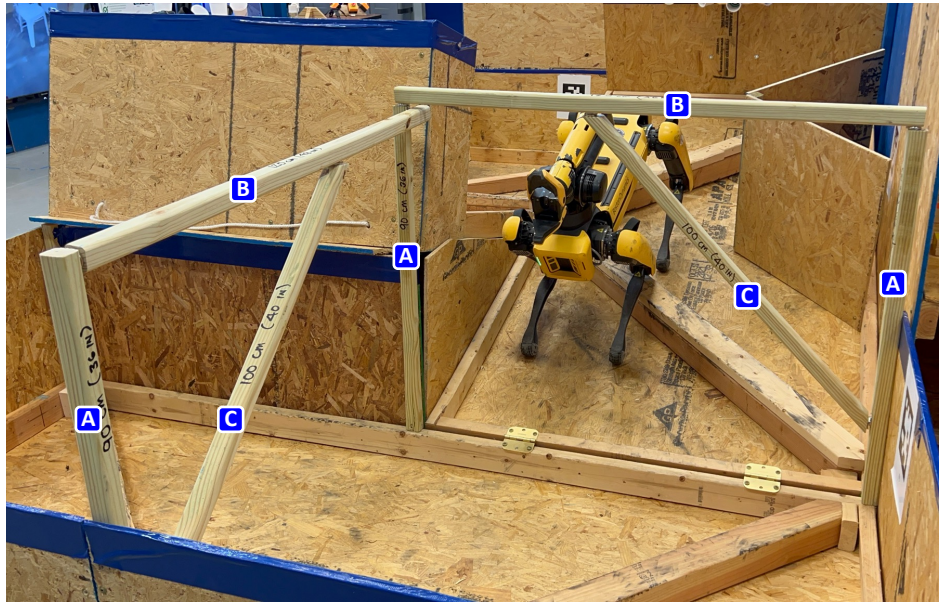
[40] **MAGNETS WITH CENTER HOLES WITH RELATED WASHERS**
3+ cm diameter, 50 kg force)
(1.3+ in diameter, 110 lb force)
https://a.co/d/8grevJL

CUT LIST:

A [40] **VERTICAL WALL POSTS**
90 cm (36 in)

B [20] **HORIZONTAL SPANS**
120 cm (48 in)

C [20] **DIAGONAL OBSTACLES**
100 cm (40 in)



- MAGNETS with WASHERS and SCREWS should be purchased together to ensure they work. https://a.co/d/8grevJL
- If they must be purchased separately, be certain NOT to purchase STAINLESS STEEL WASHERS.

NOTE: Your dimensions may vary slightly depending on the your purchasable materials. The goal is to minimize purchase costs and cuts while maintaining the rough dimensions shown.

Rolling Gantry Belay

Safety for Quadrupeds and Humanoids

Rolling Gantry Belay (Light)

Safety for Quadrupeds and Humanoids

Fabricate: 1

PURCHASE LIST:

[1] "THIN WALL OSB" PANELS
120 x 240 cm (48 x 96 in)

[9] "2x4" LUMBER
240 cm (96 in)

[4] CASTERS (2 SWIVEL, 2 FIXED)
10cm (4in) or larger
https://a.co/d/f4Lp85s

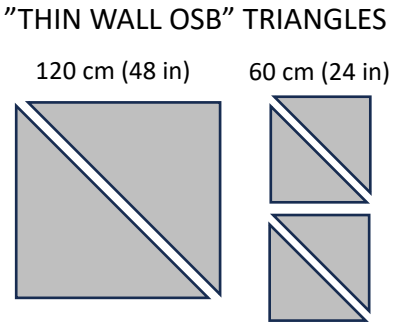
[4] TOP TRACK AND TROLLEY
150 cm (60 in) length
RAIL: https://a.co/d/gzLlpON
TROLLEY: https://a.co/d/bhYANVh

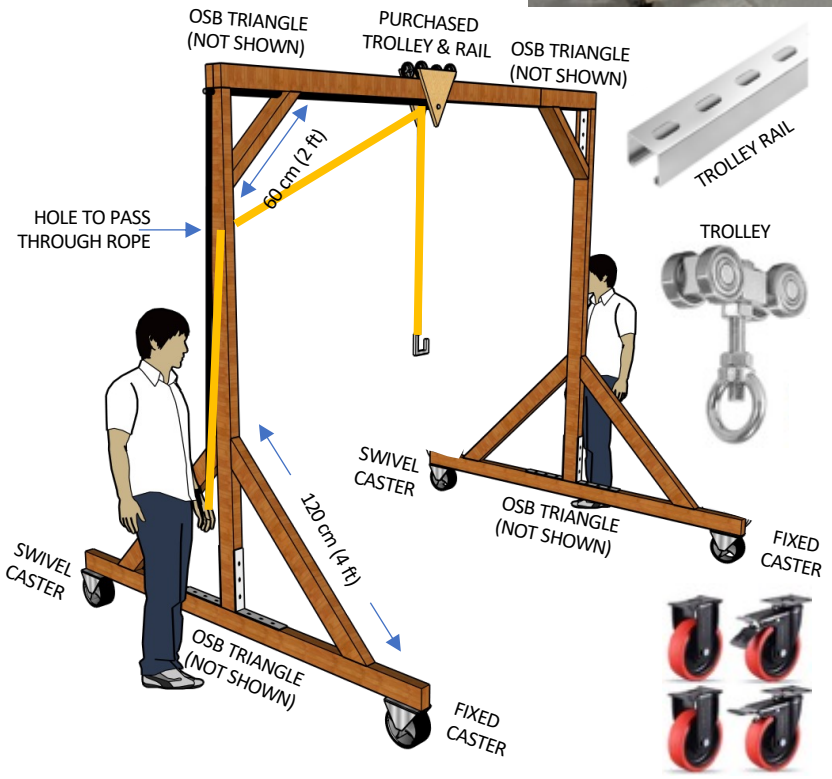
[1] ROPE FOR GOOD HAND GRIP
10 mm (1/2 in) x 10 m (30 ft)
https://a.co/d/3aVigTE

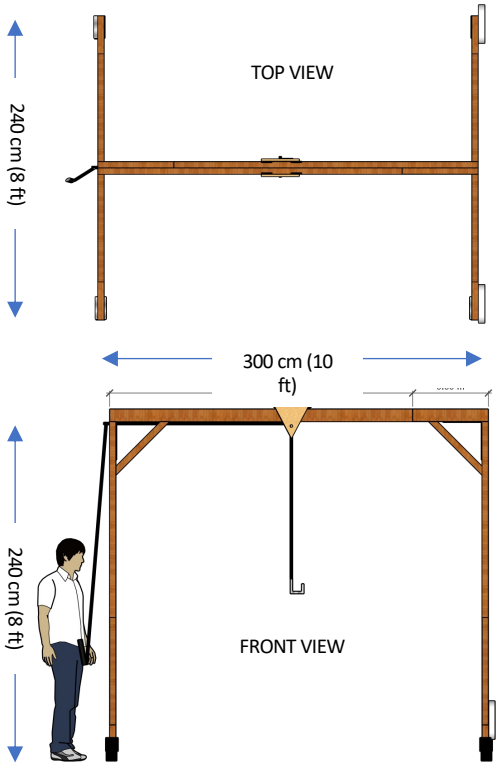
[1] CARABINER or shackle

FABRICATION TIPS:

- Assemble 1 simple composite beam for top span. Use full length "2x4s" plus 60 cm (24 in) cut fillers at both ends to total 3 m (10 ft).
- Note the tall orientation of the beams so the side plywood triangles are all on the same planes.
- Purchase a matching TOP TRACK and TROLLEY 150 cm (60 in) length.







NOTE: Your dimensions may vary slightly depending on the your purchasable materials. The goal is to minimize purchase costs and cuts while maintaining the rough dimensions shown.

Operator Stations

Optional for Semis/Finals Trials Only

QTY: 2 (OPTIONAL)

NOTE: Operator stations are optional. We have way too many (10) concurrent start points during the Prelims so use tables and chairs turned away from the test lanes. However, in the Semis and Finals, we only have 2 concurrent start points in lanes that can be seen, so 2 operator stations would ensure the audience understands the operators are out of sight of their robot at all times.

PURCHASE LIST:

[4] THIN OSB PANELS
12 mm x 120 cm x 240 cm
(7/16 in x 48 in x 96 in)

[8] LUMBER BEAMS
5 x 10 x 240 cm
(2 x 4 x 96 in)

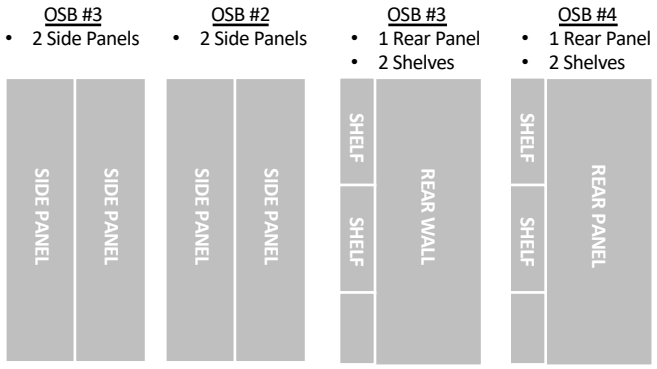
CUT LIST:

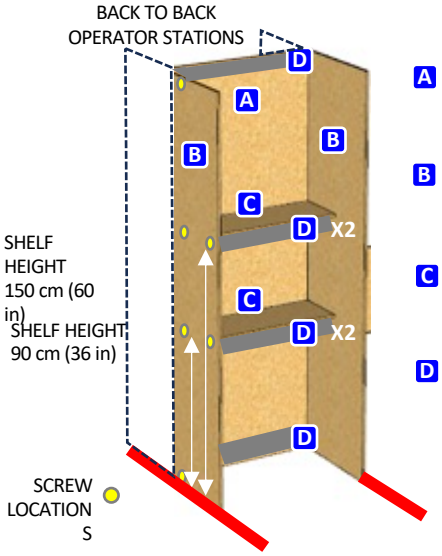
A [2] REAR PANELS
12 mm thick x 90 cm wide x 240 cm tall
(7/16 in thick x 36 in wide x 96 in tall)

B [4] SIDE PANELS
12 mm thick x 60 cm deep x 240 cm tall
(7/16 in thick x 24 in deep x 96 in tall)

C [4] SHELVES
12 mm thick x 30 cm deep x 90 cm wide
(7/16 in thick x 12 in deep x 36 in wide)

D [12] SUPPORT BEAMS
5 x 10 x 90 cm
(2 x 4 x 36 in)
Installed under front & rear of shelves.
Installed also at top and bottom of





A REAR PANEL – THIN OSB
90 cm wide x 240 cm tall
(36 in wide x 96 in tall)

B SIDE PANEL – THIN OSB
60 cm wide x 240 cm tall
(24 in wide x 96 in tall)

C SHELVES – THIN OSB
30 cm deep x 90 cm wide
(12 in deep x 36 in wide)

D SUPPORT BEAMS UNDER
FRONT & REAR OF SHELVES
and
TOP & BOTTOM OF ASSEMBLY

OPTIONAL SKID RAILS ALLOW STAND ALONE STABILITY

- These operator stations DO NOT STAND ALONE! They could tip over if pushed when standing alone without the skids on the floor.
- So they are used in PAIRS and ATTACHED back to back for stability.
- Operators should not be able to see the test lane, but they can have their back toward the lane.

NOTE: Your dimensions may vary slightly depending on the your purchasable materials. The goal is to minimize purchase costs and cuts while maintaining the rough dimensions shown.

Packing/Transport

Packing for Transport

Stacked Subfloors and Fabricated Crates

Flooring Elements

- Fabricate a “THICK FLOOR OSB” panel pallet of sorts for the forklift to get under. Add a few full length tall 2x4s to make it rigid.
- Stack the subfloors with their contents intact when possible (heaviest on bottom) up to about 2m tall or your truck’s overhead door height.
- Screw side panels on all four sides to contain them.
- Be sure side panels OVERLAP each other vertically.
- Add plastic wrap if anything loose is stacked on top

Pallets, Stepfields, Stepover Frames, Dexterity Tasks

- Fill the fabricated crates in layers of like kind items. See the suggested loading order based on last in – first out, and with heaviest or most tightly packable items on the bottom (like Ramps, Pallets, etc.).
- Use voids within the apparatuses or top spaces inside crates for DEXTERITY tasks and small items.

Ramps

- Stack with surfaces touching, right side up then upside down. Contain with side panels.

STACKED SUBFLOORS

WITH PALLETS ON TOP

STACKED PALLET OPTION

STACKED SUBFLOORS

SCREW PANELS TO ENDS

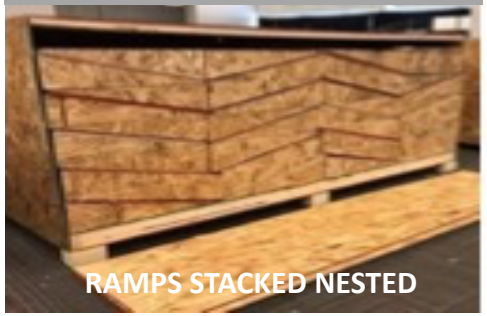
CLOSED CRATE

FRONT PANEL SCREWED ON

STAIR LANDING INVERTED

CONTAINS STAIRS AND RAILS

PACKING RAMPS



RAMPS STACKED NESTED

Packing for Transport

Shipping Crates with Packing Orders

QTY: [3] SHIPPING CRATES

PURCHASE LIST:

[3] **"THICK FLOOR OSB" PANELS**
18 mm x 120 cm x 240 cm
(19/32 in x 48 in x 96 in)

[12] **"THIN WALL OSB" PANELS**
9.5 mm x 120 cm x 240 cm
(7/16 in x 48 in x 96 in)4

[36] **"2x4" LUMBER**
5 x 11 x 240 cm (2 x 4 x 96 in)

CUT LIST:

A **[30] SHORT BEAMS**
5 x 11 x 120 cm (2 x 4 x 48 in)
SHOULD BE SAME AS OSB PANEL

B **[21] LONG BEAMS**
5 x 11 x 230 cm (2 x 4 x 93 in)
CUT TO FIT BETWEEN SHORT BEAMS

C **[6] "THIN WALL OSB" HALF PANEL**
9.5 mm x 120 cm x 120 cm
(7/16 in x 48 in x 48 in)
SIDES FOR EACH CRATE

D **[19] "THIN WALL OSB" FULL PANEL**
FRONT/BACK/TOP FOR EACH CRATE

E **[3] "THICK FLOOR OSB" FULL PANEL**
BASE FLOOR

FABRICATION TIPS:
- Assemble the crate base first without the forklift skids. Attach the walls to the base while on the floor. Then attach the skids.

CRATES SHOULD ARRIVE IN THIS ORDER

STACKED VERTICALLY AS SHOWN BOTTOM TO TOP

#1: STACKED SUBFLOORS (NO CRATE NEEDED)
Stack all subfloors up to 210 cm (7 ft) tall.
Screw on OSB sides to secure them all together
Listed bottom to top as shown due to weight.
- [4] Ramps (empty, with extra K-Rail layers)
- [4] K-Rails (intact, screwed to subfloor)
- [4] Foam (intact, heavier than you think)
- [4] Gravel (intact, double thick frames = 20cm (8in)

#2: PALLETS/WALLS LAYERS
- [20] Pallets and Pipes – 60cm (24in)
- [20] Long walls – 30cm (12in)
- [50] Short walls – 30cm (12in)
- [2] Center subfloors with baffles – 20cm (8in)

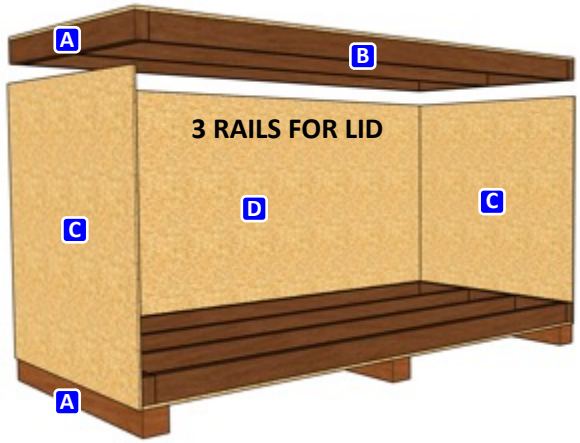
#3: TERRAIN ELEMENT LAYERS
- [32] Stepfields – 60cm (24in)
- [32] Ramps – 30cm (12in)

#4: STAIRS & LANDING (NO CRATE NEEDED)
- [1] Stairs fit into the inverted landing to close the crate.
- [4] Railings fit too. There should be remaining space.
  This is a short crate 100 cm (40 in) with OPEN TOP.

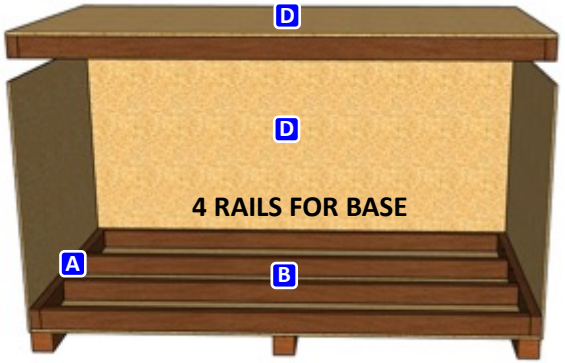
#5: LABYRINTH/MAZE, DOOR, and AVOID
- [10] Mapping fiducial tubes
- [25] Maze floor terrain diagonals and rooms
- [1] Door with U-Turn stoops
- [50] OSB wall panels
- [20] Pallets and Posts

CRATES WITH LIDD FOR SMALLER ELEMENTS

RAMPS, STEPFIELDS, PALLETS, ETC.



FRONT PANEL NOT SHOWN – AFTER FILLING, IT IS SCREWED TO TOP/BOTTOM RAILS TO CLOSE



SHIPPING CRATE BASES HAVE [4] TALL 2x4s. FRAMES LEFT TO RIGHT FOR FORKLIFTS TO GET UNDER

NOTE: Your dimensions may vary slightly depending on the your purchasable materials. The goal is to minimize purchase costs and cuts while maintaining the rough dimensions shown.