



Purchase and Fabrication Details

ICRA Autonomous Quadruped Robot Challenge

PRE-FABRICATION TASKS PRESENTED IN ORDER OF PRIORITY



Purchase List

ICRA Autonomous Quadruped Robot Challenge

Lumber	#	PRICES CHECKED IN GREEN		USA Prices		England Prices	
		PER ITEM		TOTAL		PER ITEM	
		US Dollars	US Dollars	Pounds	Pounds		
THICK Oriented Strand Board Plywood (WALKING SURFACES ONLY)	30	\$ 18.62	\$ 558.60	0.00	0		
240x120cm x 11mm thick (96x48in x 7/16in thick)							
Example THICK OSB Sheets							
[16] floors of zig-sag lanes (1 per as full sheets)	16						
[16] pallets (2 per as half sheets)	8						
[40] square ramps (used as eighth sheets)	5						
spares	1						
THIN Oriented Strand Board Plywood (WALLS ONLY)	30	\$ 11.10	\$ 333.00	0.00	0		
240x120cm x 11mm thick (96x48in x 7/16in thick)							
Example THIN OSB Sheets							
[4] walls of zig-sag lanes (used as half and quarter sheets)	16						
[1] walls of operator station with shelf (full sheets plus shelf)	4						
spares	10						
Lumber Beams (Called "4x2" in London and measures 97x47mm)	200	\$ 5.00	\$ 1,000.00	£ 9.00	1800		
5x10x240cm (2x4x96in)							
Example Beam							
[16] floor borders and wall corners in zig-sag lanes (4 per lane)	48						
[16] pallet suprtts and feet (3 per pallet)	48						
[12] pallet doorway post Ls and pipe holders (2 per doorway)	24						
[40] square ramps (used 6ft per ramp as supports and legs)	40						
[4] step-over array frames (variuos sizes)	12						
[8] k-rail diagonals (almost full beams - double wide)	16						
spares	12						
Lumber Balusters (Called "2x2" in London)	50	\$ 2.00	\$ 100.00	0.00	0		
5x5x80cm (2x2x96in)							
Example Baluster							
		Sub Total	\$ 1,991.60				

Miscellaneous							
Crates (full zig-zag lane plus spares)	120	\$ 10.00	\$ 1,200.00	15.00	1800		
30cm (12in) tall x some round multiple wide -- very sturdy)							
Example Crate							
Straps (for connecting vertical crate stacks)	60	\$ 3.00	\$ 180.00	0.00	0		
25mm (1in) wide x 2m (6ft) long or longer							
Example Tie Down Straps							
Soft Foam Flooring (bed/futon full zig-zag lane plus spares)	5	\$ 298.85	\$ 1,494.25	0.00	0		
10cm (4in) thick x 120 x 240cm (4in thick x 48 x 96in)							
Example 10cm (4in) Thick Foam Sheets - 120cm (48in) x (200cm) 80in	5	\$ 295.00					
Example Foam Sheet to cut into 32 squares of 60cm (24in) like ramps	11	\$ 75.00					
Pallets (TOO EXPENSIVE AT \$100 EACH. BETTER TO PRE-FABRICATE!)	0	\$ 99.00	\$ -				
15cm tall x 120cm x 100+cm (6in tall x 48in x 40in+)							
Example Pallet 15cm (6in) Thick							
Example Pallet 10cm (4in) thick							
PVC Pipes (as rolling exges on fabricated Pallet Steps)	10	\$ 10.00	\$ 100.00	0.00	0		
Sewer/drain pipes are thin walled. Need to be cut to 120cm (48in)							
Example PVC Sewer and Drain Pipe							
Rubber Tire Blocks (full sig-zag lane plus spares)	15	\$ 79.99	\$ 1,199.85	0.00	0		
Near 15cm (6in) tall and semi round							
Rubber quater round curb pairs 15cm (6in) tall							
Door Hings (for tilting terrains)	20	\$ 4.00	\$ 80.00	0.00	0		
5cm (2in) wide							
Example Hinges							
		Sub Total	\$ 4,254.10				



PRE-FABRICATE 16 FLOORS WITH BORDERS

- Make one floor panel fork-liftable by screwing 10x10x120cm (4x4x48in) beams underneath.
- Stack the rest on top.
- Screw WALL PANELS on all sides to hold them together for transport.

A [1] FULL PANELS OF THICK OSB

B [2] FULL BEAMS OF 2X4 AS SIDE BORDERS

5 x 10 x 240cm (2 x 4 x 96in)

C [2] HALF BEAMS OF 2X4 AS END BORDERS

CUT TO FIT BETWEEN YOUR **B** BORDERS

D [16] DOOR HINGES 5cm (2in) or so typical door hinges

FASTENERS:

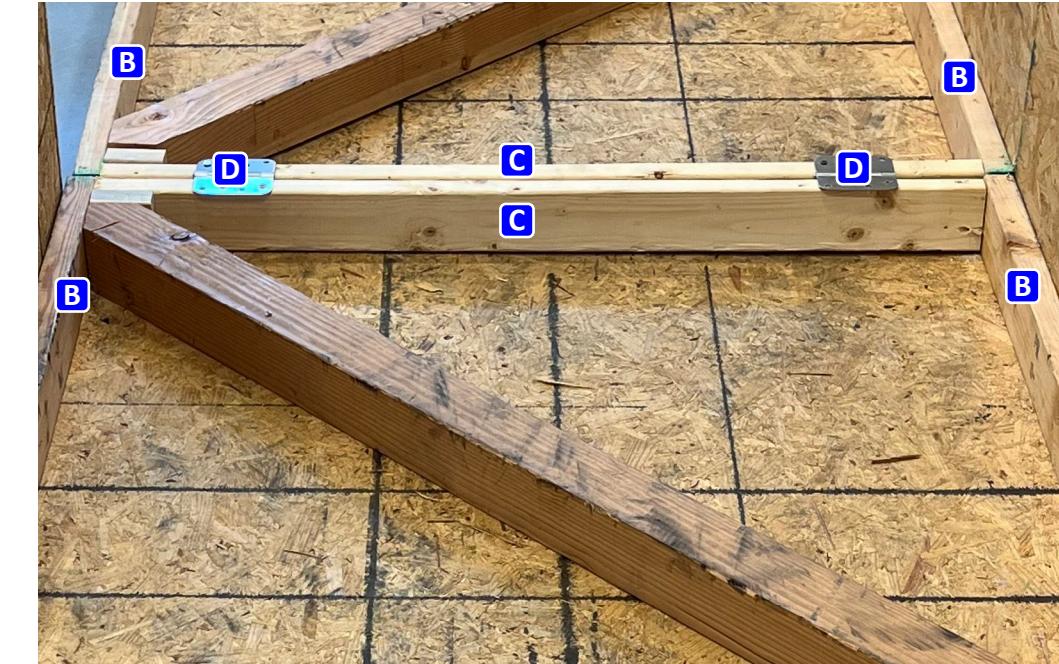
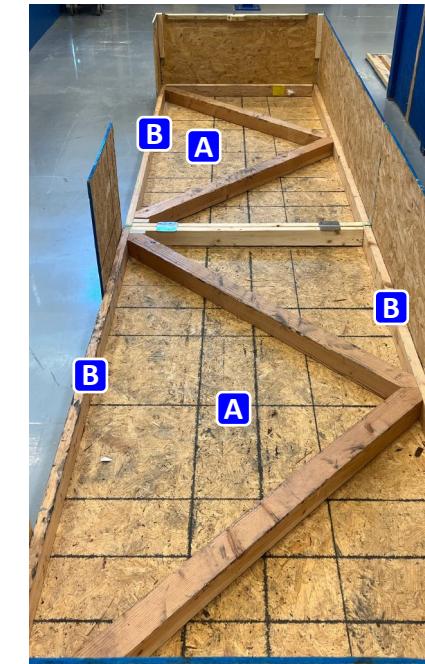
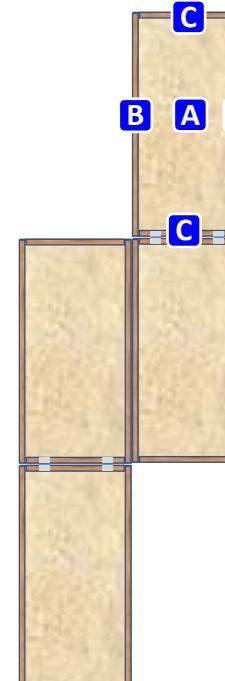
[8] LONG TORX DECK SCREWS

100mm (4in) through **B** into the end grain of **C** (2 screws per joint).

[8] WASHER HEAD TORX SCREWS

75mm (1-1/2in) through the OSB panel into the lumber frame on all sides (8 screws per pane). The WASHER HEADS keep the screw from penetrating.

These form the basis for the zig-zag lanes with 4 floors per lane. They are HINGED together in pairs to enable one floor to tilt on each side of the lane.



The pictures show HALF a lane. The other half is similar and sits next to this one offset by one floor panel.



PRE-CUT ENOUGH FOR 6 LANES

- Use some of the small walls to fasten the stack of floors together, the rest can travel inside the floors.
- The full length walls can travel on top of the floors.

A [4] HALF PANEL WALLS (THIN OSB)

60cm tall x 240cm wide (24in tall x 96in wide)

B [6] QUARTER PANEL WALLS (THIN OSB)

60cm tall x 120cm wide (24in tall x 48in wide)

C [4] SUPPORTS STRIPS (THIN OSB)

60cm tall x 15cm wide (24in tall x 6in wide)

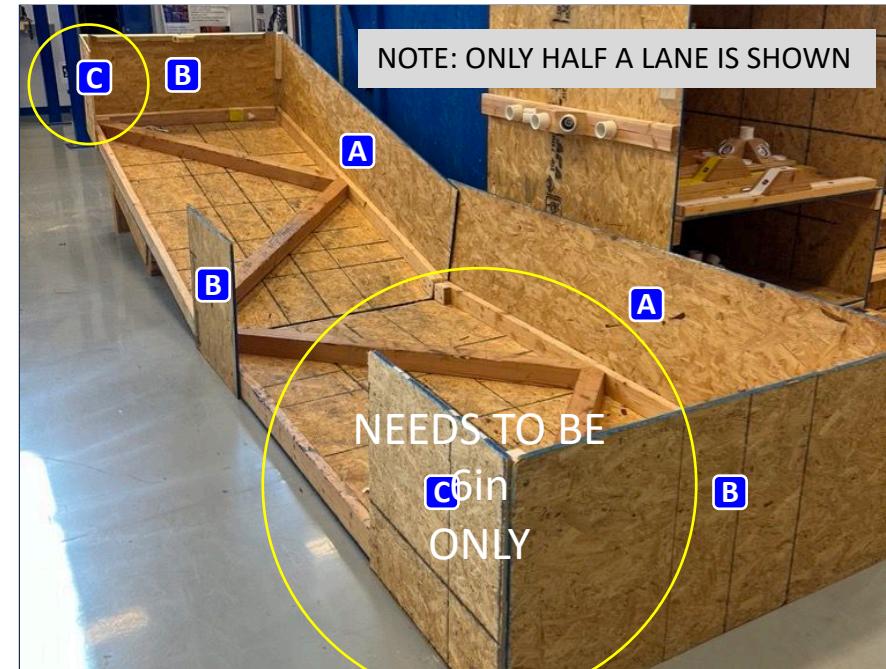
FASTENERS:

[50] WASHER HEAD TORX SCREWS
75mm (1-1/2in)

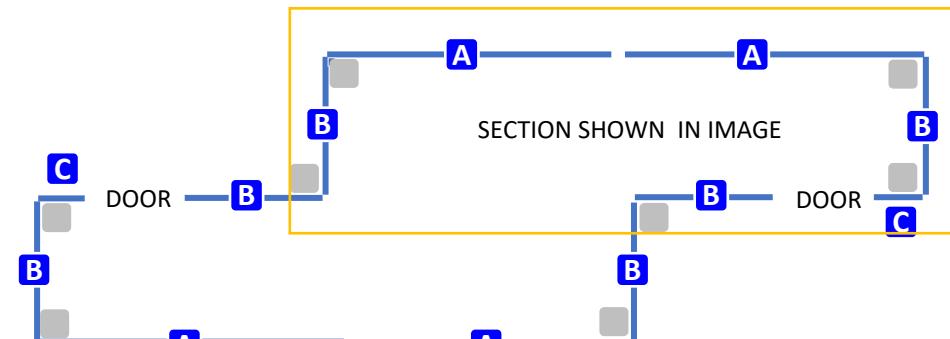
Lane Walls 60cm (24in) Tall

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These lane walls are intended to be thin OSB panels cut on a PANEL SAW either in HALF the long way or QUARTERS the short way. Plus some support strips.



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PRE-FABRICATE 40 RAMPS

- Stack them on a 120cm (48in) square pallet we use as a terrain.
- Put 120cm (48in) square panels on THREE SIDES to contain them.
- Stack them alternating upside down.
- All fit in less than than 90cm (3ft) high.

A [1] SQUARE TOP

THICK: 18mm (3/4in) OSB

SQUARE: 55cm (22-1/4in)

SEE NOTE!

B [1] FRONT PANEL - RECTANGULAR

THICK: 18mm (3/4in)

WIDE: 55cm (22-1/4in)

TALL: 15cm (6in)

Supports the entire edge of the square top.

C [2] SIDE PANELS - TRIANGULAR

THICK: 18mm (3/4in)

WIDE: 55cm (22-1/4in)

TALL: 15cm (6in) tapers at 15 deg

Supports the entire edge of the square top.

D [3] LEGS

5x10x15cm (2x4x6in)

15 deg cut one end (Cut FLAT on miter saw)

Recessed under SQUARE TOP on both sides.

E [1] CROSS SUPPORT

2x4 CUT TO WIDTH BETWEEN YOUR WALLS

FASTENERS:

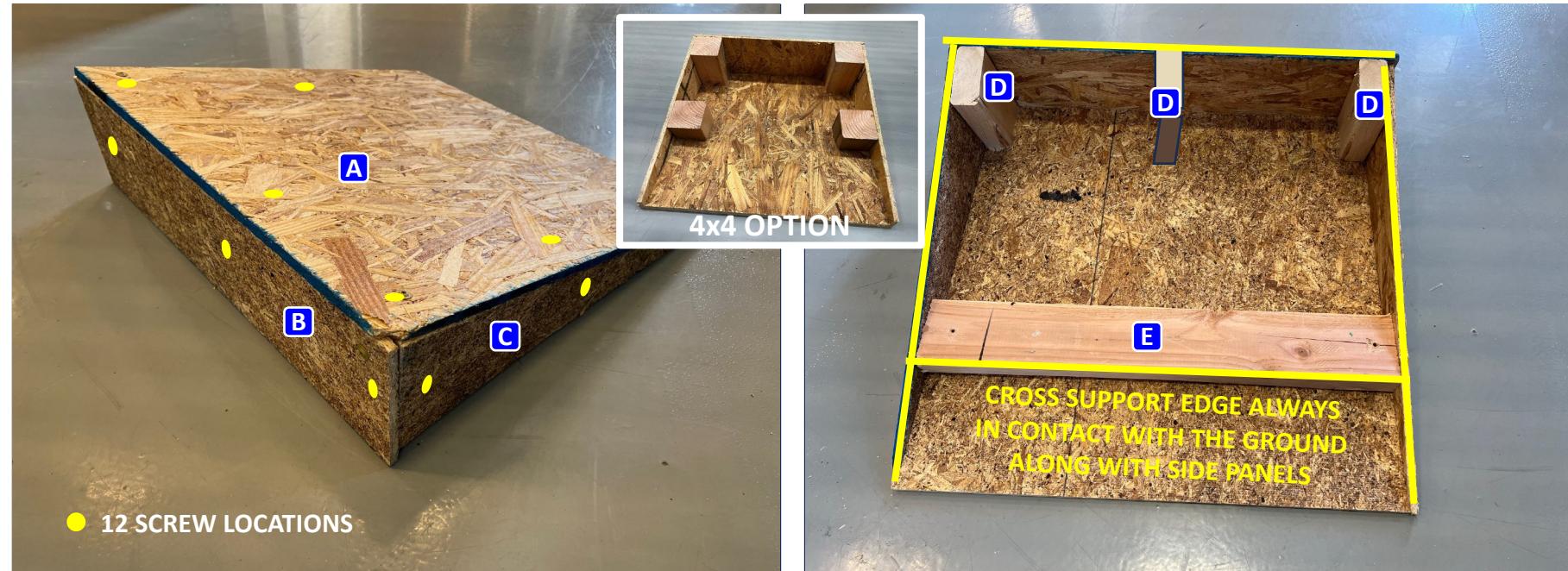
[10] WASHER HEAD SCREWS

TORX 75mm (1-1/2in)

Rotating Ramps (15deg)

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Your dimensions may vary depending on the thickness of your lumber border around your lane floors! Two ramps must fit easily within the space BETWEEN YOUR BORDERS so they can be rotated in place. Continuous Ramps are side-by-side uphills and downhills. Crossing "Pinwheel" Ramps are 4 ramps sets with cascading uphills clockwise or counter-clockwise. 32 fill a lane, but we need extras elsewhere.



- Attach the three surrounding side wall panels to the legs first as they stand squarely on the ground with the side triangles abutted to the back of the rectangular panel. Then attach the SQUARE TOP to the three LEGS.
- Flip up side down to add the CROSS SUPPORT so the EDGE WILL ALWAYS BE IN CONTACT WITH THE GROUND (SEE THE LINE ABOVE)



PRE-CUT 8 K-RAIL DIAGONALS

- They can travel inside their floors. They will not be removed at this event.
- They can be screwed to the floors and can travel as a CLAM SHELL with the HINGED FLOORS closed on each other.

A [8] K-Rail Diagonals

10 x 10cm x FIT BETWEEN YOUR BORDERS
(4 x 4in x FIT BETWEEN YOUR BORDERS)

B [4] Filler Beams

5 x 10cm x FIT BETWEEN YOUR BORDERS
(2 x 4in x FIT BETWEEN YOUR BORDERS)

The FILLER BEAMS should be at the FAR ENDS of the double floor hallway. So when K-Rails are removed the Crossing Ramps can be inserted.

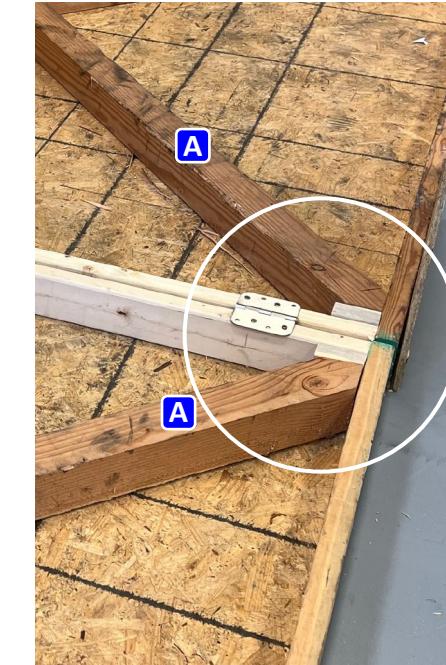
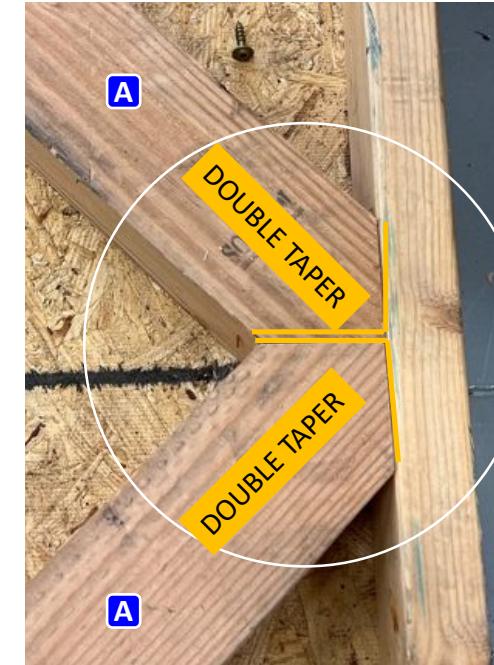
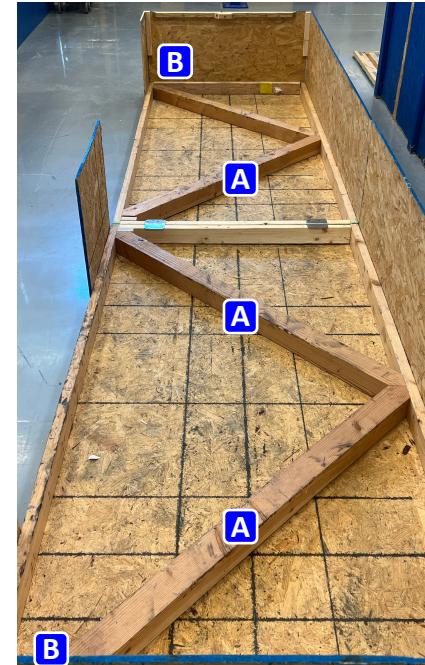
FASTENERS:

NONE. They drop in and are removable.

NOTE:

These square obstacles can be made from a SINGLE 4x4 POST or TWO 2x4 BEAMS screwed together.

These drop in rails can be solid posts cut with tapered tips or they can be two separate 2x4s with tapered tips that overlap and get secured in the center.



FILLER BEAMS

Should be at the FAR ENDS of the double floor hallway so when K-Rails are removed the Crossing Ramps can be inserted.

XXXXXXXXXX



PRE-FABRICATE 4 STEPOVER OBSTACLES

- They can travel on top of the floors or separately.

A [2] PERPENDICULAR STEP-OVERS

EACH WITH THE FOLLOWING:

- [4] 5x10x110cm (2x4x45in)
- ALL CAN BE THE SAME SIZE
- CUT TO EASILY FIT BETWEEN YOUR WALLS AND ON THE FLOOR BORDERS
- SPACE THEM APART 30cm (12in)

B [2] DIAGONAL STEP-OVERS

EACH WITH THE FOLLOWING:

- [2] FRAME SIDES
5x10x120cm (2x4x48)
- CUT TO EASILY FIT BETWEEN YOUR WALLS AND ON THE FLOOR BORDERS
- SPACE THEM APART 30cm (12in)

[2] FRAME FRONT/BACK

5x10x110cm (2x4x45)

- CUT TO EASILY FIT BETWEEN YOUR WALLS AND ON THE FLOOR BORDERS
- SPACE THEM APART 30cm (12in)

[3] DIAGONALS

SPACE THEM APART 30cm (12in)

CUT TO FIT THE FRAME.

FASTENERS:

[8] LONG TORX DECK SCREWS

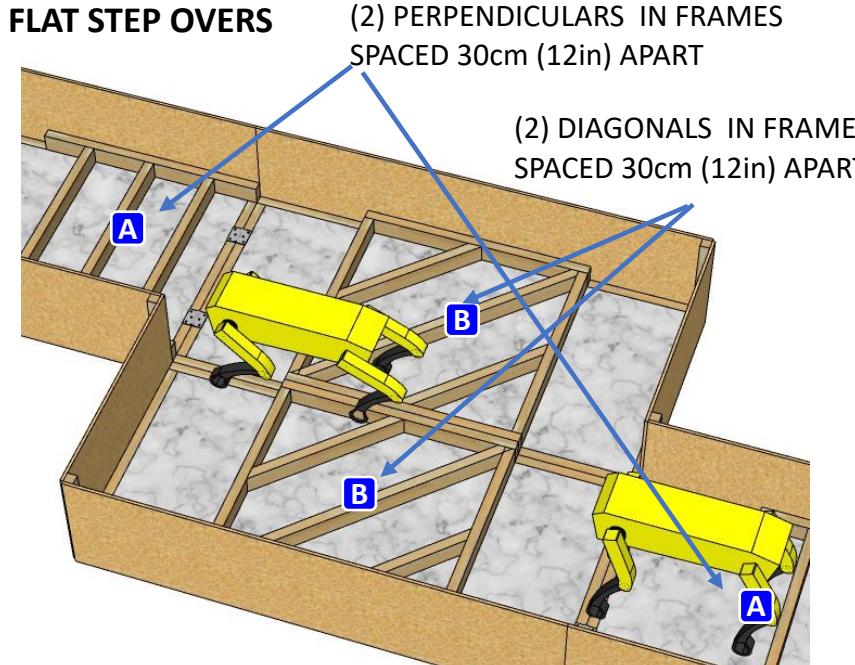
100mm (4in) through outer frame into the end grains

Soft Foam with Stepovers

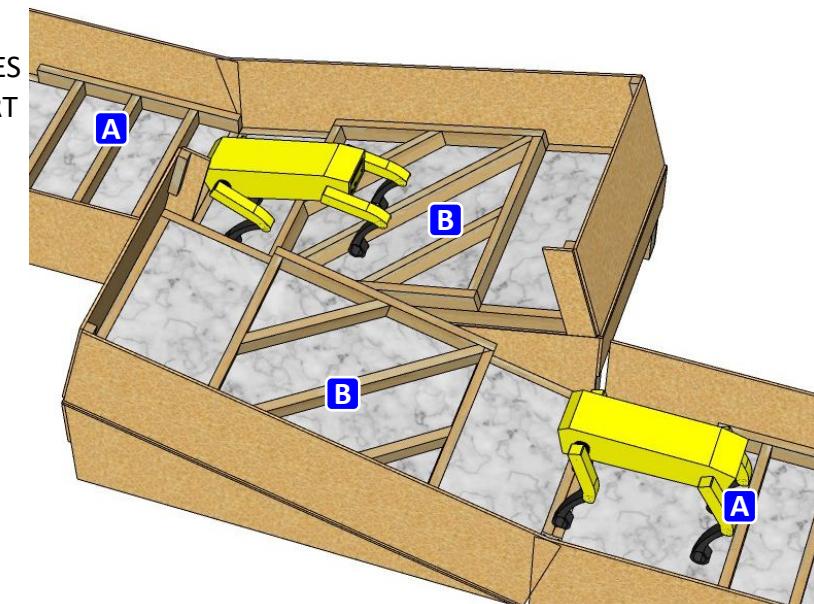
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This foam floor is intended to absorb feet like sand, gravel, or puddles to present a different ground plane than the sensors see.

FLAT STEP OVERS



SLOPED STEP OVERS



Note the dimensions rely on your particular fabrication lumber for spacing. Undersize them slightly so they fit between your lane walls and sit on the floor borders. Secure them by screwing through the walls from the outside of the lane.



PRE-FABRICATE 20 PALLETS WITH PIPES

- Add taller walls if necessary to make them good for stowing and transpiration of various elements.

A [3] LEG ASSEMBLIES

[3] 5x10x120 (2x4x48in)

[6] 10x10 (4x4in) CUT SO OVERALL HEIGHT OF
THE THICK OSB TOP IS 15cm (6in)

B [1] THICK OSB SURFACE

18mm x 120 x 120cm (3/4in x 48 x 48in)

C [2] THIN OSB SIDE WALLS

11mm x 60 x 120cm (7/16in x 24 x 48in)

D [1] THIN OSB BACK WALL

11mm x 30 x 120cm (7/16in x 12 x 48in)

E [1] 10cm (4in) PVC PIPE (or close)

- CUT TO FIT EASILY BETWEEN SIDE WALLS. THE PIPE SHOULD SPIN EASILY IN PLACE.

F [1] SPACER BEAM and UPRIGHTS

5x10x120cm (2x4x48)

- ELEVATES THE PIPE SO THE TOP OF THE PIPE COINCIDES WITH THE TOP OSB SURFACE AT 15cm (6in).
- UPRIGHTS HOLD THE PIPE IN PLACE

FASTENERS:

[12] LONG TORX DECK SCREWS

100mm (4in) through the rails down into the feet.

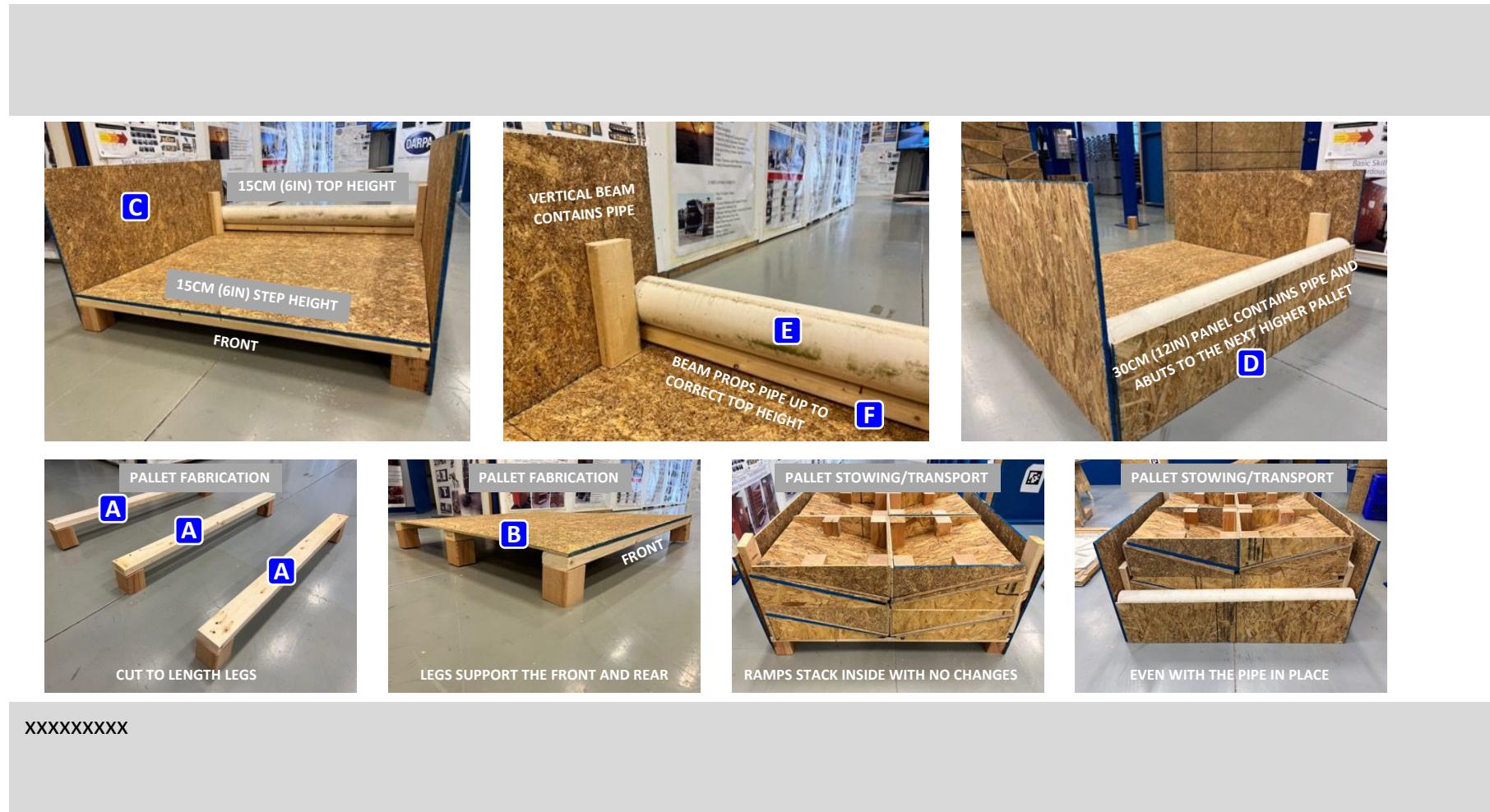
[20] WASHER HEAD SCREWS

TORX 75mm (1-1/2in)

Pallet Steps with Pipes

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These provide elevated steps with rolling pipe edges to force articulated appendages to ascend the leading edge.





Sloped Lane Option

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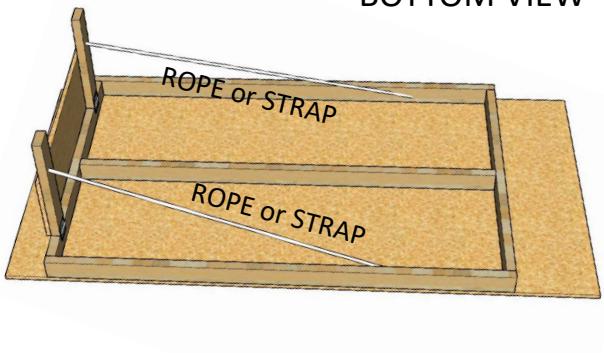
PRE-FABRICATE 6 FOLDABLE SLOPES

- These fold and stack to travel like the floors but not quite as neatly.
- Make the bottom one fork-liftable and affix OSB walls on four sides to hold them together.

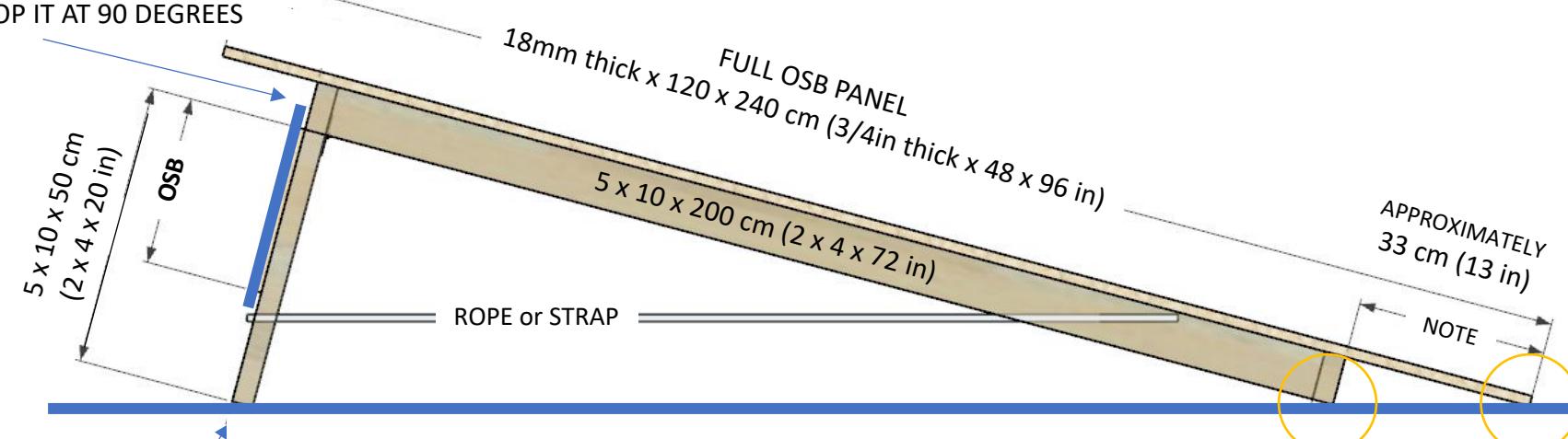
TOP VIEW



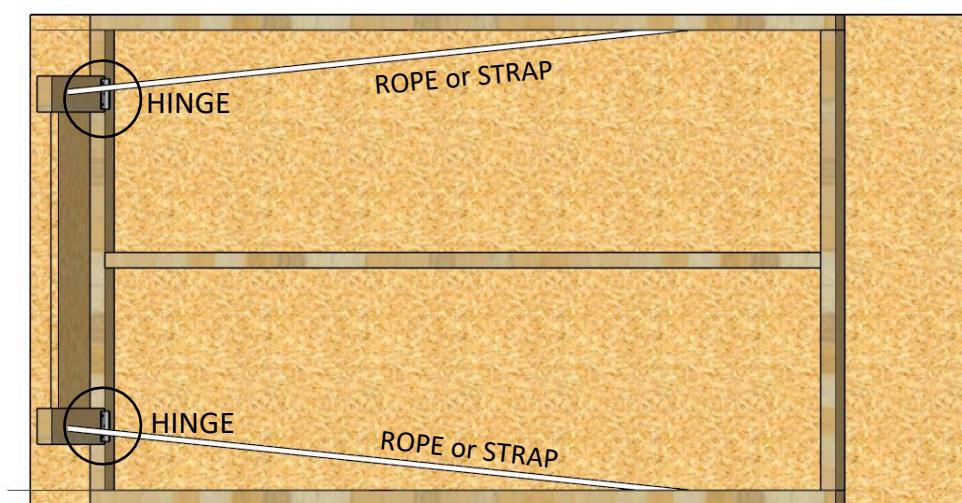
BOTTOM VIEW



OSB OVERLAPS MAIN FRAME
TO HELP STOP IT AT 90 DEGREES



Tapered Foot
15 Deg



NOTE: ATTACH THE SURFACE PANEL SO IT'S EDGE AND THE LUMBER FRAME BOTH TOUCH THE GROUND BEFORE AFFIXING THE TOP OSB PANEL.



PRE-CUT 5 OPERATOR STATIONS

- Pre-Assemble the 4 SUPPORT BEAMS to the REAR WALL at the locations shown and leave them attached to guide assembly on site.

TO MAKE 5 OPERATOR STATIONS:

Purchase List:

[5] THIN OSB PANELS
11mm x 120cm x 240 cm (7/16in x 48in x 96in)

[8] 2X4 BEAMS
5 x 10 x 240cm (2 x 4 x 96in)

Cut List:

A [5] TALL REAR PANELS THIN OSB
11mm 90cm x 240 cm (7/16in x 36in x 96in)

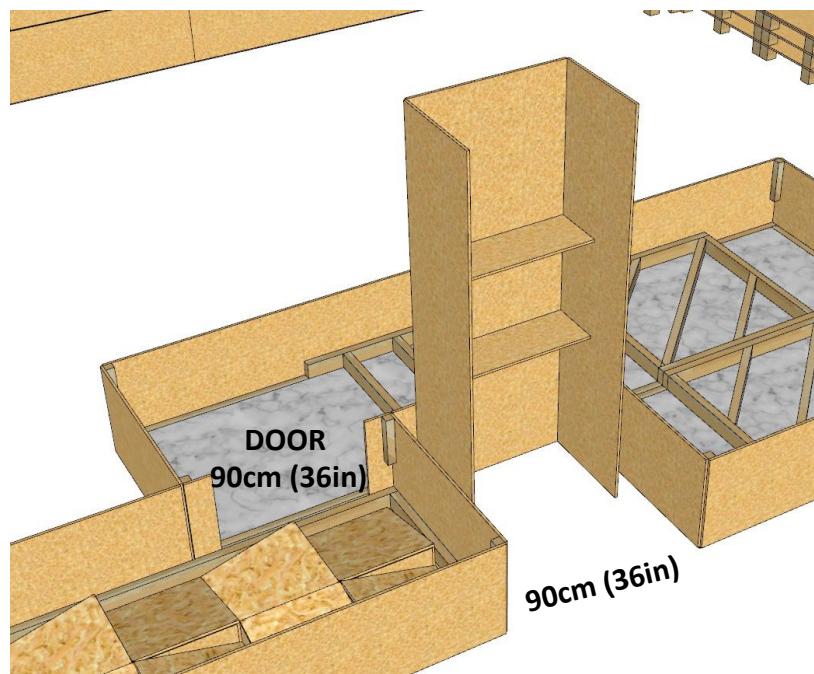
B [10] TALL SIDE PANELS THIN OSB
11mm 60cm x 240 cm (7/16in x 24in x 96in)

B [30] SUPPORT BEAMS
5 x 10 x 90cm (2 x 4 x 36in)

FASTENERS:

[30] WASHER HEAD TORX SCREWS
75mm (1-1/2in) through the OSB panel into the lumber frame on all sides (8 screws per pane). The WASHER HEADS keep the screw from penetrating.

These self-standing operator stations provide a tall wall to block views of the robot in the lane. They have half depth shelves for the robot controls at standing level. They fit in the space near the doorway. They can also be set up in open space back.



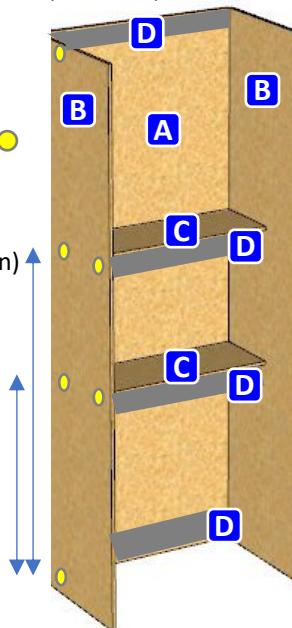
Pre-assemble 4 horizontal support beams onto the REAR PANEL at the locations shown. Leave them affixed for transport to guide assembly on site. When disassembling, leave those 4 SUPPORT BEAMS in place. The side walls are the same as lane side walls.

REAR WALL – THIN OSB
90 x 240cm (36 x 96in)

SCREW LOCATIONS

150cm (60in)

90cm (36in)



SIDE WALLS – THIN OSB
60 x 240cm (24 x 96in)

SHELVES – THIN OSB
30 x 90cm (12 x 36in)
WITH 5x10x90cm (2x4x36in) BEAMS
SUPPORTING THE FRONT AND REAR
EDGES

TOP/BOTTOM CONNECTOR BEAMS
5x10x90cm (2x4x36in) WITH



PRE-CUT 60 CRATES (Plus 40 not cut)

- These stack to travel on a pallet contained with surrounding walls like the Ramps.

A – [1] xxxxx

xxxxx

xxxxx

xxxxx

B – [1] xxxxx

xxxxx

xxxxx

xxxxx

C – [1] xxxxx

xxxxx

xxxxx

xxxxx

FASTENERS:

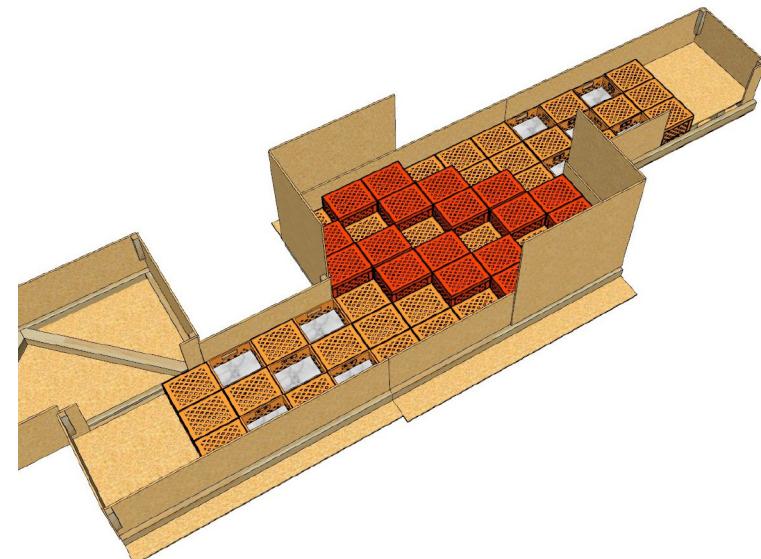
[#####] WASHER HEAD SCREWS
TORX 75mm (1-1/2in)

Crate Stepfield

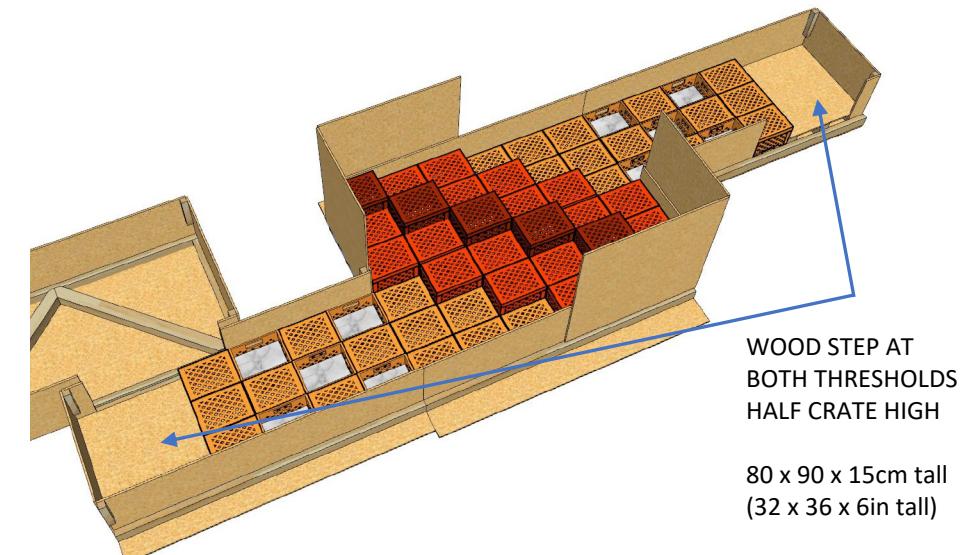
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These reconfigurable lanes have many options. The two presented enable very quick transition from one to the other with a big difference in difficulty. The diagonal stacks (lightest color) can be dropped into the Gap to increase the terrain complexity. The hallways on both sides can be flipped to alternating negative obstacles or holes as well.

DIAGONAL GAP



DIAGONAL HILL



Note: The bottom layer are 51 crates cut in half to be 15cm (6in) tall. The second layer on both sides of the GAP/HILL are full crates at 30cm (12in) tall. The GAP is filled with cut crates to hold the positions with the open side up to make it a deep GAP. Then a full crate can be placed inside the gap to protrude up another 15cm (6in) as the HILL.

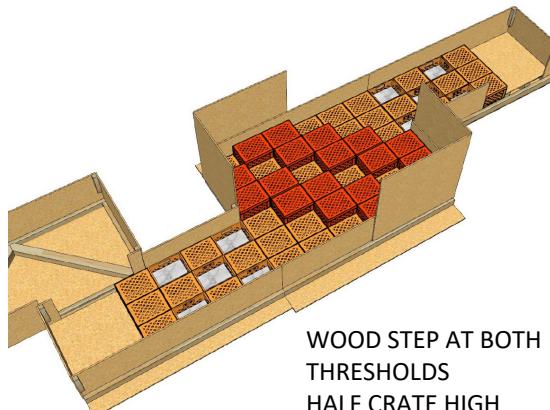


PRE-CUT 20 CRATES IN HALF

- These stack to travel on a pallet contained with surrounding walls like the Ramps.
- Fabricate STEPS at both ends to fill the space 60

CRATES MUST BE 30cm (6in) TALL
AND STURDY ENOUGH FOR TWO
TO CARRY A ROBOT OFF

[EXAMPLE CRATES HERE](#)



WOOD STEP AT BOTH
THRESHOLDS
HALF CRATE HIGH

80 x 90 x 15cm tall
(32 x 36 x 6in tall)

Crate Stepfield

ICRA Autonomous Quadruped Robot Challenge

These reconfigurable lanes have many options. The two presented enable very quick transition from one to the other with a big difference in difficulty. The room diagonal can be replaced with a two crate stack to increase the terrain complexity to the diagonal HILL. The hallways on both sides can have alternating flipped crates as negative obstacles (holes) half-filled with foam as well.

EASIER CONFIGURATION – DIAGONAL GAP



CRATE STEP
1 HIGH
HEIGHT 30cm (6in)
WIDTH 30cm (6in)
LENGTH 40cm (16in)

CRATE STEP
1.5 HIGH
CUT BOTTOM CRATE IN HALF
STACK & STRAP TOGETHER

CRATE HOLE
0.5 HIGH
0.5
CRATE UPSIDE DOWN
FOAM FILLER

WOOD STEP AT
THRESHOLD
HALF CRATE HIGH
80x90x15cm tall
(32x36x6in tall)
0.5

Note: Add a 15cm (6in) wood step threshold to get robots onto a full crate level in hallways. Cut crates in half and stack and strap them together to form the 1.5 crate height. Stack and strap two full crates together vertically to get 2 crate heights. This requires 18 crates cut in half. And 24 straps to attach crates vertically.

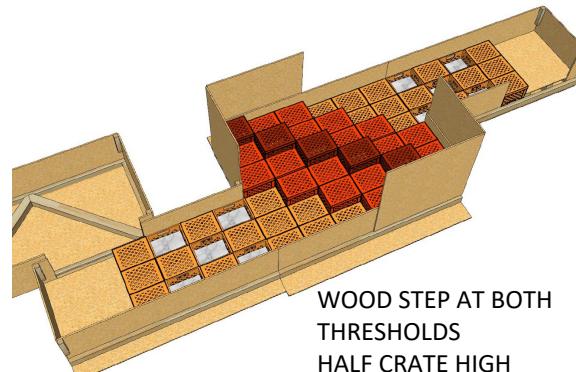


PRE-CUT 20 CRATES IN HALF

- These stack to travel on a pallet contained with surrounding walls like the Ramps.

CRATES MUST BE 30cm (6in) TALL
AND STURDY ENOUGH FOR TWO
TO CARRY A ROBOT OFF

[EXAMPLE CRATES HERE](#)



WOOD STEP AT BOTH
THRESHOLDS
HALF CRATE HIGH

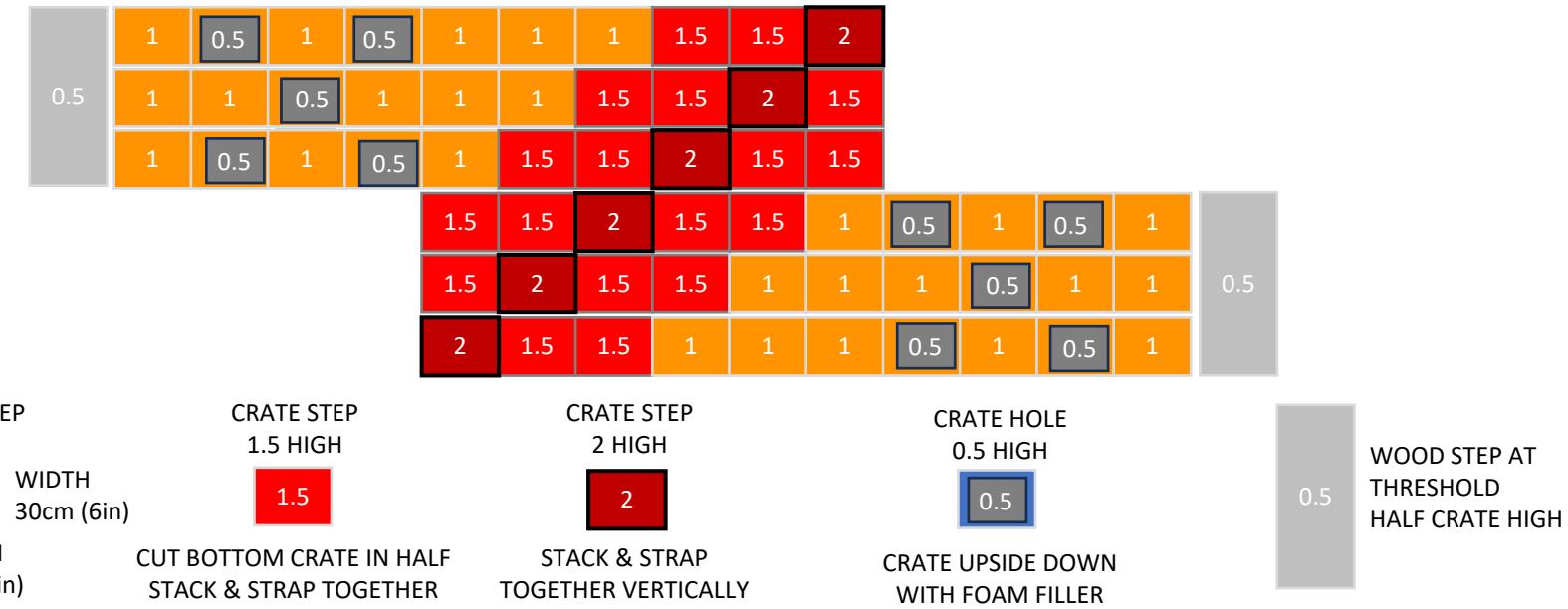
80 x 90 x 15cm tall
(32 x 36 x 6in tall)

Crate Stepfield

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These reconfigurable lanes have many options. The two presented enable very quick transition from one to the other with a big difference in difficulty. The room diagonal can be replaced with a two crate stack to increase the terrain complexity to the diagonal HILL. The hallways on both sides can have alternating flipped crates as negative obstacles (holes) half-filled with foam as well.

HARDER CONFIGURATION – DIAGONAL HILL



Note: Add a 15cm (6in) wood step threshold to get robots onto a full crate level in hallways. To make 1.5 height stacks, cut a crate in half and strap it to the BOTTOM of a full crate. Stack and strap two full crates together vertically to get 2 crate heights. This requires 18 crates cut in half. And 24 straps to attach crates vertically.



Packaging for Transportation

ICRA Autonomous Quadruped Robot Challenge

TO MAKE #### TOTAL:

- Use our fabricated PALLETS WITH PIPE STEPS as the basic forkliftable unit of storage and transport.
- The lane walls are useful for containing items within the pallet. Just attached the walls resting on the floor to the legs of the pallet on THREE SIDES.
- This allows for quick throwing of Ramps, Crates, and other items into a box when clearing the arena from the site.
- We use team members to help disassemble and stow so the organizational receipts need to be very easy for them to get our times stowed properly so we don't need to touch them again.

