

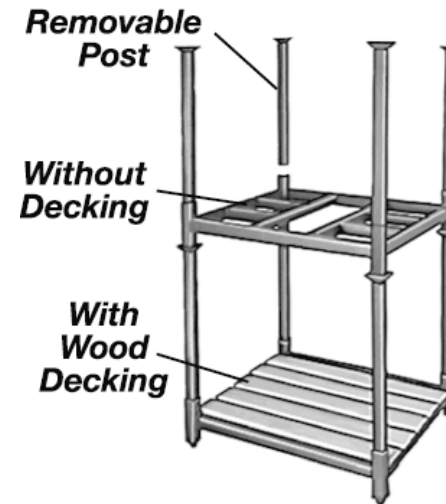
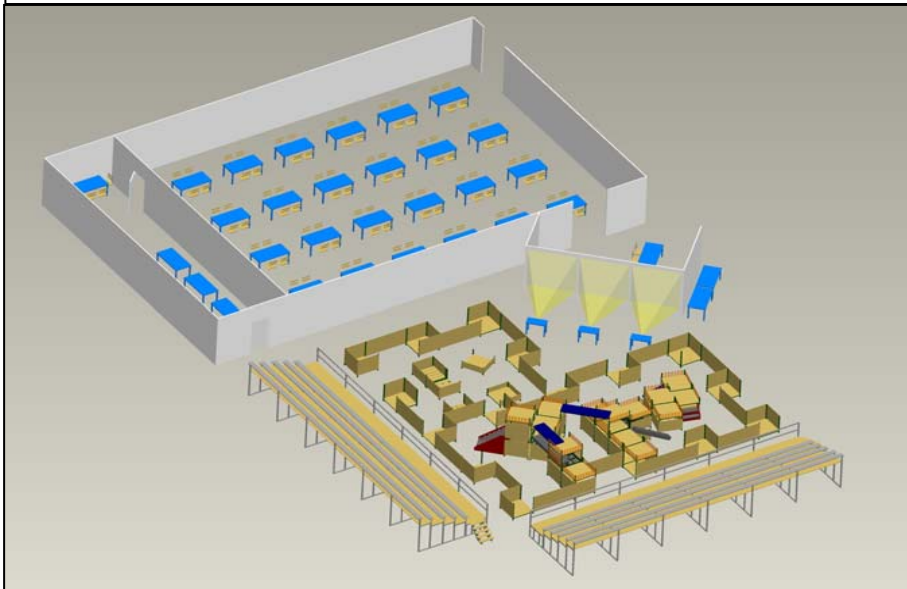
REFERENCE TEST ARENAS FOR URBAN SEARCH AND RESCUE ROBOTS

NIST

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



RESCUE ROBOT LEAGUE ARENA CONFIGURATION BASED ON PALLET-STYLE STACKING RACKS



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TEAM SETUP AREA

- (24) LARGE TABLES WITH CHAIRS
- POWER / INTERNET AT EVERY TABLE
- ORGANIZERS MAY SHAPE ROOM AS NECESSARY

ADMIN SETUP AREA

- (4) LARGE TABLES WITH CHAIRS
- POWER / INTERNET AT EVERY TABLE
- LOCKABLE DOORS TO ARENAS AND TEAM SETUP AREA
- ORGANIZERS MAY SHAPE ROOM AS NECESSARY

MAIN TEAM ENTRANCE TO SETUP AREA

- NO VISIBILITY TO ARENAS
- DOORWAY > 2m WIDE FOR SHIPPING CRATES

TEAM ACCESS TO OPERATOR STATION

- NO VISIBILITY TO ARENAS
- DOORWAY > 2m WIDE

OPERATOR STATION (8m x 4m)

- (7) TABLES WITH CHAIRS
- (2) TRANSFORMERS (15A @ 110V)
- (1) COLOR USB PRINTER/DRIVER
- (1) ALARM CLOCK

MULTIMEDIA DISPLAY

- (3) PROJECTORS
- (3) SCREENS
- (3) SMALL TABLES

OPERATOR INTERFACE

ROBOT TRACKING SYSTEM

ROBOT VIDEO and SIMULATION

YELLOW ARENA

RED ARENA

ORANGE ARENA

BLEACHERS (>1M ABOVE FLOOR)

BLEACHERS (>1M ABOVE FLOOR)

16m

16m

LOCKABLE DOORS

POWER FOR ARENAS AND OPERATORS

- SHOWS LOCATION FOR SEPARATE A/C POWER CIRCUITS (LOCAL STANDARD)



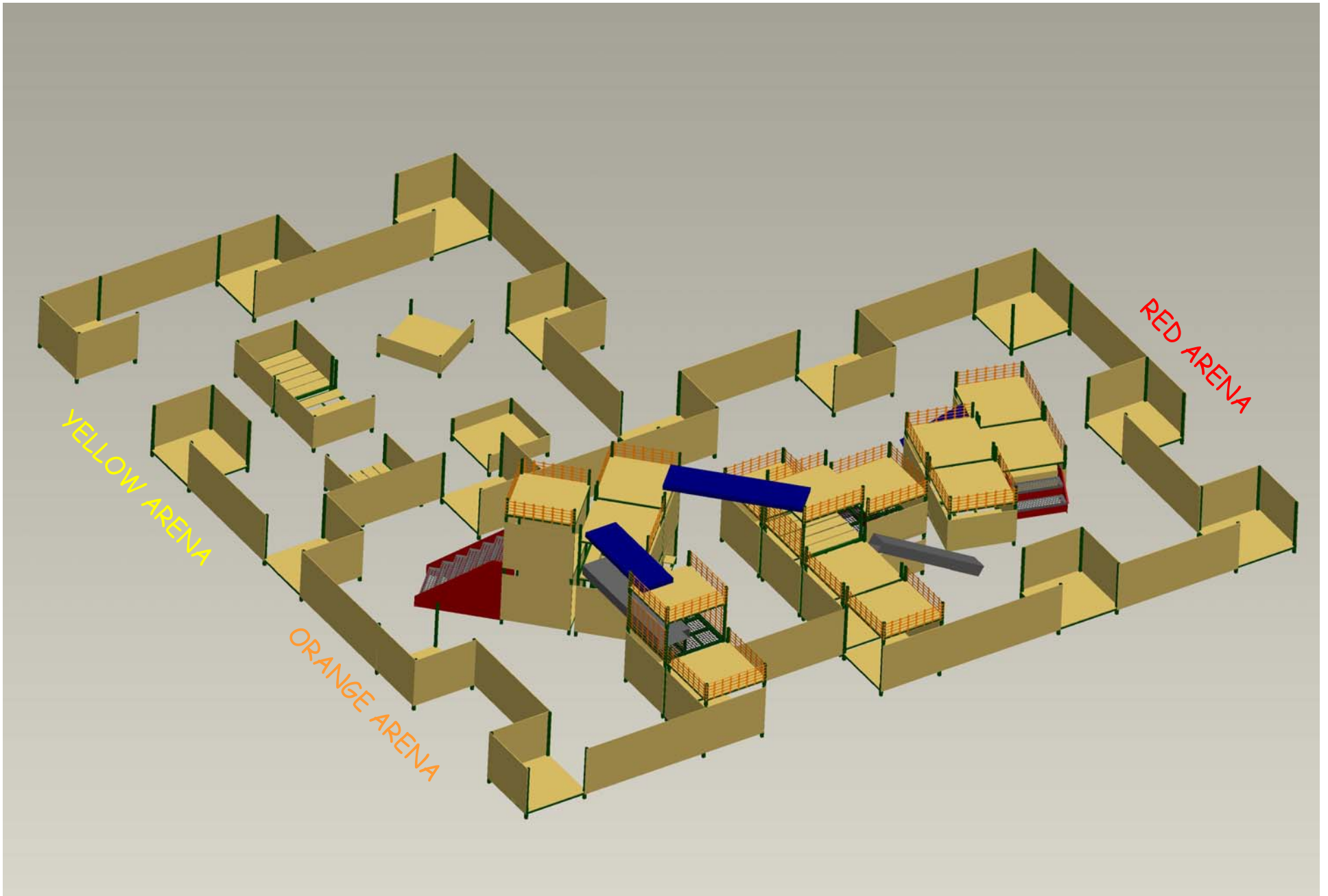
REFERENCE TEST ARENAS

FOR

URBAN SEARCH AND RESCUE ROBOTS

OVERALL LAYOUT MODEL VIEW





REFERENCE TEST ARENAS
FOR
URBAN SEARCH AND RESCUE ROBOTS

ARENAS -
MODEL VIEW

NIST



PALLET-STYLE STACKING RACK

These are purchasable items used in warehouse storage facilities. So they should be available from many sources in Europe at reasonable prices (although sizes may vary).

Assemblies include:

- **RACK FRAMES W/DECKING** (square size w/wood planks)
- **REMOVABLE POSTS** (assorted lengths)
- **ADDITIONAL DECKING** (plywood, metal, other)
- **PANELS** (assorted sizes of plywood)
- **CABLE TIES** (also known as ZIP TIES)

For example:

We purchased from McMaster-Carr Supply Company, a huge supplier of all kinds of industrial products

[<http://www.mcmaster.com/> search on "stacking rack"]

48" x 48", with 36" tall posts, with decking, 2000lb capacity = \$156 USD each

We ordered other post heights (24" and 12") from the manufacturer, Jarke.

[http://www.jarke.com/products/modular_port_stack/airector/specifications/airp1.htm]

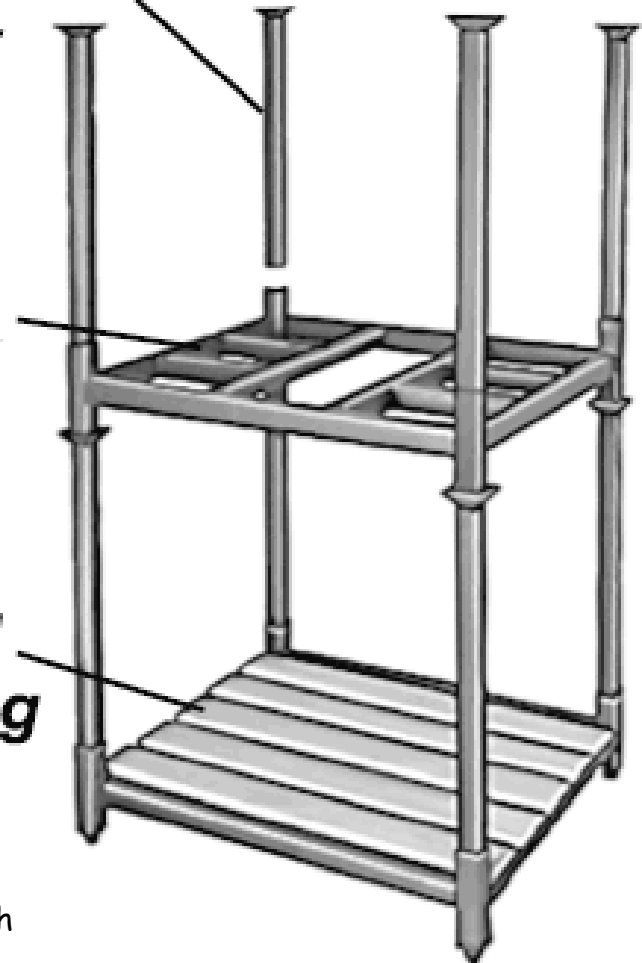
For international sales, Grainger sells to Europe, Asia, Africa, and South America]

[<http://www.grainger.com/> search on "stacking rack"]

**Removable
Post**

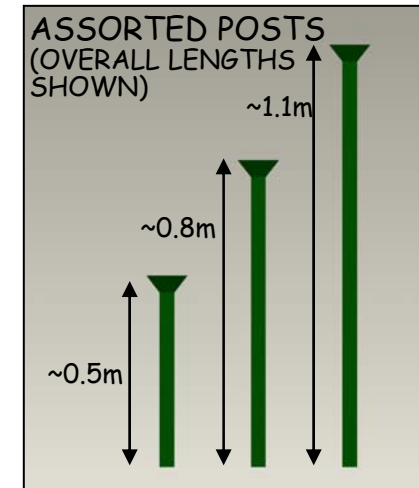
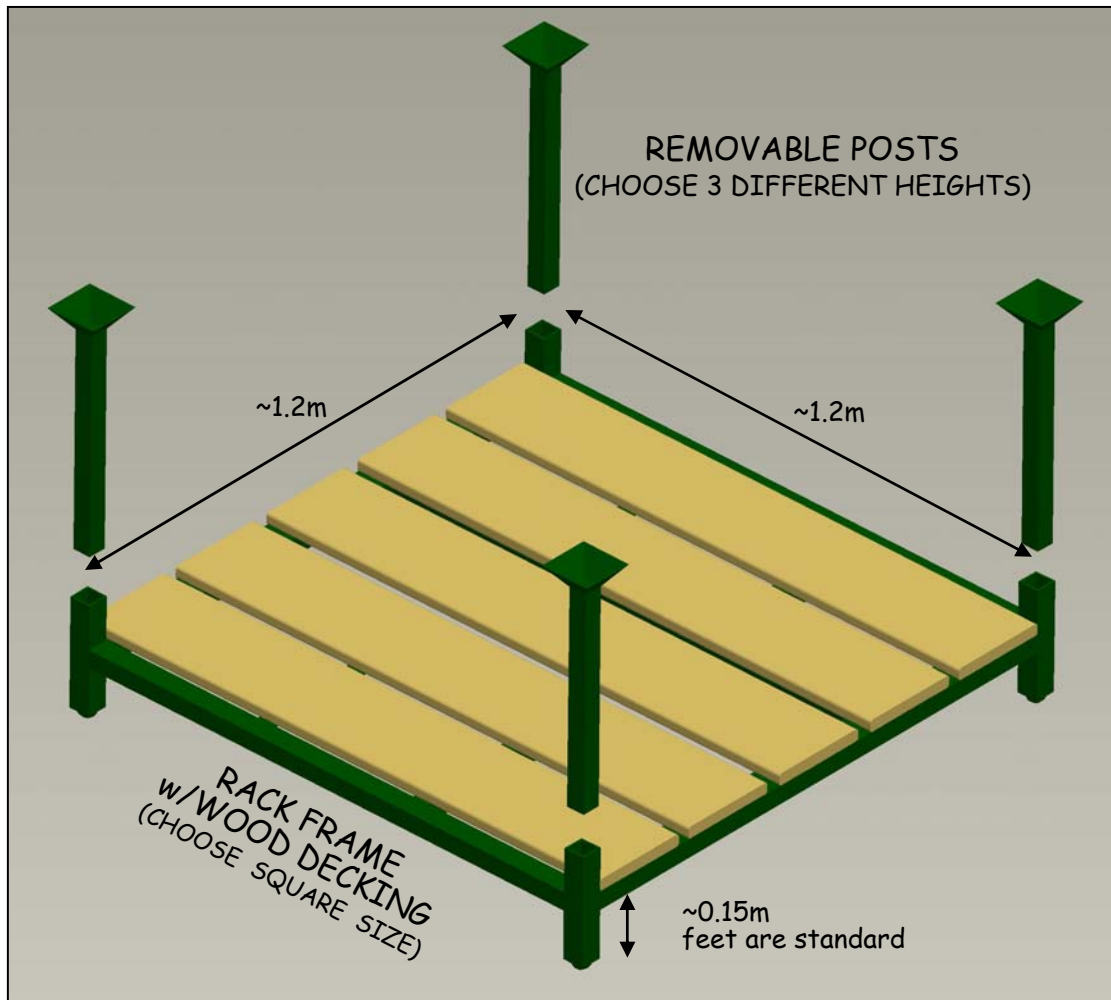
**Without
Decking**

**With
Wood
Decking**



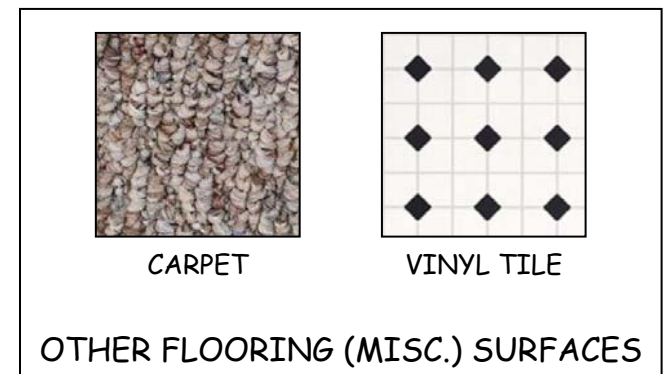
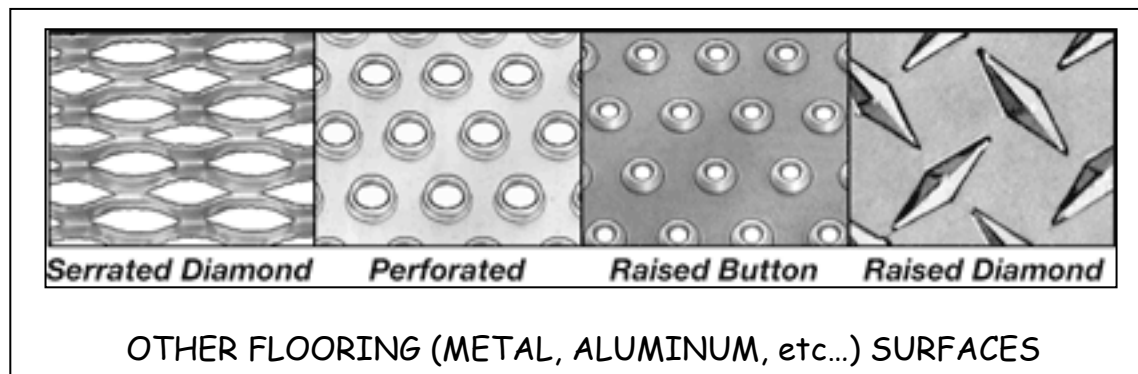
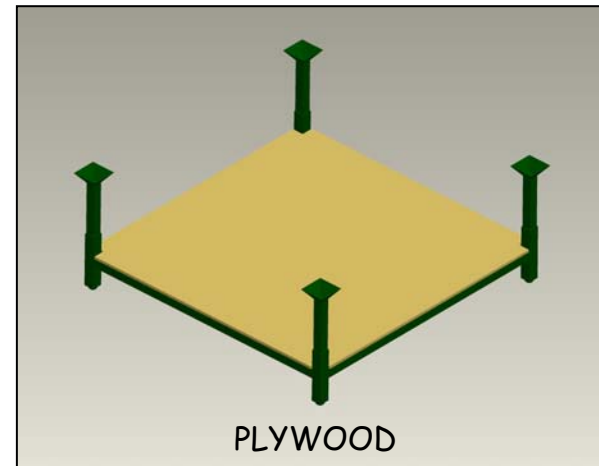
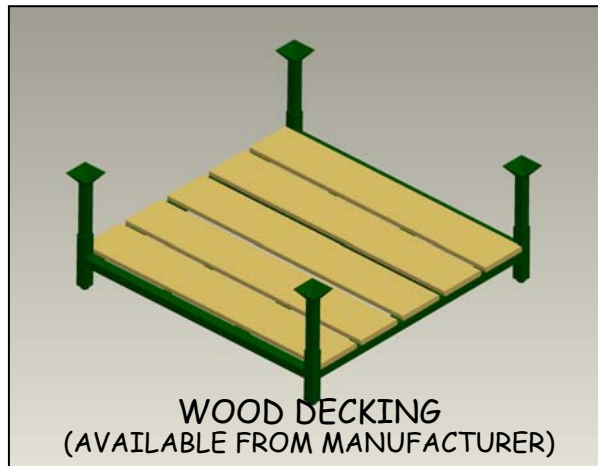
- RACK FRAMES are fork lift-able from all sides due to standard feet
- RACK FRAMES are rated for >1000kg (much more than required)
- RACK FRAMES **should** be purchased with WOOD DECKING
- REMOVABLE POSTS (assorted heights) fit into frames for easy setup
- If specific POST heights are not available, purchase larger sizes and cut to length

STACKING RACKS			
√	PART #	PART (DESCRIPTION)	QUANTITY
	1	Stacking Rack: Rack (~ 1.2m x ~ 1.2m) w/Wood Decking	60 frames w/decking
	2	Stacking Rack: Posts (~ 1.1m height)	112 (~ 1.1m) posts
	3	Stacking Rack: Posts (~ 0.8m height)	56 (~ 0.8m) posts
	4	Stacking Rack: Posts (~ 0.5m height)	80 (~ 0.5m) posts



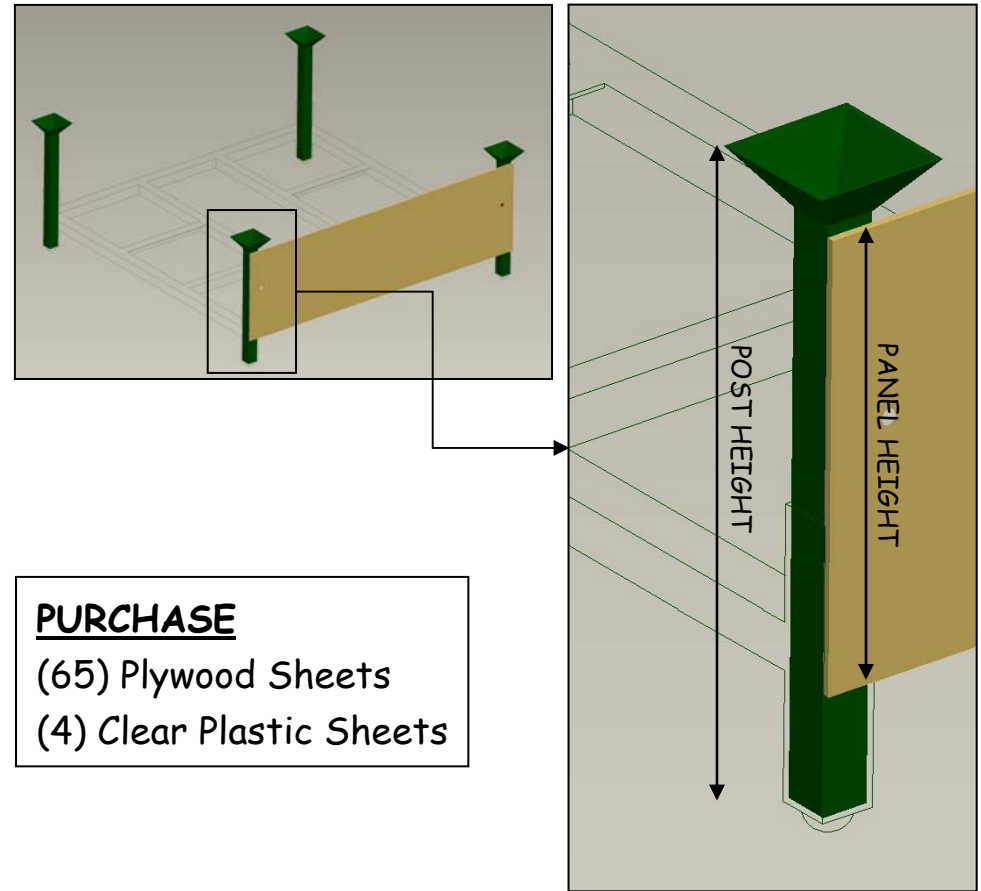
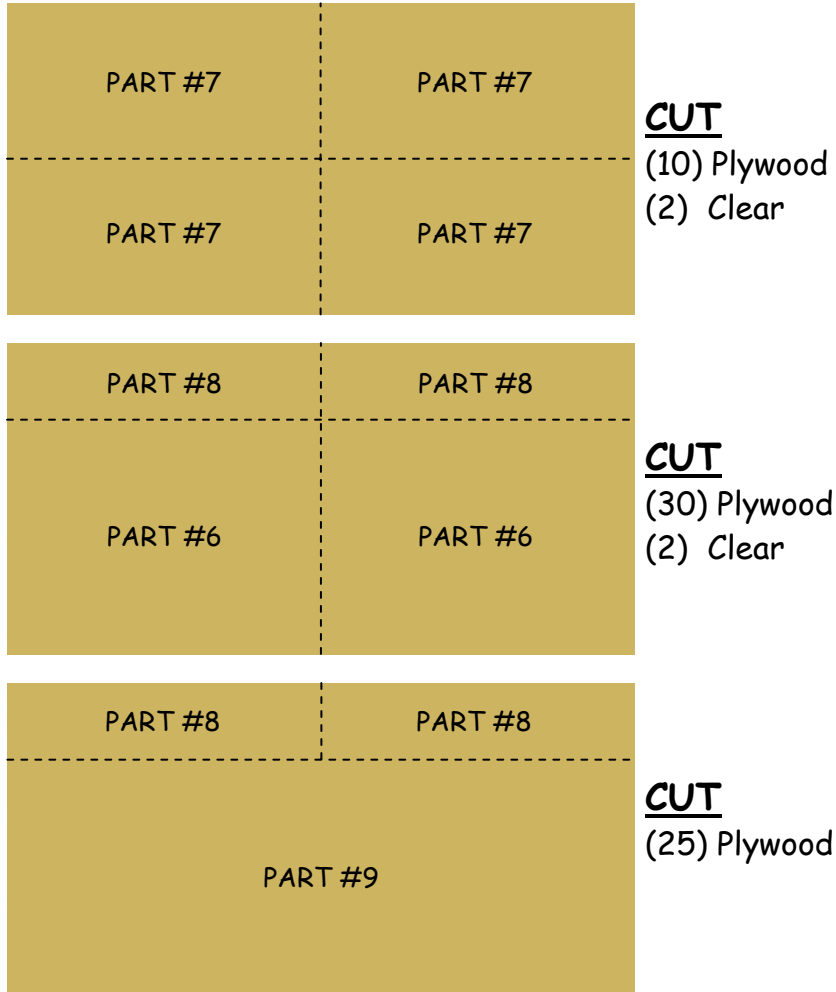
- Additional Assorted DECKING surfaces should be purchased (see below) from the manufacturer (vary according to selection)
- Simple >12mm plywood, cut to fit, can be used
- Other local flooring surfaces may also be used (carpet, tile, metal, etc.)
- Quantity of additional surfaces will increase if RACK FRAMES w/WOOD DECKING are unavailable
- WOOD DECKING should **not** cover post holes

ADDITIONAL DECKING			
✓	PART #	PART (DESCRIPTION)	QUANTITY
	5	Decking: Various Surfaces - (plywood, tile, carpet, metal, etc.)	15 surfaces

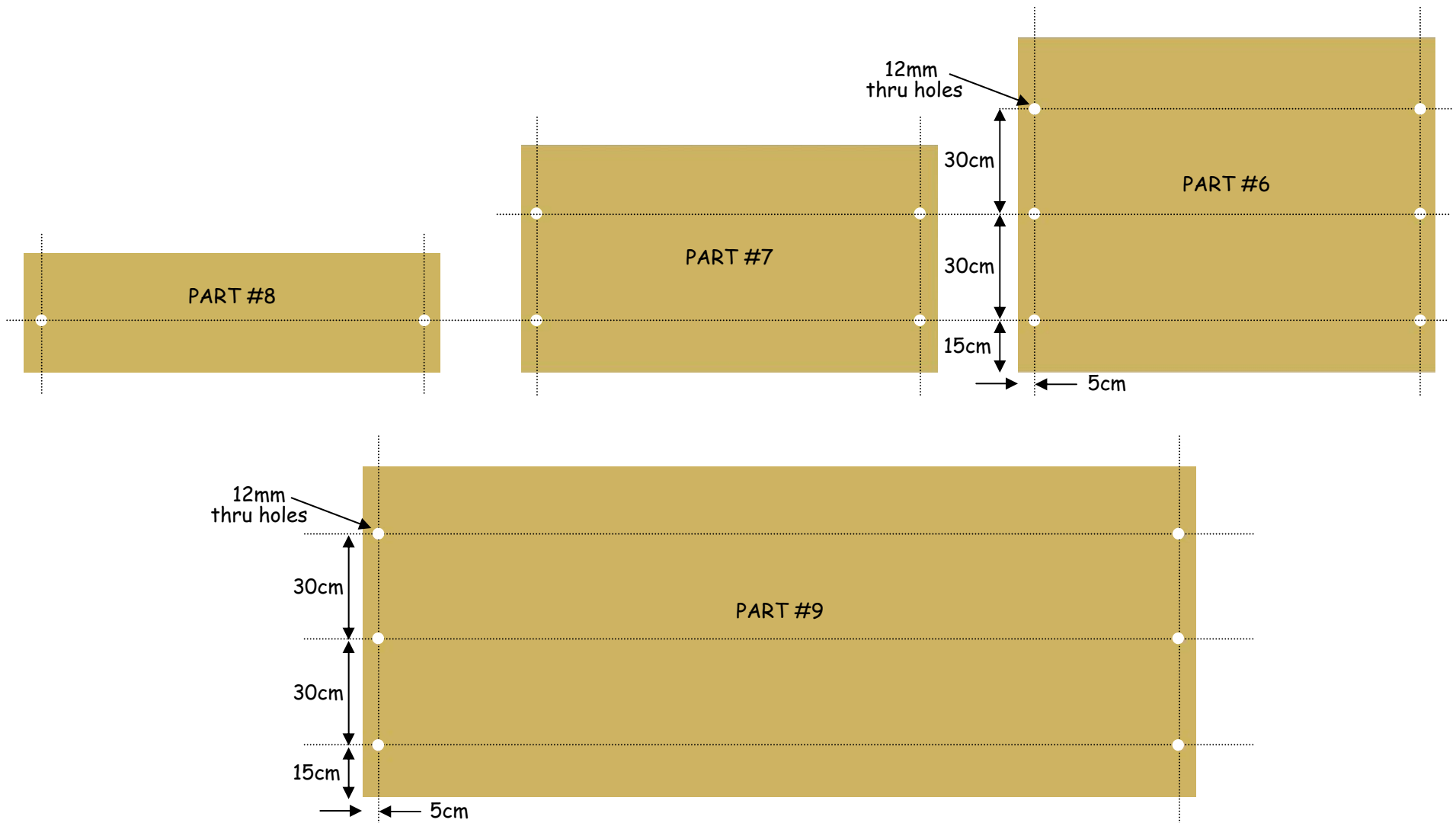


- PANELS widths should be cut to fit RACK FRAME widths/lengths
- PANEL height is from the bottom of the RACK FRAME to just under POST top guide
- PANELS should be cut from 2.4m x 1.2m x ~3mm plywood sheets and clear plastic sheets
- All PANELS may be plywood if clear plastic is unavailable

PANELS					
√	PART #	PART (DESCRIPTION)	LENGTH	WIDTH	QUANTITY
	6	Panels: 1.2x0.9	1.2m	0.9m	64 panels
	7	Panels: 1.2x0.6	1.2m	0.6m	48 panels
	8	Panels: 1.2x0.3	1.2m	0.3m	114 panels
	9	Panels: 2.4x0.9	2.4m	0.9m	25 panels



- PANEL holes are dimensioned so that different sized panels can be attached to one another
- PANEL holes are symmetric about each PANEL

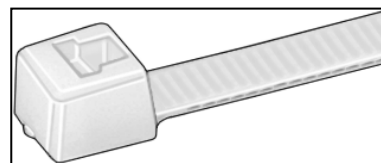
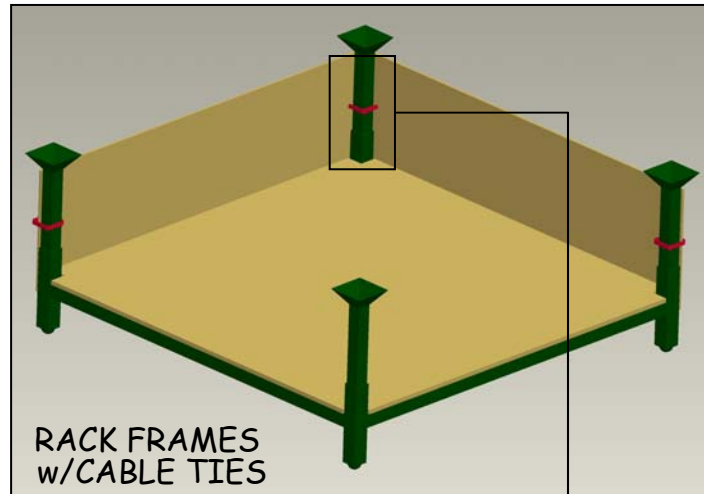


- PANELS are connected to the REMOVABLE POSTS using standard nylon CABLE TIES (~8mm width x >250mm length)
- A maximum of 4 CABLE TIES should be used to connect each PANEL (unless you are connecting a 0.6m tall PANEL to a 0.9m tall PANEL)

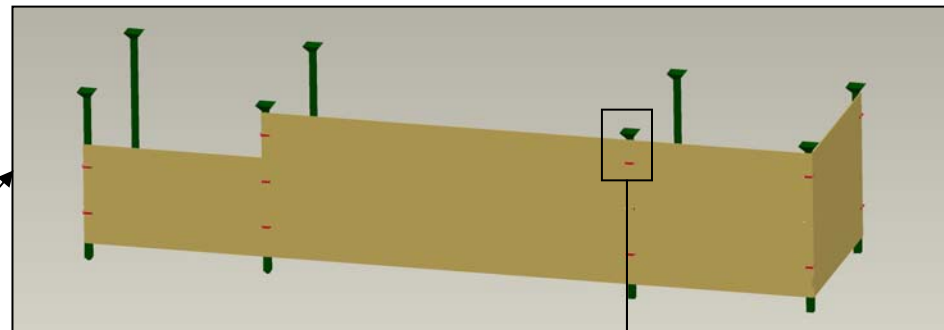
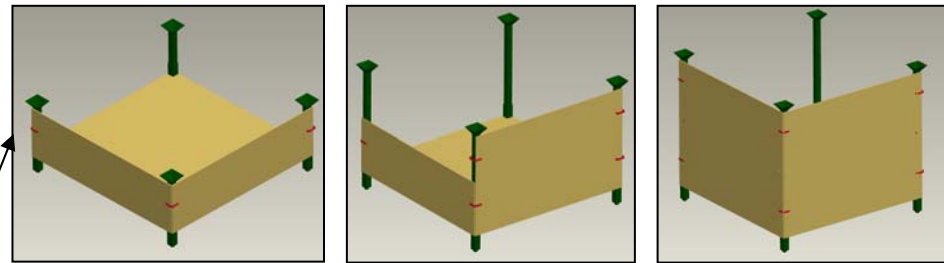
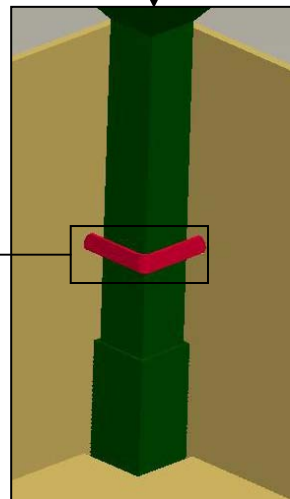
CABLE TIES

✓	PART #	PART (DESCRIPTION)	QUANTITY
	10	Cable Ties: Standard Nylon, ~8mm width x >250mm length	800 cable ties

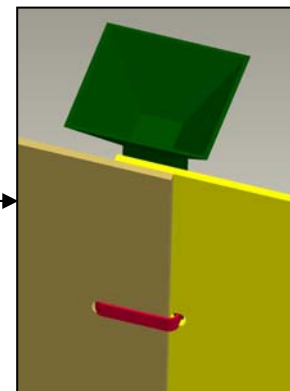
NOTE: CABLE TIES are also known as ZIP TIES

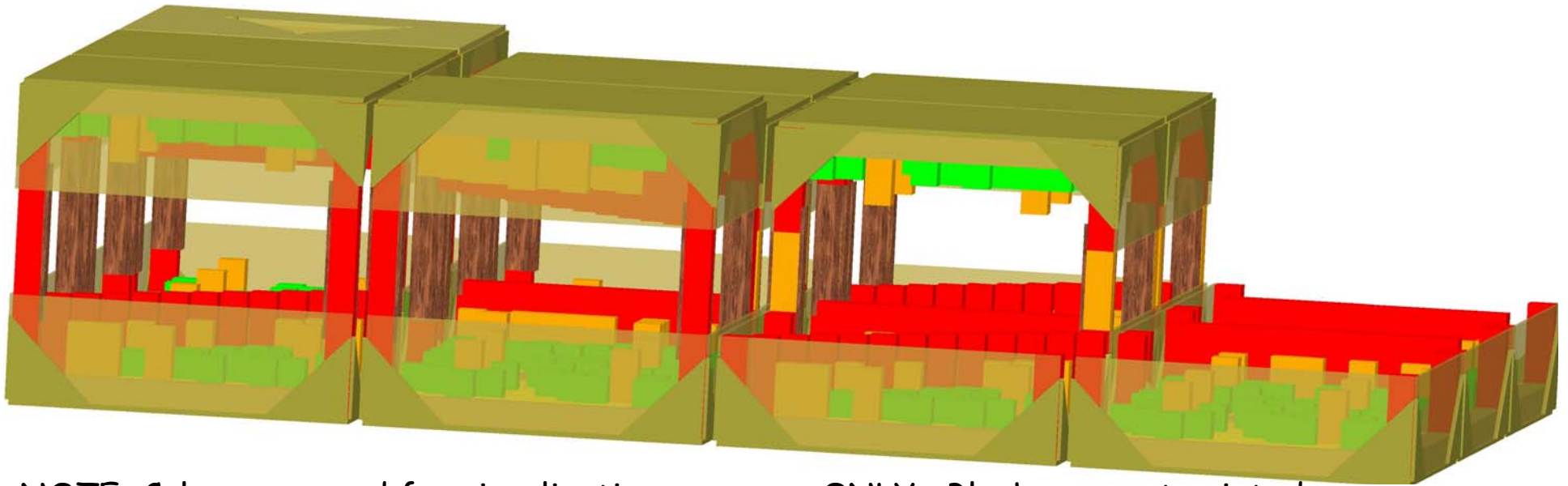


CABLE TIE



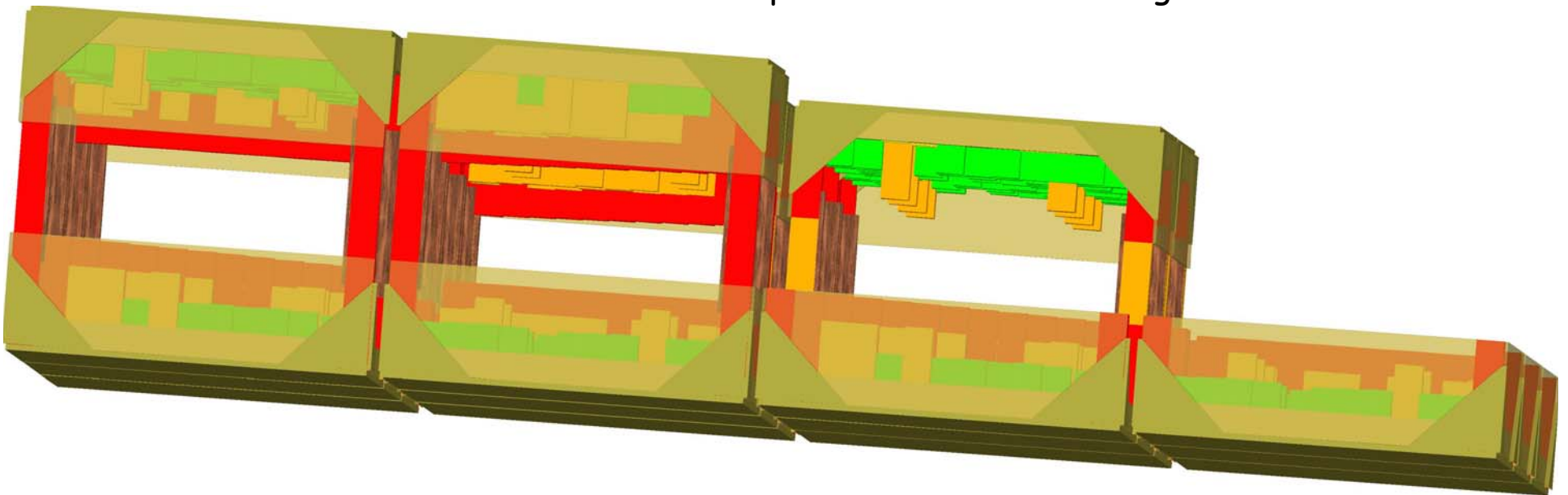
NOTE: PANELS will be overlapped on one another when connecting adjacent walls, but the PANEL HOLES do not interfere with each other. (PANELS are colored differently to highlight overlap)





NOTE: Colors are used for visualization purposes ONLY. Blocks are not painted

NOTE: Walls are transparent for easier viewing

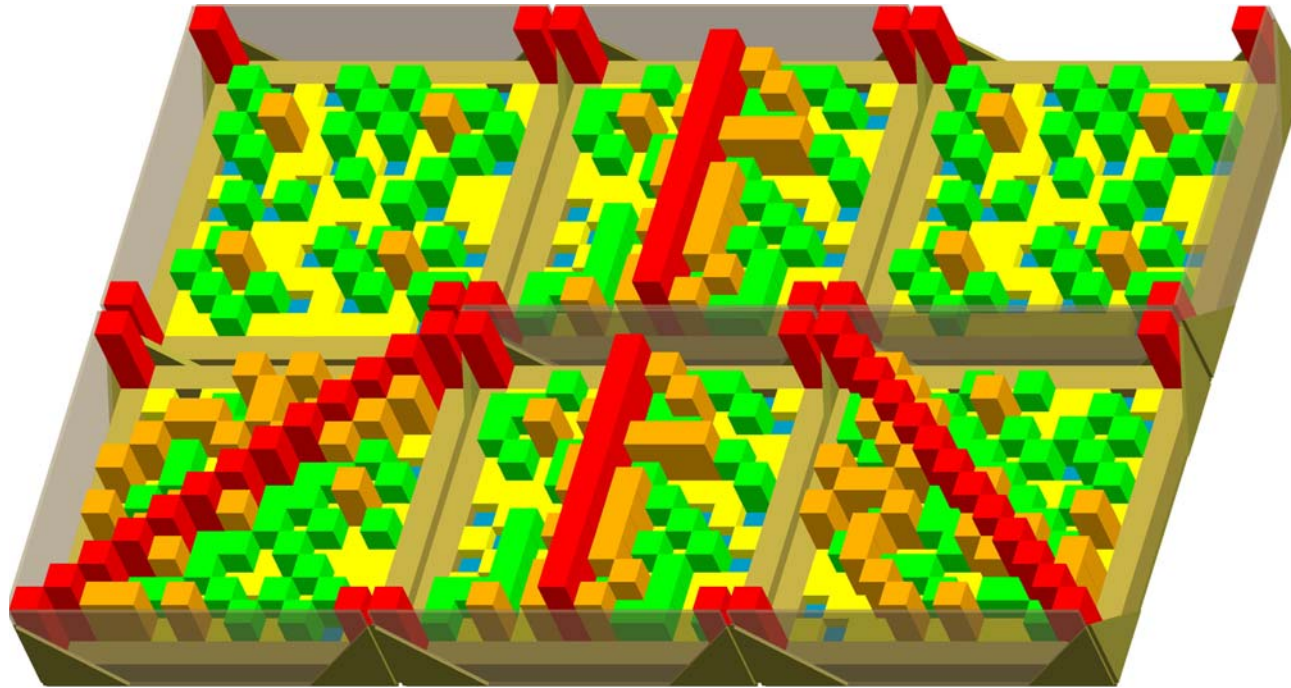


REFERENCE TEST ARENAS
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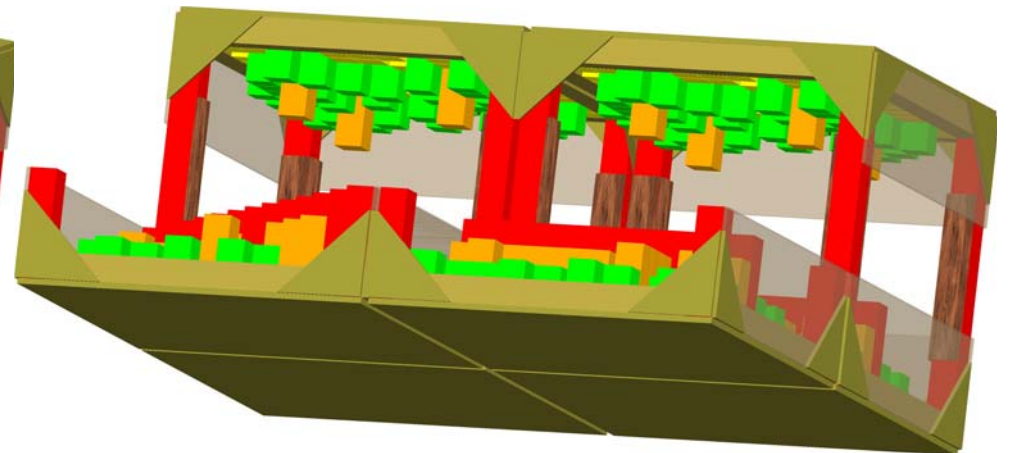
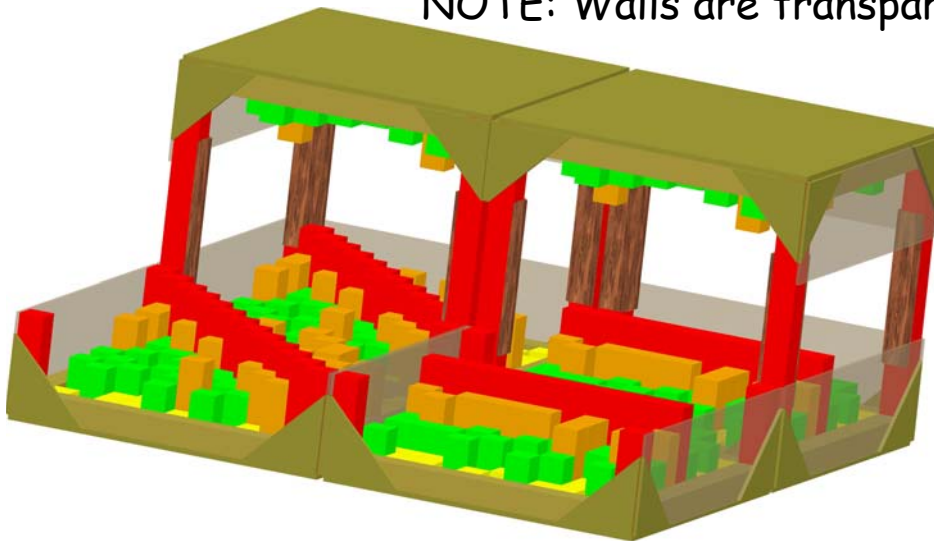
RANDOM STEP FIELDS

NIST





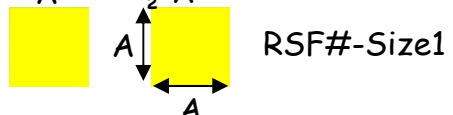
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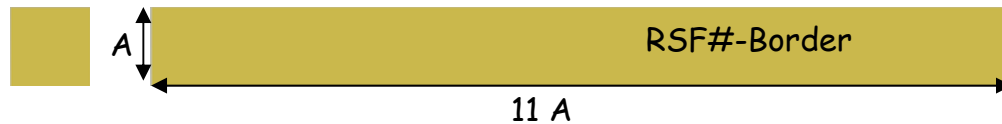
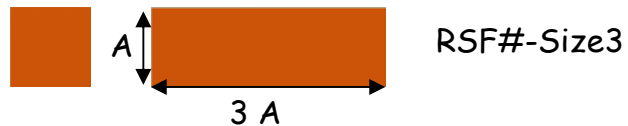
Material: AxA Lumber

Suggested size:
A ~ 3.5" or 90 mm



Note: DO NOT use pressure treated lumber if storing or using fields indoors

Note: RSF# indicates parts to be used in the Random Step Fields



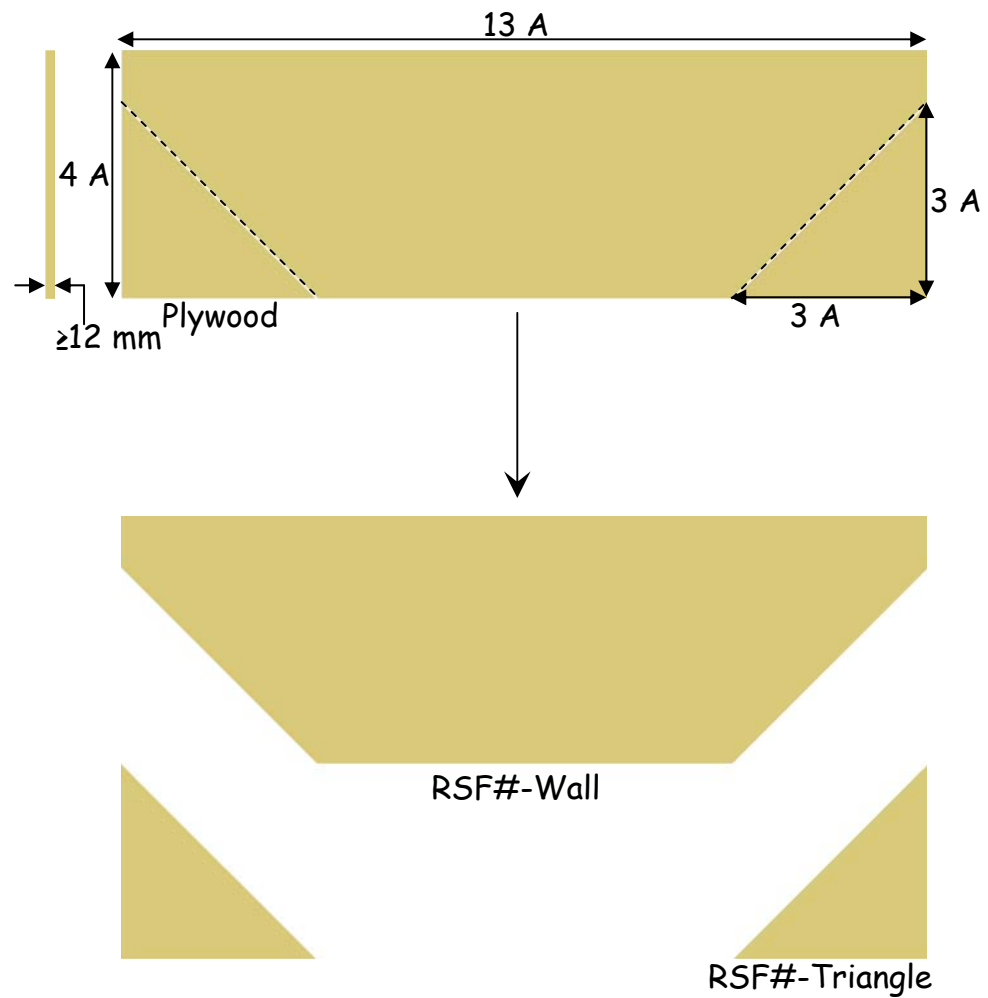
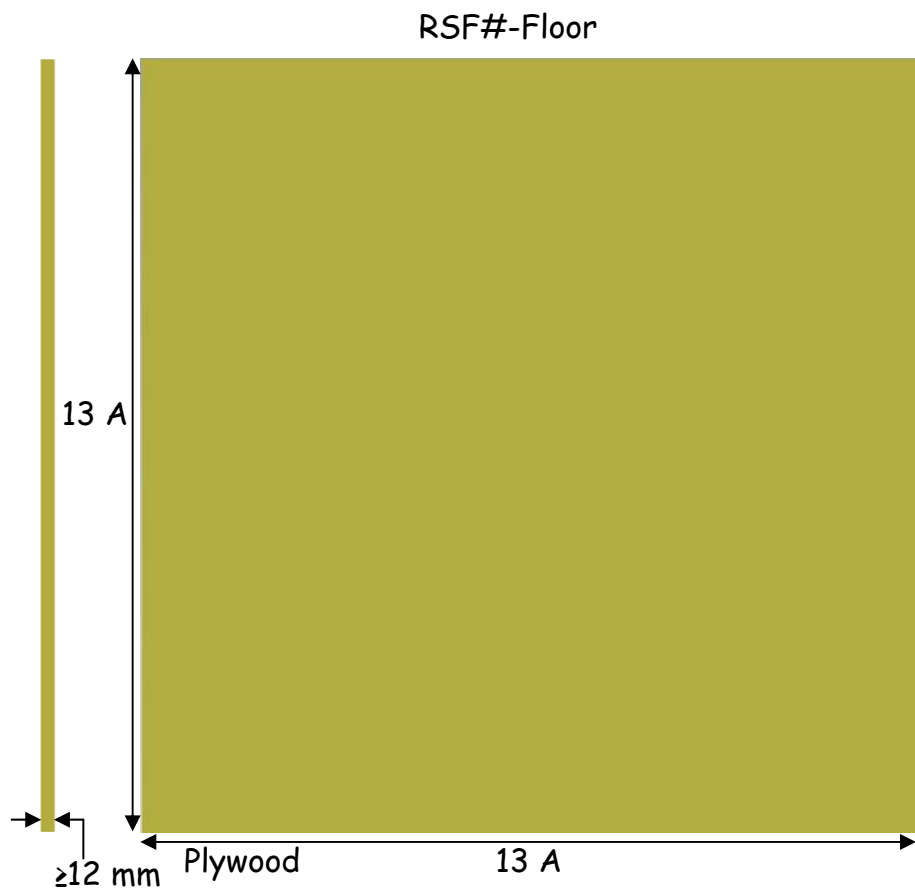
Material: ≥12mm plywood



<http://www.shepherdhardware.com/Pages/Catalog/dollies.html>



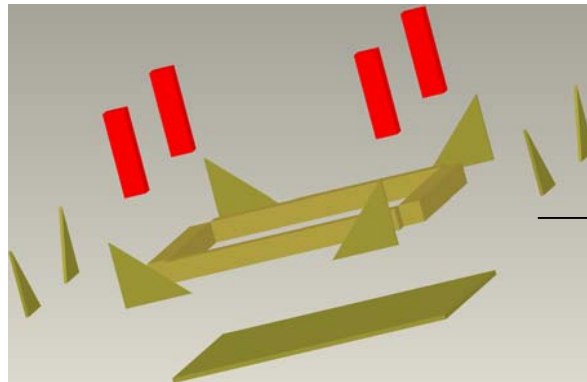
Caster, place 4 beneath a field to make it more portable



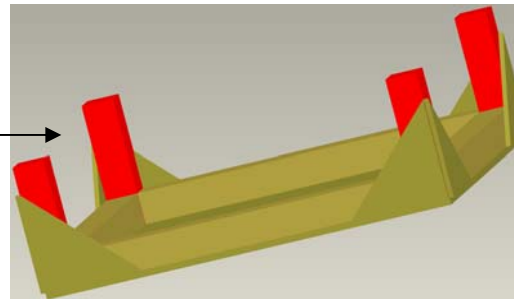
NOTE: Efficient assembly requires at least 2 people

Required Components:

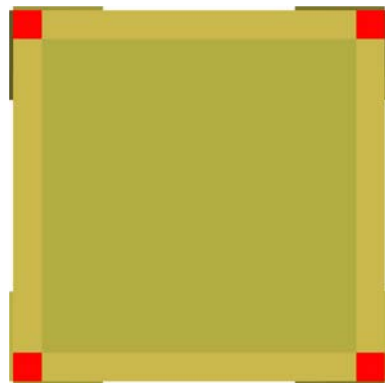
- 1 x RSF#-Floor
- 4 x RSF#-Border
- 4 x RSF#-Size4
- 8 x RSF#-Triangle



Exploded View



Assembled View



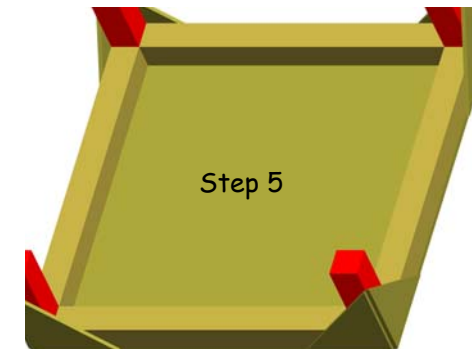
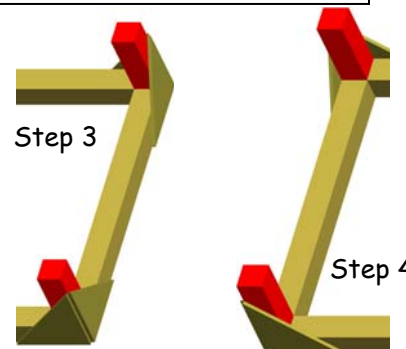
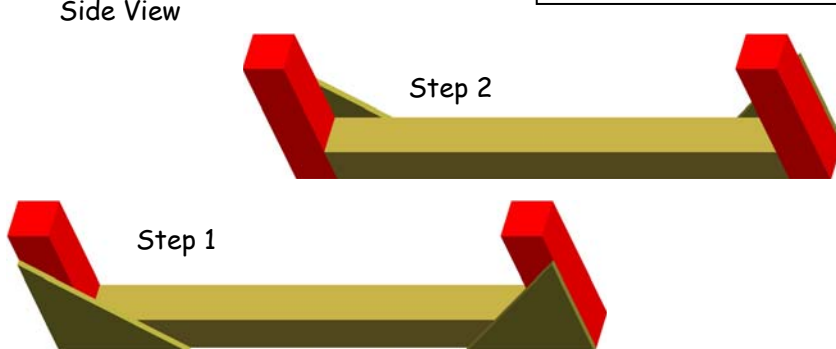
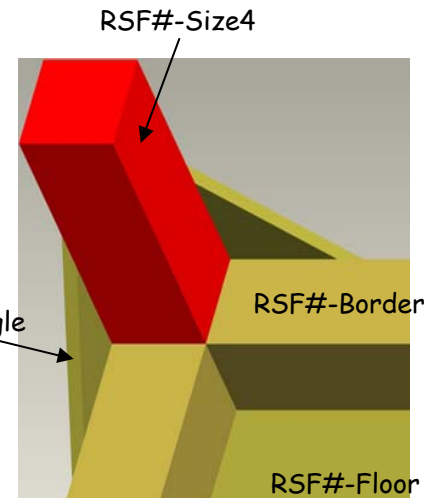
Top View



Side View

Assembly Instructions:

1. Assemble 1 RSF#-Border with 2 RSF#-Size4 and 2 RSF#-Triangle to make one side. Attach with 5 screws on each triangle.
2. Repeat step 1 to make a second side.
3. Use 2 RSF#-Triangle to attach another RSF#-Border.
4. Repeat step 3 to attach the fourth side.
5. Attach the RSF#-Floor. (Screw through RSF#-Floor into RSF#-Border)



Part Name	Layout Grid	3D View	Side View																																																																																																																									
RSF#-Flat <u>Parts List</u> •26 x RSF#-Size0 •60 x RSF#-Size1 •31 x RSF#-Size2 •4 x RSF#-Size3	<table border="1"> <tr><td>2</td><td>0</td><td>0</td><td>0</td><td>0</td><td>2</td><td>0</td><td>1</td><td>0</td><td>1</td><td>1</td></tr> <tr><td>0</td><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td><td>2</td><td>2</td><td>2</td><td>2</td><td>1</td></tr> <tr><td>1</td><td>2</td><td>3</td><td>1</td><td>1</td><td>2</td><td>1</td><td>2</td><td>3</td><td>2</td><td>1</td></tr> <tr><td>2</td><td>1</td><td>1</td><td>0</td><td>1</td><td>0</td><td>0</td><td>1</td><td>1</td><td>0</td><td>0</td></tr> <tr><td>1</td><td>1</td><td>0</td><td>0</td><td>1</td><td>2</td><td>1</td><td>1</td><td>2</td><td>1</td><td>1</td></tr> <tr><td>0</td><td>0</td><td>2</td><td>2</td><td>1</td><td>1</td><td>1</td><td>0</td><td>2</td><td>1</td><td>1</td></tr> <tr><td>0</td><td>1</td><td>1</td><td>1</td><td>1</td><td>0</td><td>0</td><td>1</td><td>0</td><td>1</td><td>1</td></tr> <tr><td>1</td><td>2</td><td>1</td><td>0</td><td>1</td><td>2</td><td>0</td><td>1</td><td>1</td><td>0</td><td>2</td></tr> <tr><td>2</td><td>2</td><td>3</td><td>1</td><td>1</td><td>1</td><td>2</td><td>2</td><td>3</td><td>1</td><td>1</td></tr> <tr><td>1</td><td>1</td><td>1</td><td>2</td><td>0</td><td>1</td><td>0</td><td>2</td><td>2</td><td>1</td><td>2</td></tr> <tr><td>1</td><td>1</td><td>2</td><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td><td>0</td><td>1</td><td>1</td></tr> </table>	2	0	0	0	0	2	0	1	0	1	1	0	0	1	0	0	0	2	2	2	2	1	1	2	3	1	1	2	1	2	3	2	1	2	1	1	0	1	0	0	1	1	0	0	1	1	0	0	1	2	1	1	2	1	1	0	0	2	2	1	1	1	0	2	1	1	0	1	1	1	1	0	0	1	0	1	1	1	2	1	0	1	2	0	1	1	0	2	2	2	3	1	1	1	2	2	3	1	1	1	1	1	2	0	1	0	2	2	1	2	1	1	2	1	1	1	1	1	0	1	1		
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RSF#-Hill <u>Parts List</u> •12 x RSF#-Size0 •41 x RSF#-Size1 •38 x RSF#-Size2 •19 x RSF#-Size3 •11 X RSF#-Size4	<table border="1"> <tr><td>1</td><td>1</td><td>1</td><td>2</td><td>2</td><td>4</td><td>2</td><td>2</td><td>2</td><td>1</td><td>0</td></tr> <tr><td>2</td><td>2</td><td>1</td><td>1</td><td>3</td><td>4</td><td>3</td><td>1</td><td>3</td><td>2</td><td>1</td></tr> <tr><td>2</td><td>1</td><td>3</td><td>1</td><td>2</td><td>4</td><td>2</td><td>2</td><td>1</td><td>1</td><td>0</td></tr> <tr><td>1</td><td>1</td><td>2</td><td>2</td><td>2</td><td>4</td><td>3</td><td>3</td><td>3</td><td>1</td><td>2</td></tr> <tr><td>1</td><td>1</td><td>1</td><td>2</td><td>3</td><td>4</td><td>2</td><td>1</td><td>1</td><td>1</td><td>0</td></tr> <tr><td>0</td><td>1</td><td>1</td><td>1</td><td>3</td><td>4</td><td>3</td><td>1</td><td>0</td><td>1</td><td>2</td></tr> <tr><td>1</td><td>0</td><td>2</td><td>0</td><td>2</td><td>4</td><td>3</td><td>1</td><td>2</td><td>1</td><td>0</td></tr> <tr><td>0</td><td>1</td><td>2</td><td>1</td><td>3</td><td>4</td><td>3</td><td>1</td><td>2</td><td>1</td><td>0</td></tr> <tr><td>1</td><td>0</td><td>2</td><td>0</td><td>2</td><td>4</td><td>3</td><td>2</td><td>2</td><td>1</td><td>1</td></tr> <tr><td>2</td><td>2</td><td>2</td><td>1</td><td>3</td><td>4</td><td>2</td><td>2</td><td>2</td><td>1</td><td>1</td></tr> <tr><td>0</td><td>1</td><td>3</td><td>1</td><td>3</td><td>4</td><td>3</td><td>2</td><td>2</td><td>1</td><td>2</td></tr> </table>	1	1	1	2	2	4	2	2	2	1	0	2	2	1	1	3	4	3	1	3	2	1	2	1	3	1	2	4	2	2	1	1	0	1	1	2	2	2	4	3	3	3	1	2	1	1	1	2	3	4	2	1	1	1	0	0	1	1	1	3	4	3	1	0	1	2	1	0	2	0	2	4	3	1	2	1	0	0	1	2	1	3	4	3	1	2	1	0	1	0	2	0	2	4	3	2	2	1	1	2	2	2	1	3	4	2	2	2	1	1	0	1	3	1	3	4	3	2	2	1	2		
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0	1	3	1	3	4	3	2	2	1	2																																																																																																																		
RSF#-Diagonal <u>Parts List</u> •7 x RSF#-Size0 •43 x RSF#-Size1 •36 x RSF#-Size2 •24 x RSF#-Size3 •11 X RSF#-Size4	<table border="1"> <tr><td>1</td><td>0</td><td>1</td><td>1</td><td>3</td><td>1</td><td>1</td><td>3</td><td>1</td><td>2</td><td>4</td></tr> <tr><td>1</td><td>1</td><td>1</td><td>1</td><td>2</td><td>3</td><td>1</td><td>2</td><td>3</td><td>4</td><td>3</td></tr> <tr><td>0</td><td>1</td><td>3</td><td>3</td><td>2</td><td>3</td><td>1</td><td>3</td><td>4</td><td>3</td><td>1</td></tr> <tr><td>1</td><td>3</td><td>2</td><td>1</td><td>3</td><td>1</td><td>3</td><td>4</td><td>3</td><td>2</td><td>0</td></tr> <tr><td>3</td><td>1</td><td>1</td><td>2</td><td>2</td><td>2</td><td>4</td><td>2</td><td>2</td><td>1</td><td>1</td></tr> <tr><td>1</td><td>2</td><td>2</td><td>1</td><td>2</td><td>4</td><td>2</td><td>2</td><td>1</td><td>3</td><td>2</td></tr> <tr><td>3</td><td>1</td><td>1</td><td>3</td><td>4</td><td>3</td><td>2</td><td>1</td><td>2</td><td>1</td><td>0</td></tr> <tr><td>2</td><td>1</td><td>3</td><td>4</td><td>2</td><td>1</td><td>2</td><td>1</td><td>1</td><td>1</td><td>1</td></tr> <tr><td>1</td><td>2</td><td>4</td><td>3</td><td>2</td><td>2</td><td>1</td><td>0</td><td>0</td><td>1</td><td>1</td></tr> <tr><td>2</td><td>4</td><td>2</td><td>1</td><td>2</td><td>2</td><td>2</td><td>0</td><td>1</td><td>0</td><td>2</td></tr> <tr><td>4</td><td>3</td><td>1</td><td>1</td><td>3</td><td>1</td><td>1</td><td>1</td><td>1</td><td>0</td><td>1</td></tr> </table>	1	0	1	1	3	1	1	3	1	2	4	1	1	1	1	2	3	1	2	3	4	3	0	1	3	3	2	3	1	3	4	3	1	1	3	2	1	3	1	3	4	3	2	0	3	1	1	2	2	2	4	2	2	1	1	1	2	2	1	2	4	2	2	1	3	2	3	1	1	3	4	3	2	1	2	1	0	2	1	3	4	2	1	2	1	1	1	1	1	2	4	3	2	2	1	0	0	1	1	2	4	2	1	2	2	2	0	1	0	2	4	3	1	1	3	1	1	1	1	0	1		
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REFERENCE TEST ARENAS
FOR
URBAN SEARCH AND RESCUE ROBOTS

RANDOM STEP FIELDS
EXTRA FLAT FIELDS

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REFERENCE TEST ARENAS
FOR
URBAN SEARCH AND RESCUE ROBOTS

RANDOM STEP FIELDS
EXTRA HILL FIELDS

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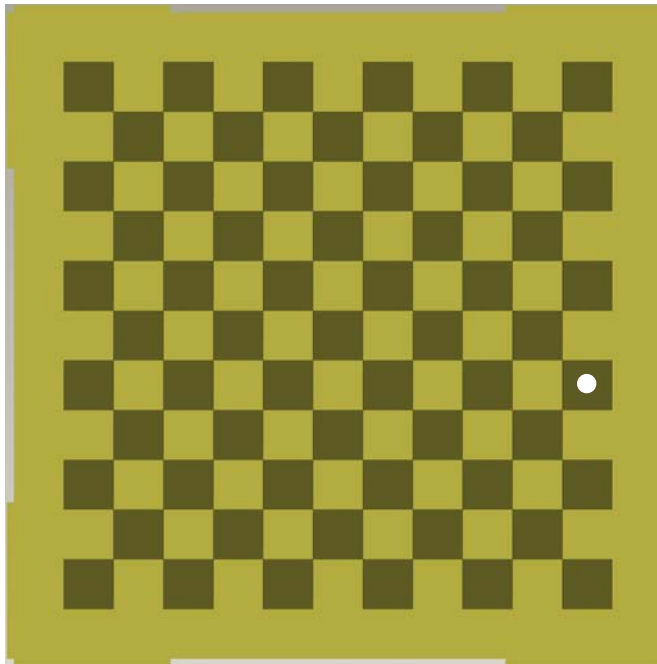
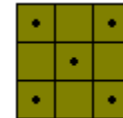
2	2	2	0	1	0	1	1	3	3	4
2	1	2	1	0	1	1	1	2	4	2
1	1	2	0	1	1	1	2	4	2	1
1	1	0	2	2	1	2	4	2	2	3
2	1	1	1	1	3	4	2	3	1	3
1	3	1	3	3	4	2	3	1	3	1
3	3	2	3	4	3	1	3	1	1	1
2	3	2	4	3	1	1	1	0	2	0
3	3	4	2	1	2	1	2	2	0	1
2	4	3	1	2	1	0	1	0	2	0
4	3	2	1	3	2	1	0	1	1	2

1	0	1	0	1	1	2	0	2	2	4
2	2	0	2	1	3	1	2	2	4	2
1	0	1	0	1	1	2	2	4	3	2
1	2	1	1	3	2	3	4	3	2	1
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2	2	1	3	3	4	3	3	1	2	2
3	1	1	2	4	2	3	1	1	1	1
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1	3	4	2	3	1	1	0	1	0	1
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4	2	1	2	1	1	2	1	1	0	2

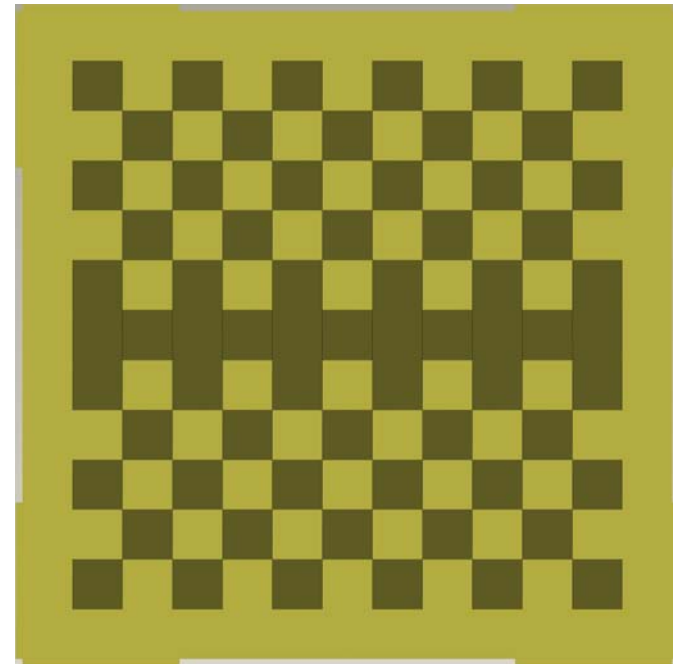
REFERENCE TEST ARENAS
FOR
URBAN SEARCH AND RESCUE ROBOTS

RANDOM STEP FIELDS
EXTRA DIAGONAL FIELDS

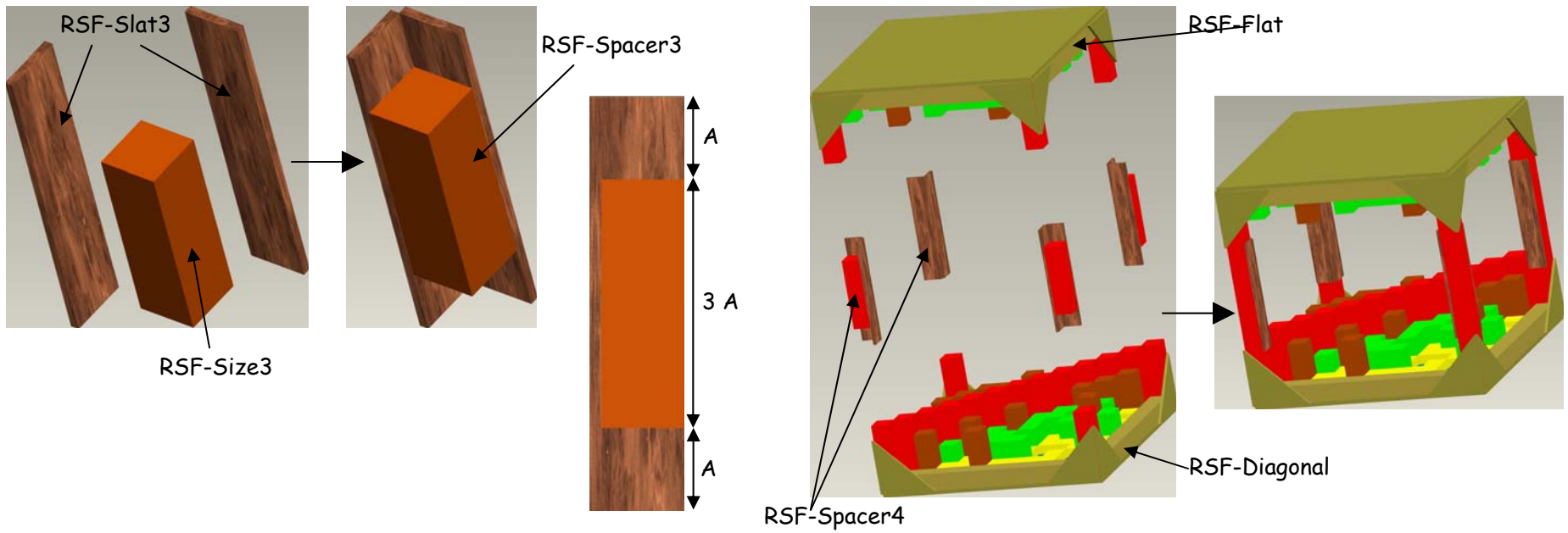
- For fields that are to be used as ceilings, some of the pieces must be screwed down to RSF-Floor.
 - The pieces which are not screwed down will fall out when the field is turned over to become a ceiling.
 - For the Flat and Diagonal fields, the pieces that should be screwed (dark squares) in are shown in the figure below left
 - For the Hill fields, the pieces that should be screwed (dark squares) in are shown in the figure below right
- Note: The hill pattern is the same as the Flat/Diagonal pattern except that all the RSF-Size4 pieces are screwed in.
- It is suggested that you create a 3Ax3A cardboard template for putting screws in (See picture to the right)



Screw Pattern for Flat & Diagonal Fields

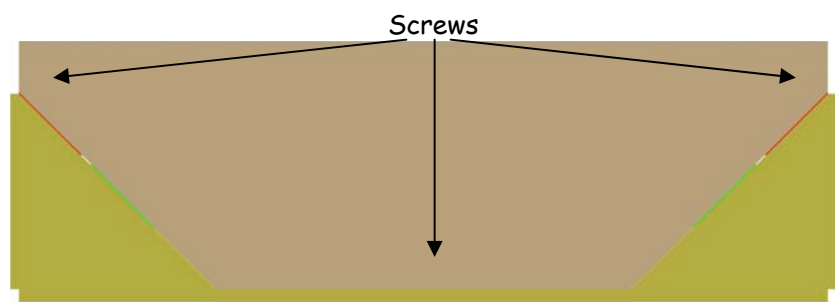
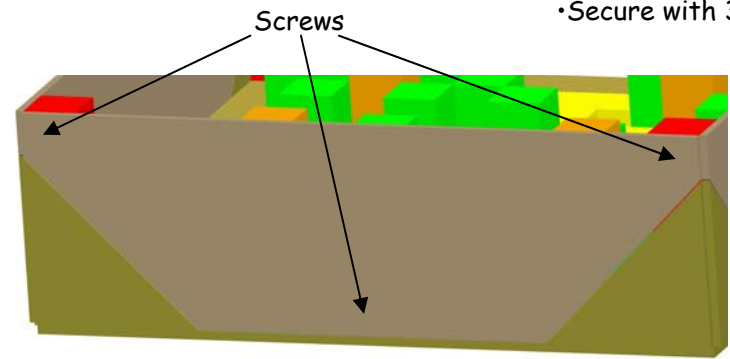


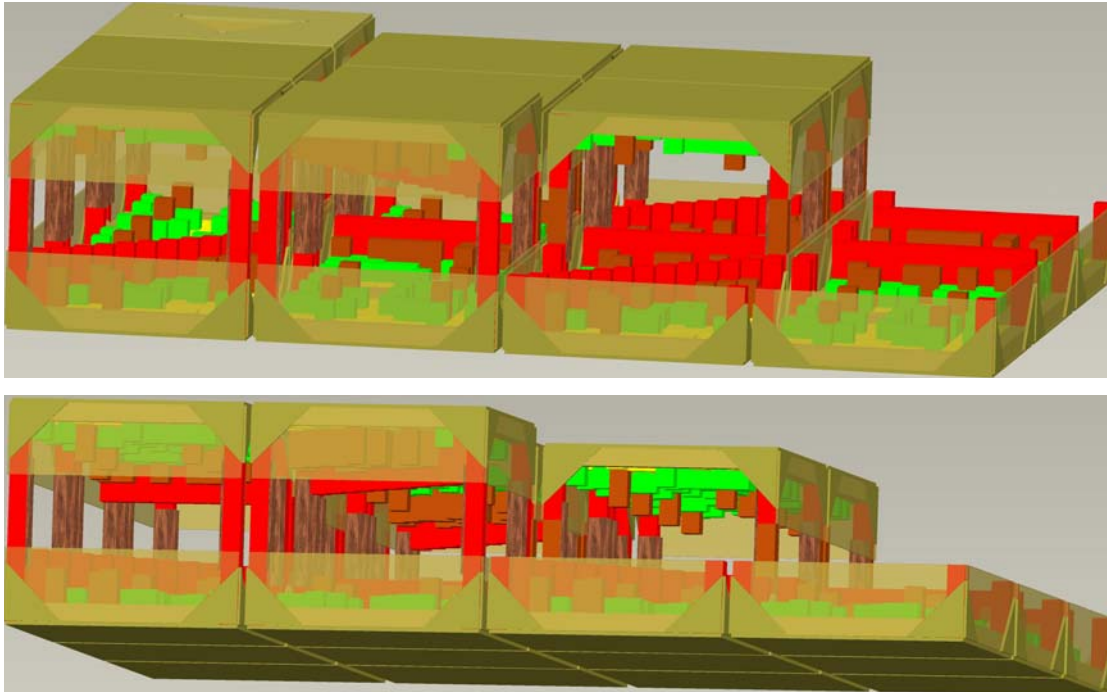
Screw Pattern for Hill Fields



Wall Placement Instructions:

- Align RSF-Wall cutouts with RSF-Triangles
- Secure with 3 screws as shown below





Quantities needed:

RSF-Flat: 9

RSF-Hill: 5

RSF-Diagonal: 5

Empty Field (with Triangle cutout): 1

RSF-Spacer3: 16

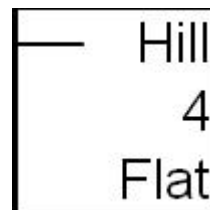
RSF-Spacer4: 16

RSF-Wall: 33

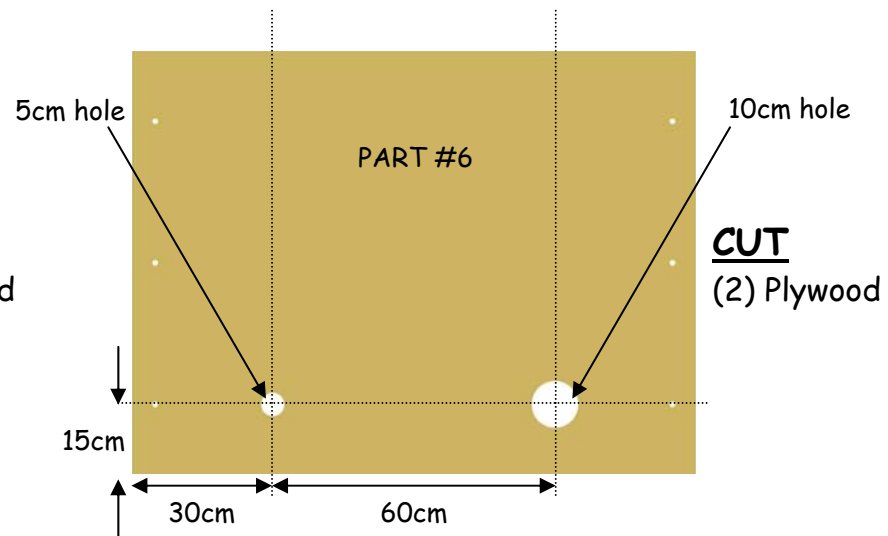
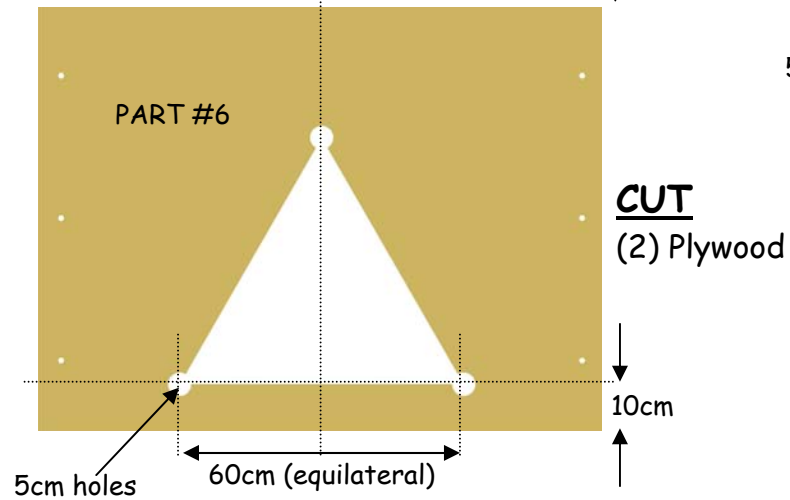
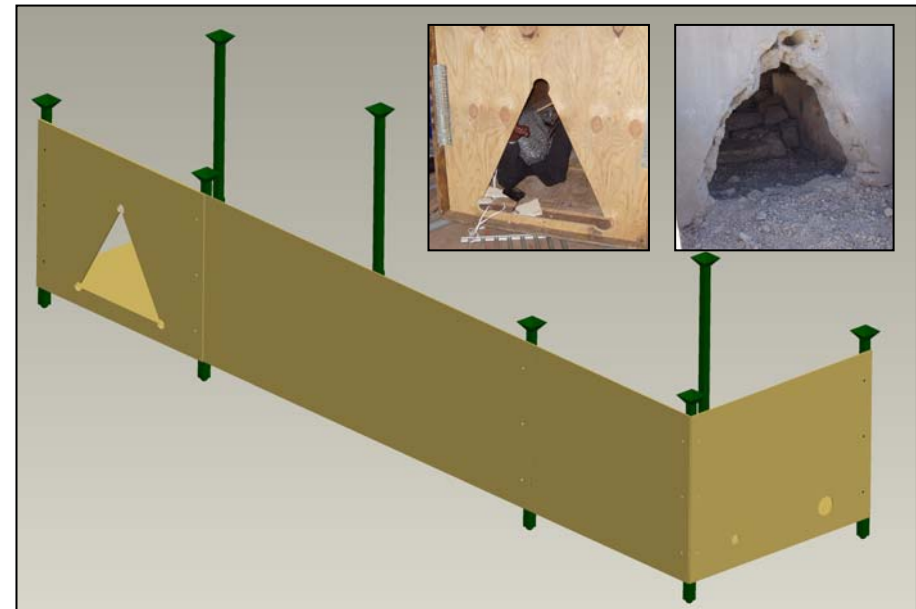
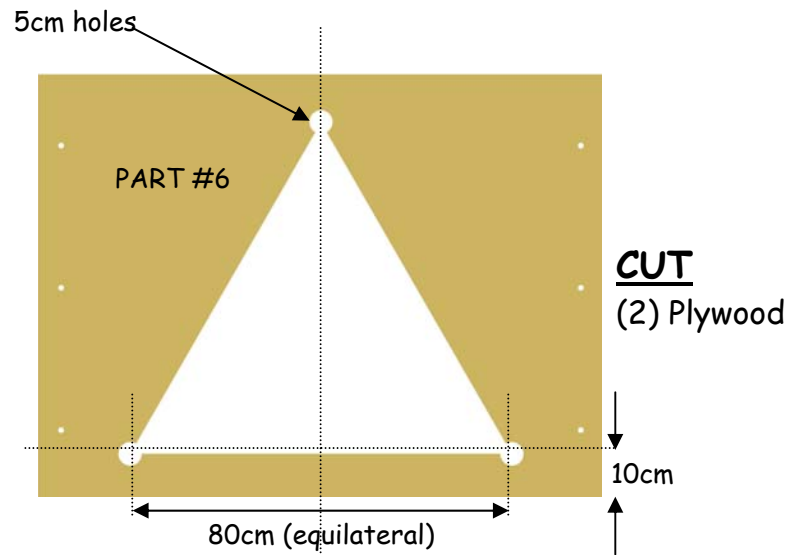
Full Parts List for Step Fields

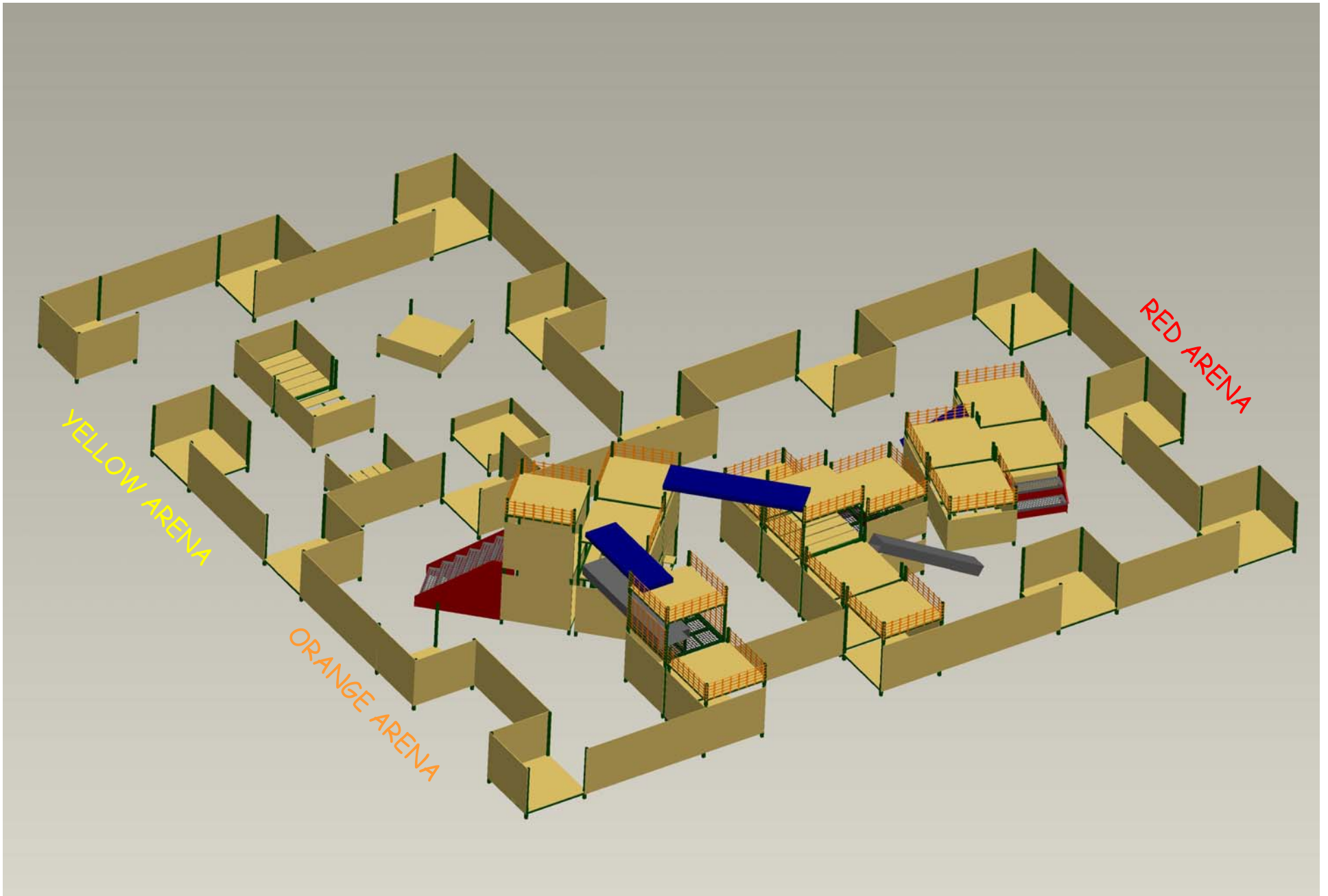
RSF-Floor	20
RSF-Border	80
RSF-Size4	206
RSF-Size3	221
RSF-Size2	592
RSF-Size1	967
RSF-Size0	389
RSF-Slat4	32
RSF-Slat3	32
RSF-Triangle	160
RSF-Wall	33

Hole 4	Diag 3	Flat 3	
Flat	Flat	Diag	Hill
Hill 4	Flat 3	Flat 3	
Flat	Hill	Hill	Hill
Flat 4	Diag 4		
Diag	Flat	Diag	Flat



- ACCESS FEATURES should be cut from PART #6 (1.2m x 0.9m x ~3mm plywood PANELS)
- All triangular access holes are **equilateral**





REFERENCE TEST ARENAS
FOR
URBAN SEARCH AND RESCUE ROBOTS

ARENAS -
MODEL VIEW

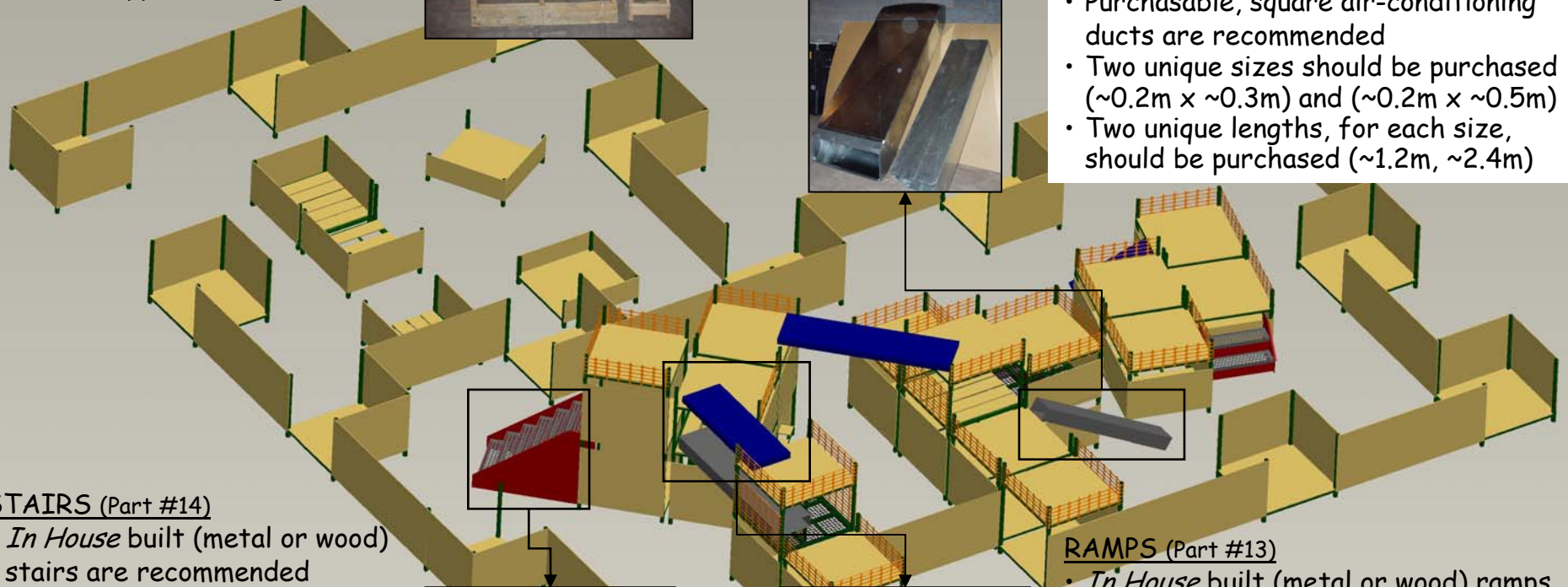
NIST



TRANSITION COMPONENTS			
√	PART #	PART (DESCRIPTION)	QUANTITY
	11	Ducts: Various sizes and lengths	4 ducts
	12	Pallets: Common sizes	>4 pallets
	13	Ramps: 75cm wide x 3 lengths (~1.2m, ~1.8m, ~2.4m)	3 ramps
	14	Stairs: 3 Heights based upon Stacking Rack and Posts	3 stair sets

PALLETS (Part#12 - not shown in model)

- Pre-fabricated, wooden pallets are recommended.
- Any readily accessible size(s) may be used
- Should support >100kg



DUCTS (Part #11)

- Purchasable, square air-conditioning ducts are recommended
- Two unique sizes should be purchased (~0.2m x ~0.3m) and (~0.2m x ~0.5m)
- Two unique lengths, for each size, should be purchased (~1.2m, ~2.4m)



STAIRS (Part #14)

- *In House* built (metal or wood) stairs are recommended
- Free-standing (preferred) or easily attachable to other sections (support >200kg)
- Height should be sized based upon the stacking rack heights
- Three unique heights should be constructed

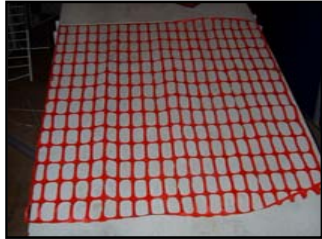


RAMPS (Part #13)

- *In House* built (metal or wood) ramps are recommended (~75cm width)
- Ramp may have a metal or wood surface, but should support >200kg
- Easily attachable to any stacking rack
- Should not exceed 30 degrees
- Three unique lengths should be constructed (~1.2m, ~1.6m, ~2.4m)



- Each MOBILITY OBSTACLE may be substituted with similar components based upon availability and local building materials
- ADDITIONAL DECKING surfaces (page 6) and ACCESS FEATURES (page 10) are also categorized as MOBILITY OBSTACLES



ORANGE BARRIER MESH
(PART #15)

- Attach horizontally to RACK FRAMES to restrict airship robots
- Cut and CABLE TIE to REMOVABLE POSTS to act as a barrier on upper levels (page 11)
- Place on ramps and ground



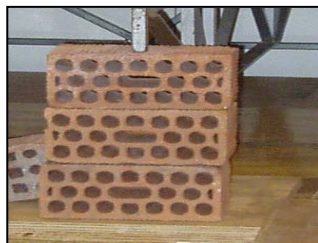
PLASTIC HARDWARE NET
(PART #16)

- Attach vertically to RACK FRAMES to block movement inside RACKS
- Place on pallets and ground to hinder mobility



CINDER BLOCKS
(PART #19)

- Construct walls
- Put in disorganized piles to force robots to climb them
- Hold up PALLETS at angles to add instability



BRICKS
(PART #20)

- Construct walls
- Put in disorganized piles to force robots to climb them



PLASTIC BIN
(PART #17)

- Place/stack as obstacles
- Turn upside-down to hide entombed victims (one edge propped up to allow probing)



PLASTIC TUBING
(PART #18)

- Hinder robot mobility
- Cut to ~1m lengths
- Place on ground (in clusters)



LAVA ROCK
(PART #21)

- Hinder robot mobility
- Place on spare tarps on the ground



GARDEN LOG EDGING
(PART #22)

- Hinder robot mobility
- Place on ramp(s) and/or RACK FRAME floors

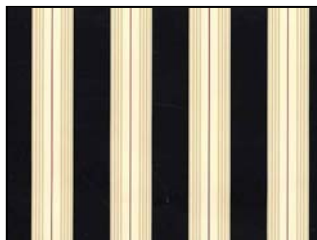
MOBILITY OBSTACLES			
√	PART #	PART (DESCRIPTION)	QUANTITY
	15	Orange Barrier Mesh	3 rolls
	16	Plastic Hardware Net	3 rolls
	17	Plastic Bins: ~60cm length x ~40cm width x ~30cm height	10 bins
	18	Plastic Tubing: ~1m lengths (2 diameters, 25mm - 100mm)	> 60 pieces
	19	Cinder Blocks: ~20cm x ~20cm x ~40cm	100 blocks
	20	Bricks: ~20cm x ~10cm x ~10cm	100 bricks
	21	Lava Rock	> 50 kgs
	22	Garden Log Edging: Wood, any available size	> 10 sets

- Each VISUAL OBSTACLE may be substituted with similar components based upon availability and local building materials
- CLEAR PLASTIC SHEETS (page 7) are also categorized as VISUAL OBSTACLES



TARP (DUST GREY PREFERRED)
(PART #23)

- Use to blackout sections/rooms of the ARENAS
- Produce a monochrome environment
- Hang from PANELS using BINDER CLIPS (page 15)



FABRIC (STRIPPED AND COMPLEX)
(PART #24)

- Produce false visual cues for wall-following robots
- Hang from PANELS using BINDER CLIPS (page 15)

VISUAL OBSTACLES			
✓	PART #	PART (DESCRIPTION)	QUANTITY
	23	Dust Grey Tarp: ~3.6m x ~3.6m	10 tarps
	24	Fabric: 1.2m x 0.9m, striped and complex patterns	10 pieces
	25	Blinds: ~1.0m wide x ~1.0m tall	10 blinds
	26	Dust Grey Curtains	10 curtains
	27	Spotlight	3 lights
	28	Acrylic Mirror Paneling: ~1.2m x ~0.6m x ~5mm	10 sheets



BLINDS
(PART #25)

- Variable visual occlusion to force robot interaction
- Hang from RACK FRAMES using CABLE TIES



CURTAINS (DUST GREY)
(PART #26)

- Complete visual occlusion to force robot interaction
- Hang from RACK FRAMES



SPOTLIGHT
(PART #27)

- Provide high intensity light and shadows
- Place in RACK FRAMES, paths and near victims
- May attach to REMOVABLE POSTS using CABLE TIES



ACRYLIC MIRROR PANELS
(PART #28)

- Visually disorienting for operator
- Visual duplication of victims and arena elements
- Place against PANELS throughout the arenas

- Each **ACOUSTIC OBSTACLE** may be substituted with similar components based upon availability and local building materials



- Absorb sonar emissions
- May be attached to **RACK FRAMES**
- Ceiling tile may be used as one possible solution

ACOUSTIC ABSORPTIVE PANEL
(PART #29)



- Split sonar emissions
- Should be ~1.2m tall x ~0.6m x ~0.6m
- May be constructed out of extra **PANELS** and **CABLE TIES**

ACOUSTIC ANGLE
(PART #30)



RADIO
(PART #32)

- Provide audible distractions to operators
- AC (as opposed to battery) powered is preferred
- Place in enclosed areas or on elevated **RACK FRAMES**

ACOUSTIC OBSTACLES			
√	PART #	PART (DESCRIPTION)	QUANTITY
	29	Acoustic Absorptive Panel: ~1.2m tall x ~0.6m wide	10 panels
	30	Acoustic Angle: ~1.2m tall x ~0.6m x ~0.6m	3 angles
	31	Acoustic Reflector Pairs: ~75cm tall x ~5cm wide	5 pairs
	32	Radio	1 radio



ACOUSTIC REFLECTOR PAIRS
(PART #31)

- Reflect sonar emissions
- Each lightweight piece should be ~75cm tall and ~5cm wide
- Must be placed in pairs opposite to one another in corridors/hallways
- Attach vertically to **REMOVABLE POSTS** using **CABLE TIES**
- Lightweight aluminum angle may be used as one possible solution

REAL ENVIRONMENTS



ARENAS

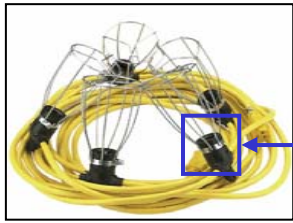


REFERENCE TEST ARENAS
FOR
URBAN SEARCH AND RESCUE ROBOTS

COLLAPSE TYPES -
EXAMPLES

NIST





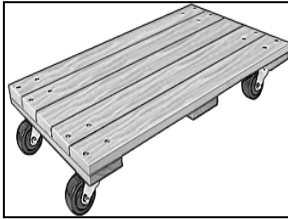
LIGHT STRING
(PART #33)



with **AC PLUG INSERT**
(PART #34)



DUCT TAPE
(PART #36)



DOLLEY (PART #35)

- To be used to quickly transport **RACK FRAMES**
- Tall enough to raise **RACK FRAMES** off the ground



PACKING TAPE
(PART #37)

MISCELLANEOUS ITEMS

√	PART #	PART (DESCRIPTION)	QUANTITY
	33	Light Strings: ~18m length - 5 outlets w/AC plug adapters	3 strings
	34	Electrical AC Plug Insert	20 inserts
	35	Dolleys: Solid Plank, ~0.6m x ~0.9m, >300kg capacity	3 dollies
	36	Duct Tape	5 rolls
	37	Packing Tape: Clear, Large	5 rolls
	38	Binder Clips: Small and Medium Sizes	10 packs
	39	Paint: "Dust-Colored" Grey, ~5L bucket	3 buckets

TOOLS

√	PART #	PART (DESCRIPTION)	QUANTITY
	40	Paint Roller Kit with roller tray	5 kits
	41	Utility Knife with Blade Refills	3 knives
	42	Cutters	5 cutters
	43	Corded Drill	1 drill
	44	Drill Bit Set: Assorted Sizes	1 set
	45	Hole Saw: ~5cm and ~10cm diameters	2 hole saws
	46	Circular Saw: Corded	1 circular saw



BINDER CLIPS
(PART #38)

- To be used to clip **TARPS** to **PANELS**
- **CLIPS** should fit **PANEL** thickness



DUST GREY PAINT
(PART #39)

- Provide "dust-covered" look to **ARENA** components
- Paint most components (**RACK FRAMES**, **REMOVABLE POSTS**, **PANELS**, **TARPS**, etc...)



PAINT ROLLER KIT
(PART #40)



UTILITY KNIFE
(PART #41)



CUTTERS
(PART #42)



CORDED DRILL
(PART #43)



DRILL BIT SET
(PART #44)



HOLE SAWS
(PART #45)



CIRCULAR SAW
(PART #46)

STACKING RACKS (~\$9200 USD)

√	PART #	PART (DESCRIPTION)	QUANTITY
	1	Stacking Rack: Rack (~ 1.2m x ~ 1.2m) w/Wood Decking	60 frames w/decking
	2	Stacking Rack: Posts (~ 1.1m height)	112 (~ 1.1m) posts
	3	Stacking Rack: Posts (~ 0.8m height)	56 (~ 0.8m) posts
	4	Stacking Rack: Posts (~ 0.5m height)	80 (~ 0.5m) posts

ADDITIONAL DECKING (~\$500 USD)

√	PART #	PART (DESCRIPTION)	QUANTITY
	5	Decking: Various Surfaces - (plywood, tile, carpet, metal, etc.)	15 surfaces

PANELS (~\$1400 USD)

√	PART #	PART (DESCRIPTION)	LENGTH	WIDTH	QUANTITY
	6	Panels: 1.2x0.9	1.2m	0.9m	64 panels
	7	Panels: 1.2x0.6	1.2m	0.6m	48 panels
	8	Panels: 1.2x0.3	1.2m	0.3m	114 panels
	9	Panels: 2.4x0.9	2.4m	0.9m	25 panels

TRANSITION COMPONENTS (~\$1000 USD)

√	PART #	PART (DESCRIPTION)	QUANTITY
	11	Ducts: Various sizes and lengths	4 ducts
	12	Pallets: Common sizes	>4 pallets
	13	Ramps: 75cm wide x 3 lengths (~1.2m, ~1.8m, ~2.4m)	3 ramps
	14	Stairs: 3 Heights based upon Stacking Rack and Posts	3 stair sets

MOBILITY OBSTACLES (~\$900 USD)

√	PART #	PART (DESCRIPTION)	QUANTITY
	15	Orange Barrier Mesh	3 rolls
	16	Plastic Hardware Net	3 rolls
	17	Plastic Bins: ~60cm length x ~40cm width x ~30cm height	10 bins
	18	Plastic Tubing: ~1m lengths (2 diameters, 25mm - 100mm)	> 60 pieces
	19	Cinder Blocks: ~20cm x ~20cm x ~40cm	100 blocks
	20	Bricks: ~20cm x ~10cm x ~10cm	100 bricks
	21	Lava Rock	> 50 kgs
	22	Garden Log Edging: Wood, any available size	> 10 sets

CABLE TIES (~\$100 USD)

√	PART #	PART (DESCRIPTION)	QUANTITY
	10	Cable Ties: Standard Nylon, ~8mm width x >250mm length	800 cable ties

VISUAL OBSTACLES (~\$750 USD)

√	PART #	PART (DESCRIPTION)	QUANTITY
	23	Dust Grey Tarp: ~3.6m x ~3.6m	10 tarps
	24	Fabric: 1.2m x 0.9m, stripped and complex patterns	10 pieces
	25	Blinds: ~1.0m wide x ~1.0m tall	10 blinds
	26	Dust Grey Curtains	10 curtains
	27	Spotlight	3 lights
	28	Acrylic Mirror Paneling: ~1.2m x ~0.6m x ~5mm	10 sheets

ACOUSTIC OBSTACLES (~\$150 USD)

√	PART #	PART (DESCRIPTION)	QUANTITY
	29	Acoustic Absorptive Panel: ~1.2m tall x ~0.6m wide	10 panels
	30	Acoustic Angle: ~1.2m tall x ~0.6m x ~0.6m	3 angles
	31	Acoustic Reflector Pairs: ~75cm tall x ~5cm wide	5 pairs
	32	Radio	1 radio

MISCELLANEOUS ITEMS (~\$800 USD)

√	PART #	PART (DESCRIPTION)	QUANTITY
	33	Light Strings: ~18m length - 5 outlets w/AC plug adapters	3 strings
	34	Electrical AC Plug Insert	20 inserts
	35	Dolleys: Solid Plank, ~0.6m x ~0.9m, >300kg capacity	3 dollies
	36	Duct Tape	5 rolls
	37	Packing Tape: Clear, Large	5 rolls
	38	Binder Clips: Small and Medium Sizes	10 packs
	39	Paint: "Dust-Colored" Grey, ~5L bucket	3 buckets

TOOLS (~\$200 USD)

√	PART #	PART (DESCRIPTION)	QUANTITY
	40	Paint Roller Kit with roller tray	5 kits
	41	Utility Knife with Blade Refills	3 knives
	42	Cutters	5 cutters
	43	Corded Drill	1 drill
	44	Drill Bit Set: Assorted Sizes	1 set
	45	Hole Saw: ~5cm and ~10cm diameters	2 hole saws
	46	Circular Saw: Corded	1 circular saw

~\$15,000 USD

REFERENCE TEST ARENAS
FOR
URBAN SEARCH AND RESCUE ROBOTS

ARENAS -
ESTIMATED COSTS

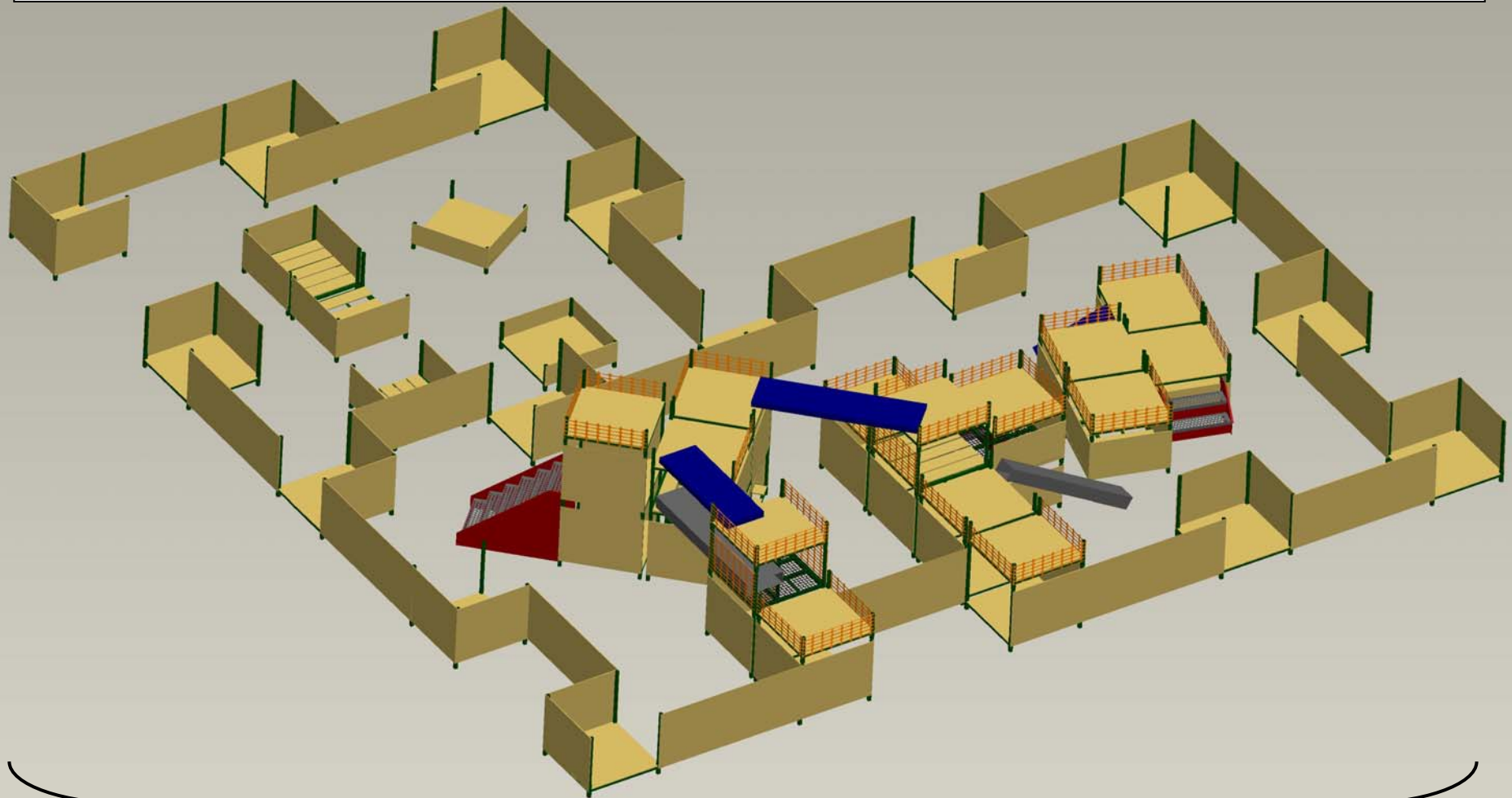
NIST



NOTE:

ABOVE PRICING IS FOR A FULL INTERNATIONAL CONFIGURATION. OTHER CONFIGURATIONS WILL BE A FRACTION OF THE SIZE AND COST:

- REGIONAL CONFIGURATION WILL BE $\sim 2/3$ THE AMOUNT OF COMPONENTS & COST
- RESEARCH CONFIGURATION WILL BE $\sim 1/3$ THE AMOUNT OF COMPONENTS & COST



~\$15,000 USD

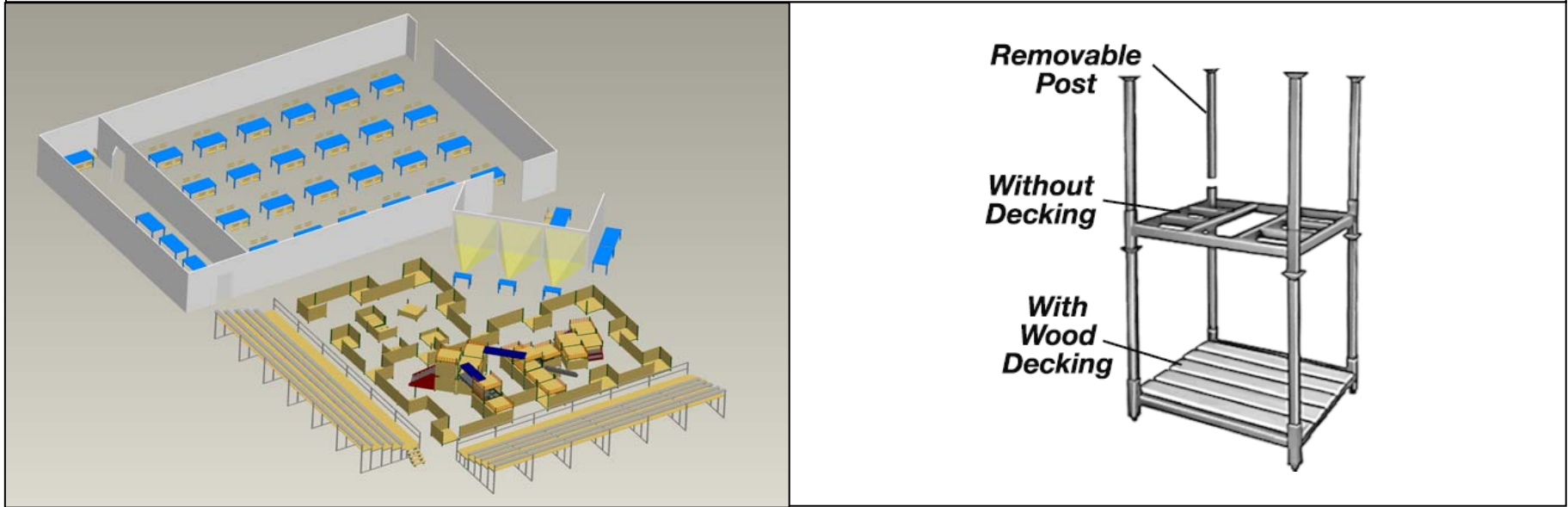
REFERENCE TEST ARENAS
FOR
URBAN SEARCH AND RESCUE ROBOTS

**ARENAS -
ESTIMATED COSTS**

NIST



RESCUE ROBOT LEAGUE ARENA CONFIGURATION **BASED ON** **PALLET-STYLE STACKING RACKS**



FOR MORE INFORMATION...

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