DRC Trials Task Description

Release 11 on December 8, 2013

DISTAR Case 22197

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Revision History

This section captures changes to this document.

Version	Date	Author	Section	Description
Release 11	12/8/2013	E. Krotkov	Document	Enumerated below

Changes include the following:

Vehicle

- Original seat cushions used (statement in Release 10 about removing seat cushions was incorrect)

Debris

- Updated weights of lightweight wood debris pieces

Wall

- Changed cut-off time for drill from 10 to 5 minutes

Introduction

This document describes the tasks to be performed by the human-robot teams at the DRC Trials in December, 2013. This document differs from the previous document (*DRC Trials Initial Task Description*) by focusing on the competition tasks for December 2013, rather than focusing on the practice tasks leading up to the Trials.

The document describes the general outline of the tasks, and does not describe the exact parameters of the tasks. The rationale for this level of abstraction is to encourage and promote generality, and prevent solutions that “over-fit” the general problem of disaster response. DARPA reserves the right to change the task parameters.

The task numbering differs from the task numbering in the *DRC Trials Initial Task Description* document, and from the numbering scheme in the BAA.

Many of the drawings in the *DRC Trials Initial Task Description* document show a floor. At the DRC Trials, runs will take place on a flat level concrete or asphalt surface for the following tasks: Vehicle, Terrain, Debris, Wall, Valve, and Hose. At the DRC Trials, runs will take place on a floor surface for the following tasks: Ladder and Door.

To distinguish the DRC’s efforts in mobile manipulation from prior efforts in fixed base manipulation, tasks requiring significant manipulation (Ladder, Debris, Door, Wall, Valve, and Hose) will have the robot start near, but not in immediate proximity to, the objects, and not in a precisely predetermined position. The robot will need to travel a short distance, typically one meter, before it can begin manipulation, and calibrate its location and orientation relative to the environment.

The drawings in the document may show distances such as the distance from the start line to a wall. These distances are representative, not definitive. DARPA reserves the right to create tasks that have different distances in order to satisfy real-world constraints not currently anticipated. Teams should not base their technical approaches or “scripts” on the dimensions in the drawings, because those dimensions are not guaranteed.

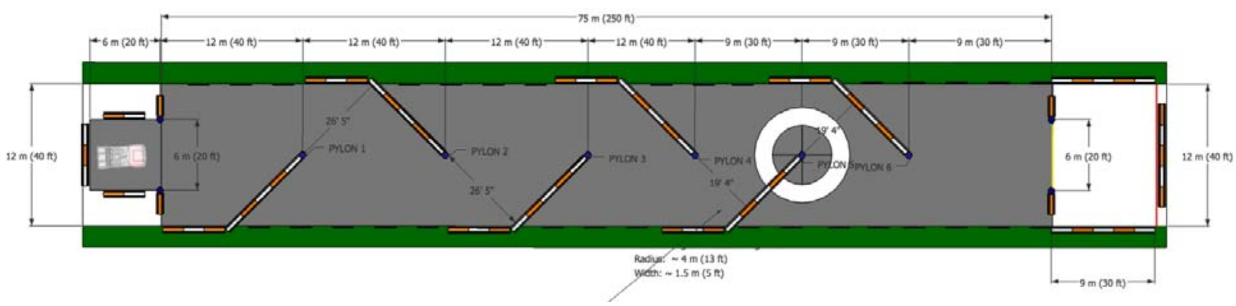
Commercial Disclaimer: Certain commercial equipment, instruments, or materials are identified in this document. Such identification does not imply recommendation or endorsement by DARPA, nor does it imply that the products identified are necessarily the best available for the purpose, nor does it guarantee that the products identified will be used in the DRC Trials.

Related documents include the following:

- *DRC Trials Initial Task Description* - Describes the practice tasks to be performed by the human/robot system in preparation for the DRC Trials
- *DRC Trials Rules* - Defines the official rules for the DRC Trials
- *DRC Trials Qualification* - Defines the qualification tasks that must be performed to qualify for participation in the DRC Trials

Task 1 Vehicle

Figure 1 shows the course layout for the Vehicle task. The start line is on the left of the diagram, and the finish line is on the right. The course consists of a series of pylons (orange and white in the figure) with plastic barrels at the the end (blue in the figure). The circle drawn on the ground at Pylon 5 represents the turning radius of the Polaris Ranger XP 900. “Parking bumpers” (the blue, linear features at the edges of the course in Figure 1) define the boundaries of the course.



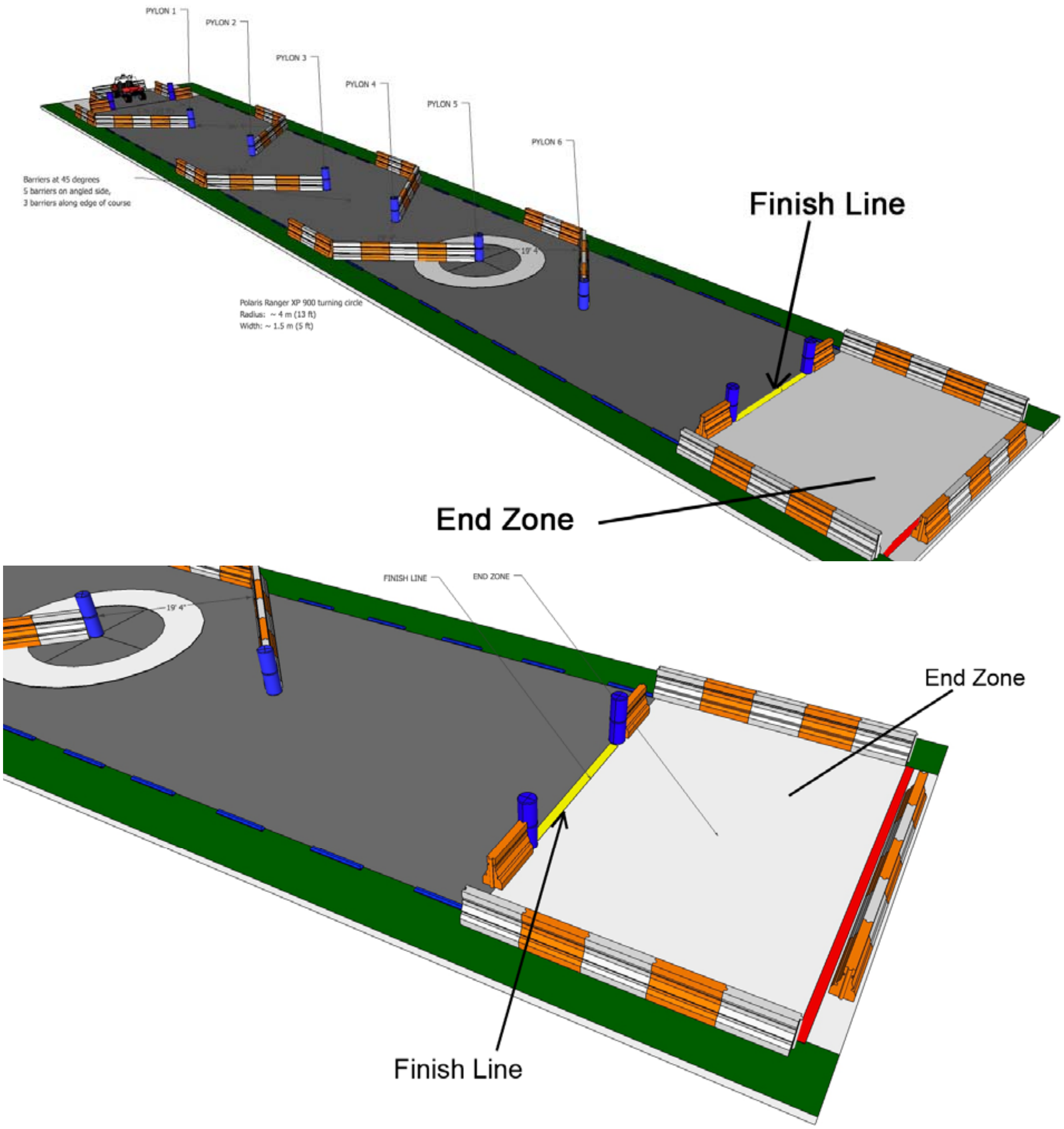


Figure 1. Course layout for Vehicle task
Note that the pylon spacing shown in the top graphic is internally inconsistent because the graphics and the dimensions do not agree. It is not clear at this time which is correct, the graphics or the dimensions.

The Vehicle task consists of two sub-tasks: (1) Robot drives the vehicle through the course (1 point), and (2) Robot gets out of the vehicle and travels dismounted out of the end zone (2 points).

For the first sub-task, the robot begins in the vehicle, drives through the course, and crosses the finish line. This sub-task shall be considered complete when both rear wheels of the vehicle have crossed the finish line.

For the second sub-task, the robot gets out of the vehicle, and travels dismounted out of the end zone. This sub-task shall be considered complete when all parts of the robot have departed from the end zone after passing through one of the exits. In Figure 1, the exits from the end zone appear at the upper right corner and the lower right corner of the diagram, as gaps between the barriers that define the end zone. The robot may exit from either side of the end zone.

The robot will begin the run in the vehicle, with the key in the ignition, and the vehicle turned on and running, and the vehicle in “high” gear (because it offers the smoothest start-up). The robot may operate the shift lever to change gear, but this is not required. To drive the vehicle, the robot needs to depress the accelerator and to rotate the steering wheel. To get out of the vehicle, the robot is not required to to move the shift lever from “drive” to “park,” although that would be prudent to prevent the vehicle from driving as the robot is getting out.

The barriers shown in Figure 1 will be empty. A line will be drawn around each barrier, at a distance of approximately 3.5 inches (the width of a 2x4 piece of lumber) from the barrier. If during the course of the run, any barrier moves outside of that line (for example because it was struck by either the vehicle or the robot), the run will terminate with a score of zero.

If during the course of the run all four wheels of the vehicle cross the outer boundaries of the course, the run will terminate with a score of zero.

No interventions are allowed for the Vehicle task.

Task 2 Terrain

Figure 2 shows the planned course layout for the Terrain task. The start line is on the upper right of the figure, and the finish line is on the lower left.

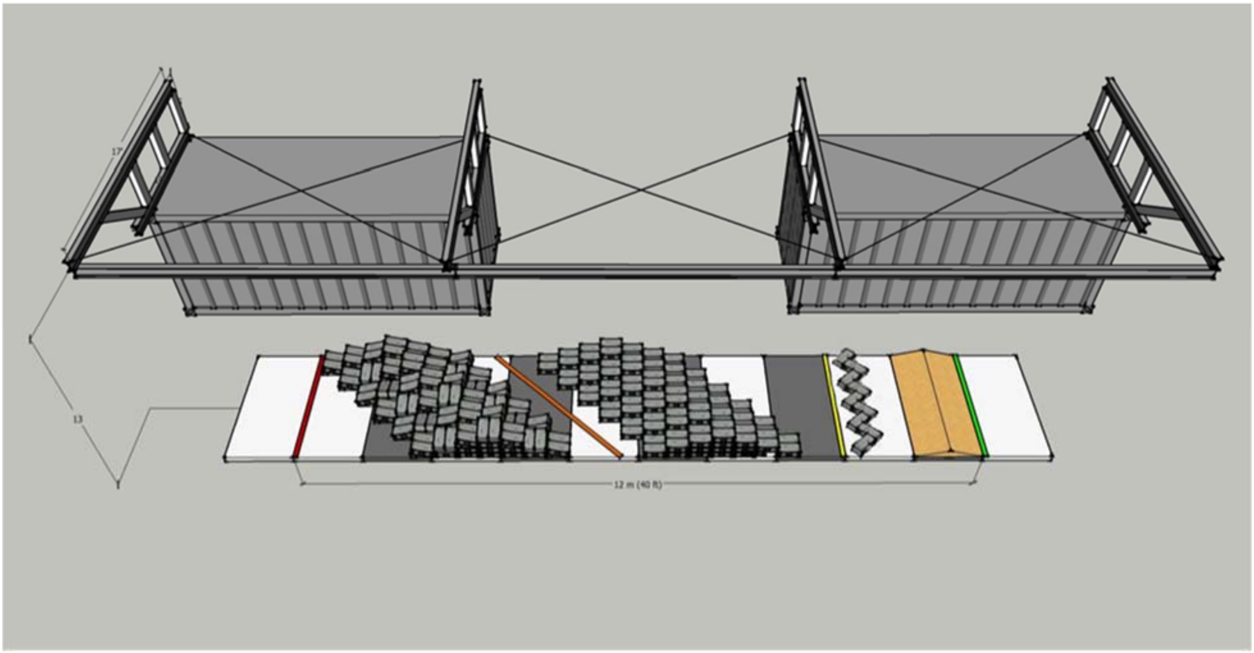


Figure 2a. Course layout for Terrain task.
This is a sketch, not intended to be exact. The graphic does not correctly show the boundary between the middle terrain segment and the final terrain segment. In reality, there will be less of a gap between those two terrain segments.

Figure 2b. Course layout for Terrain task
This is a photograph of a mock-up and will serve as the model for the terrain to be constructed for the Trials.

The Terrain task consists of three sub-tasks: (1) Traverse initial terrain segment (1 point), (2) Traverse middle terrain segment (1 point), and (3) Traverse final terrain segment (1 point). Visible lines will mark the boundary between terrain segments: the green line is the start line, the yellow line is the boundary between the initial and middle terrain segments, the orange line is the boundary between the middle and final terrain segments, and the red line is the boundary between the final terrain segment and the end zone.

For the first subtask, the robot begins entirely behind the green start line shown in the figure, crosses the pitch ramps and the chevron hurdle, and the yellow line shown in the figure. The chevron hurdle is one block high, or about 15 cm (6 in). This sub-task shall be considered complete when all contacts between the terrain and the robot (excepting the tether[1]) occur in the middle terrain segment, or in other words, when no terrain/robot contact occurs in the initial terrain segment. Note that this sub-task shall be considered complete even though part of the robot, such as the rear-most "foot," may be in the air and still above the initial terrain segment.

For the second sub-task, the robot crosses the flat-top steps and the orange line shown in the figure. This sub-task shall be considered complete when all contacts between the terrain and the robot (excepting the tether) occur in the final terrain segment, or in other words, when no terrain/robot contact occurs in the middle terrain segment.

For the third sub-task, the robot crosses the angle-top steps and the red line shown in the figure. This sub-task shall be considered complete when all contacts between the terrain and the robot (excepting the tether) occur in the end zone, or in other words, when no terrain/robot contact occurs in the final terrain segment.

The blocks will be laid out, as much as possible and practical, so that any holes face the side of the course rather than the start or end of the course. The blocks will not be fastened to the ground. Terrain may shift during a run. Terrain that shifts will be restored to its initial state at the end of a run and during interventions.

If an intervention takes place during the first sub-task, the robot will be reset at the start of the course. If an intervention takes place during the second sub-task, the robot will be reset at a place chosen by the team with ground contacts entirely in the initial terrain segment. If an intervention takes place during the third sub-task, the robot will be reset at a place chosen by the team with ground contacts entirely in the middle terrain segment.

Task 3 Ladder

Figure 3 shows the course layout for the Ladder task, and specifications of the ladder.

[1] It is expected that there will be a physical tether for the E-Stop function, independent of power and comms.

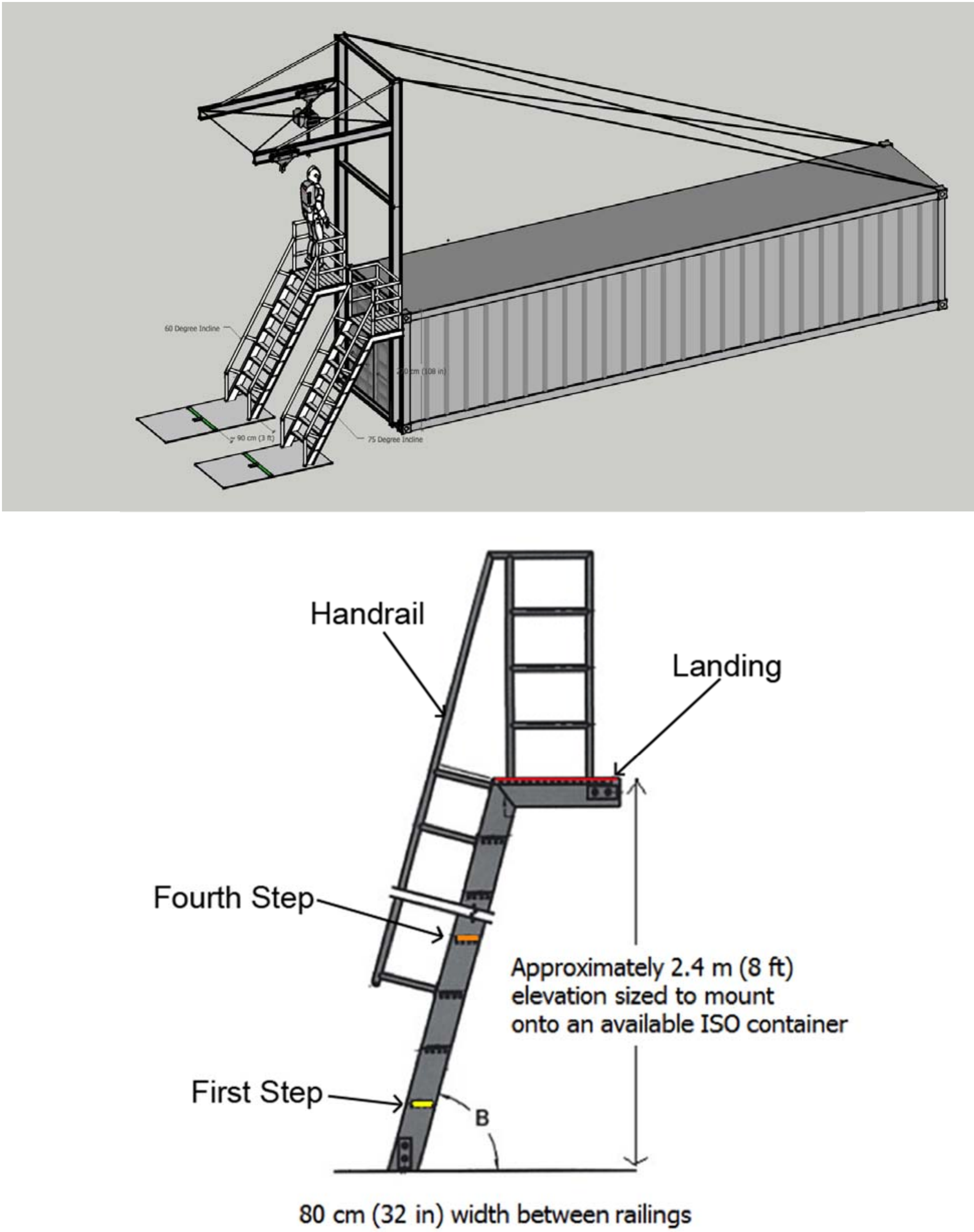


Figure 3. Course layout for Ladder task (top) and ladder specifications (bottom)

The Ladder task consists of three sub-tasks: (1) All contact points on or above the first step (1 point), (2) All contact points on or above the fourth step (1 point), and (3) No contact points below the landing (1 point).

Teams may choose the angle B in Figure 3 to be 60 degrees or 75 degrees.

Teams may choose to have zero (0), one (1), or two (2) handrails.

The base of the ladder will be secured directly to the floor.

The ladder is expected to have eight (8) steps, not counting the ground or the landing. Figure 3 shows one ladder with 6 steps; that is not the correct number of steps. It is possible but not expected that the ladder will have nine (9) steps.

All robots must use the fall limiter for the Ladder task. At the conclusion of a run, the robot will be lowered to the ground by DARPA officials if needed, that is, the robot does not need to descend the ladder.

If an intervention takes place, the robot will be reset at the start.

Task 4 Debris

Figure 4 shows the course layout for the Debris task. The robot begins behind the start line, so that the debris lies directly between the start point and the doorway. The green line in Figure 4 represents the start line. The start line has a “tick mark” at the center (directly under the overhead truss).

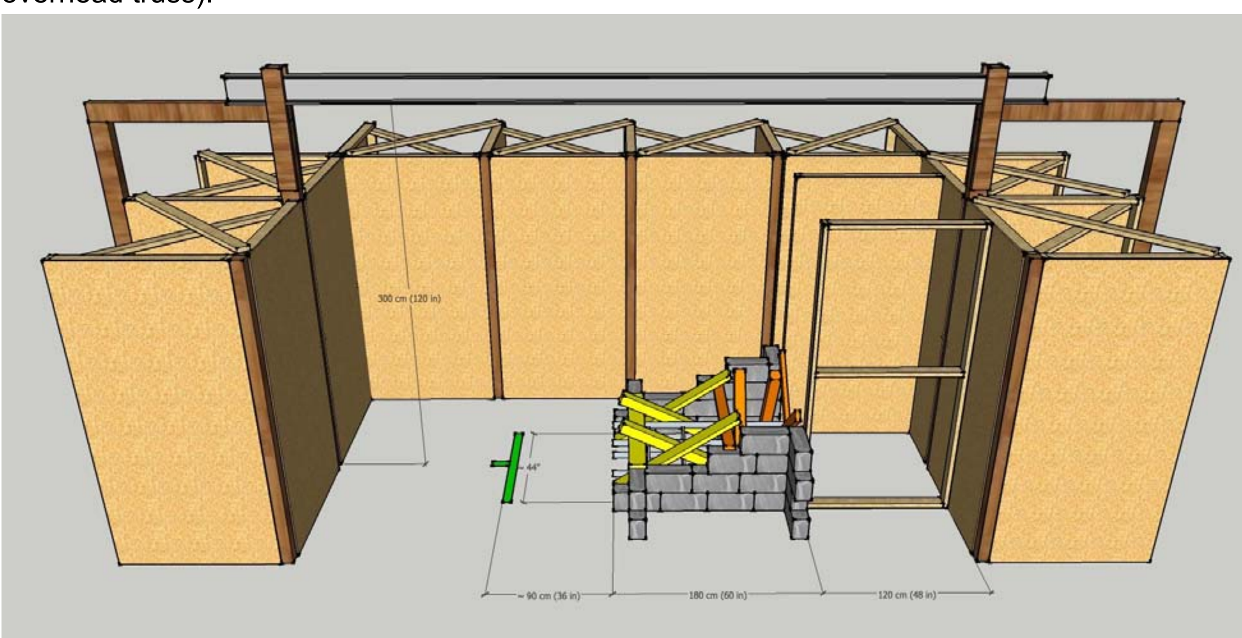


*Figure 4a. Course layout for Debris task. This graphic does **NOT** accurately depict the lengths of the debris pieces and their layout.*

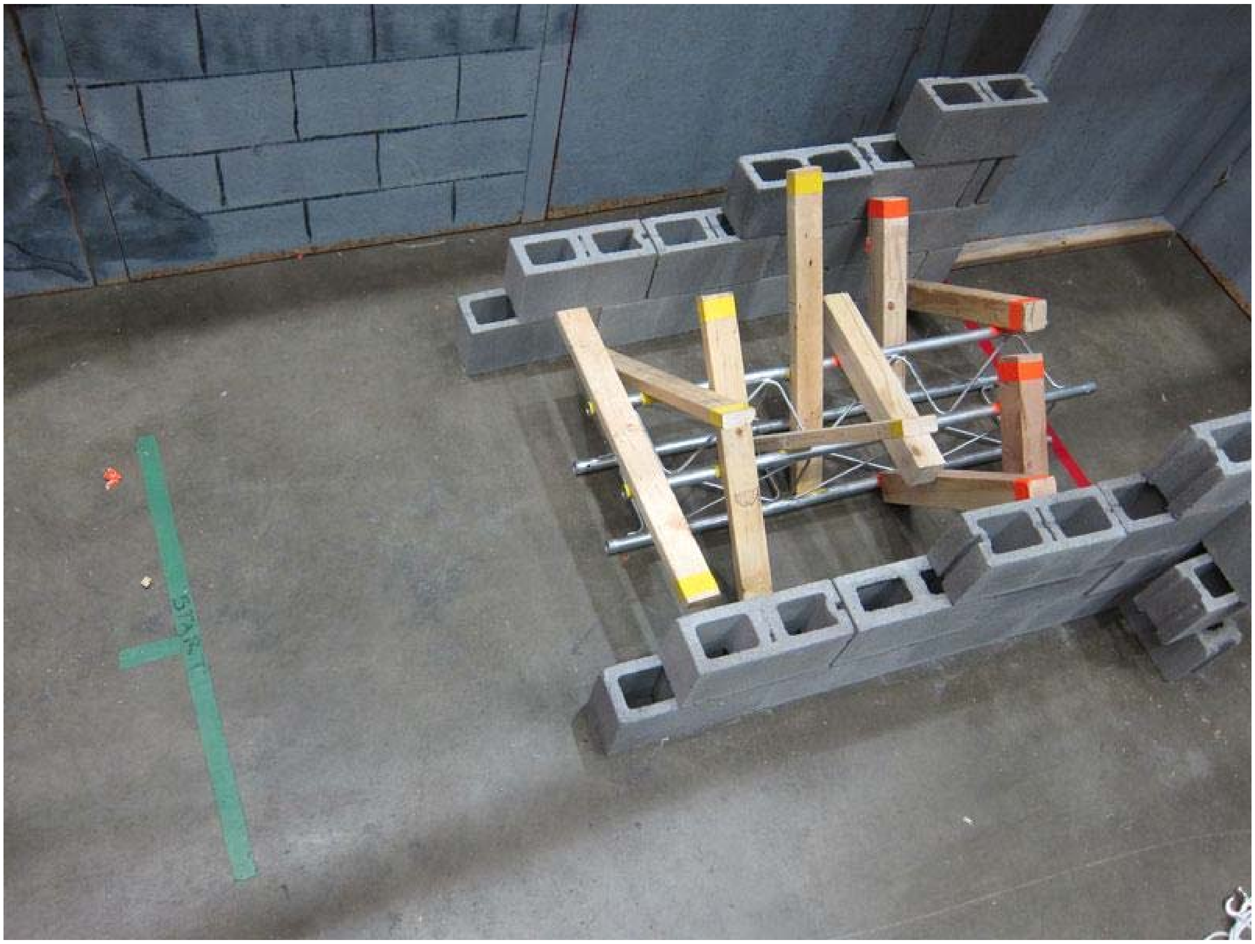


Figure 4b. Photo of mockup of Debris task. The debris pieces marked yellow are 24" long and the debris pieces marked red are 36" long

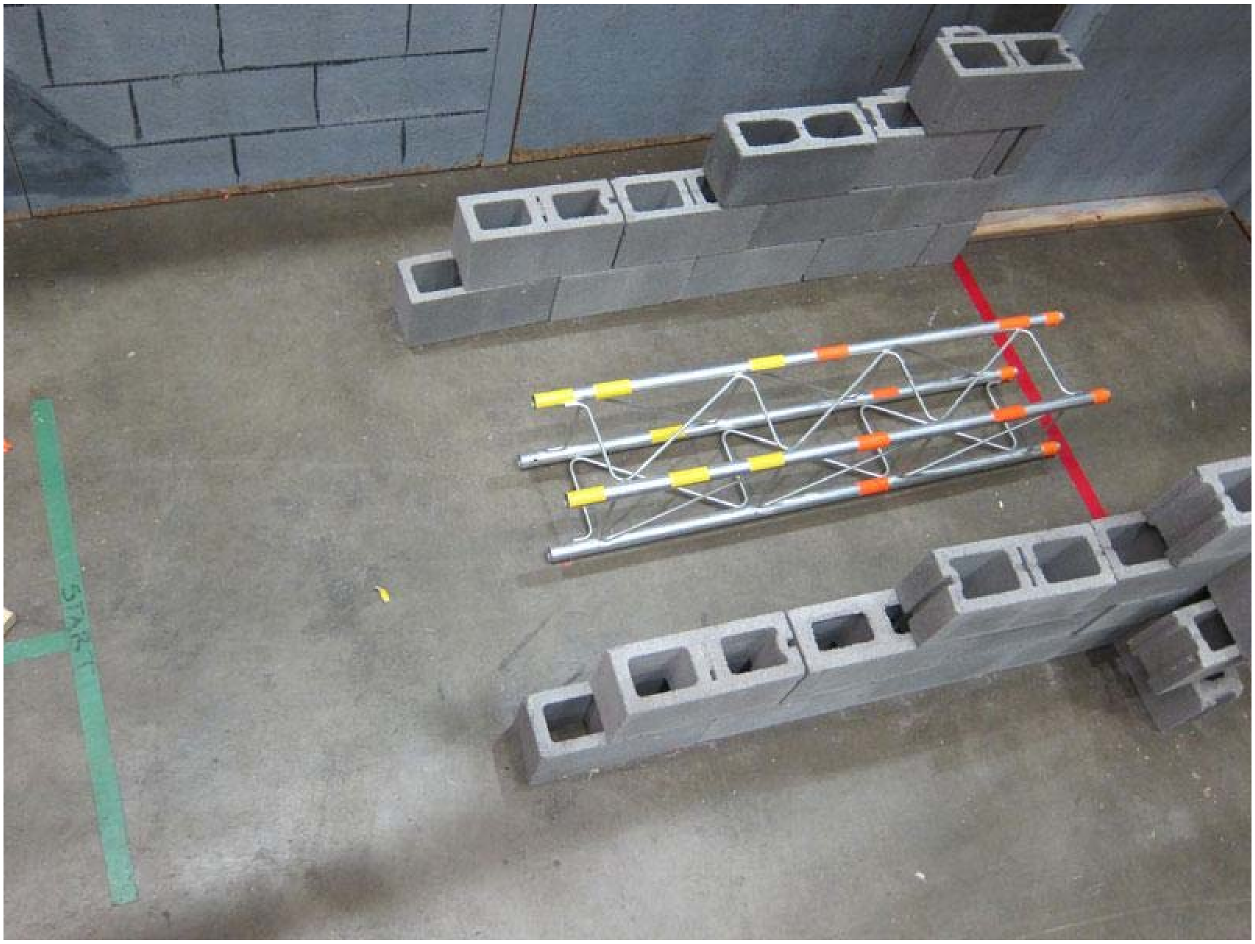


Figure 4c. Photo of mockup of truss used for Debris task

The Debris task consists of three sub-tasks: (1) Remove five pieces of debris (1 point), (2) Remove an additional five pieces of debris (1 point), and (3) Travel through the open doorway (1 point).

For the first and second sub-tasks, the robot removes debris by moving it from its initial position to a position outside the path of the robot. No part of the cleared debris may touch the floor inside a rectangle formed by the doorway and start line. This sub-task shall be considered complete when the required number of debris pieces are at rest outside of the lane between the concrete block walls. Cleared debris may lean against or rest entirely on top of the wall of concrete blocks. Cleared debris may end up on either side of the wall of concrete blocks or may end up behind the robot (away from the doorway).

For the third sub-task, the robot must travel through the open doorway, which has no threshold. The robot may remove the truss (metal structure holding the debris), but that is not necessary. This sub-task shall be considered complete when all parts of the robot (excepting the tether) have crossed a line marked on the ground after the door threshold.

Teams may choose debris pieces made of regular wood or lightweight wood.

The regular wood pieces will be made of pine or similar lumber material. For sub-task 1, the regular wood pieces will have size of approximately 1.5 x 3.5 x 36 inches, and will weigh approximately 3.2 pounds each. For sub-task 2, the regular wood pieces will have size of approximately 3.5 x 3.5 x 24 inches, and will weigh approximately 5.0 pounds each.

The lightweight wood pieces will be made of Balsa wood or similar material. For sub-task 1, the lightweight wood pieces will have size of approximately 1.5 x 3.0 x 36 inches, and will weigh approximately 0.5 pounds each. For sub-task 2, the lightweight wood pieces will have size of approximately 3.0 x 3.0 x 24 inches, and will weigh approximately 0.75 pounds each.

The size of the truss is 12 x 12 x 48 inches. The weight of the truss is not known at this time; we will announce on the DRC Forum when known.

At the beginning of the run, the debris pieces will be supported in part by the truss, so that none of the debris pieces lies on the ground. At least one end of all debris pieces will initially be at a height of at least 16 inches.

If an intervention takes place during sub-task 1, all debris pieces will be reset. If an intervention takes place during sub-task 2, the second 5 debris pieces will be reset. If an intervention takes place during sub-task 3, the robot will be returned to the start, and no debris pieces will be reset.

Task 5 Door

Figure 5 shows the course layout for the Door task. The robot begins to the right of the diagram and proceeds to the left. The green line represents the start line.

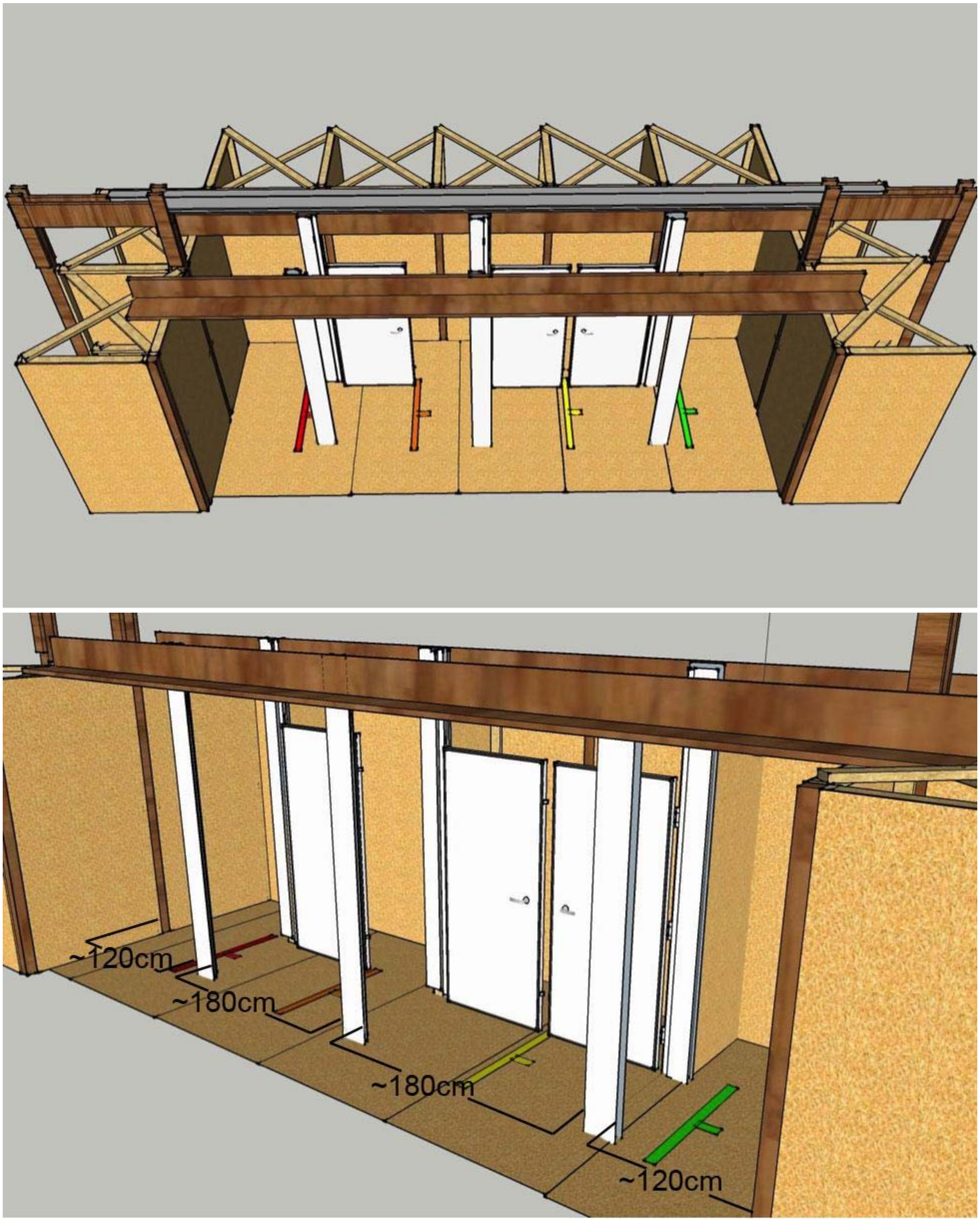


Figure 5. Course layout for Door task with all doors shown open. The dimensions are NOT accurate. The distances from right to left (that is, from start to finish) have been adjusted based on team feedback to be approxiately 6 feet, 6 feet, 6 feet, and 5 feet.

The Door task consists of three sub-tasks: (1) Enter push door (1 point), (2) Enter pull door (1 point), and (3) enter pull door with weighted closer (1 point). These sub-tasks must be completed in the given order.

For each of the three sub-tasks, completion requires the robot to first open the door and then travel through the open doorway. This sub-task shall be considered complete when all parts of the robot (excepting the tether) have traveled through the doorway.

None of the doors will have a threshold. The task will take place on a flat floor surface.

The DRC Trials will use a 36 inch doorway. Note that when a 36” door frame opens, the true width with jamb and the side of door is approximately 33.5 inches. (The DRC Trials Initial Task Description Bill of Materials specifies a 36 inch doorway. Note that the DRC Qualification document initially specified a 32 inch doorway, which was then relaxed to a 36 inch doorway.)

The start line for most of the tasks is three (3) feet from the beginning of the task. The start line for the Door task is closer than that, because of space limitations on the task stage.

The DRC Trials will use a lever-style handle on each of the three doors. The lever handle will be the same as that specified in the Initial Task Description document, namely, the Schlage Standard Duty Lever Lockset Passage Function, 2-3/8" Backset, Chrome (http://www.mcmaster.com/?error_redirect=true#13045a111/=p1p310), or similar. The door handle operates either by rotating downward or by rotating upward.

The height of a door handle shall be approximately 37 inches above the ground, no less than 32 inches above the ground, and no more than 48 inches above the ground.

The force required to open the pull door with weighted closer is approximately three pounds of force (3 lbf) applied at the handle.

For interventions that take place in the first sub-task, the robot will be returned to the start (behind the green line in Figure 5). For interventions that take place in the second or third sub-task, the robot will be returned to the designated location earlier in the course (behind the yellow and orange lines, respectively, in Figure 5), and all doors in front of the robot will be closed.

Task 6 Wall

Figure 6 shows the course layout for the Wall task. The robot will use a cordless drill to cut through wall boards to remove a prescribed triangular shape.

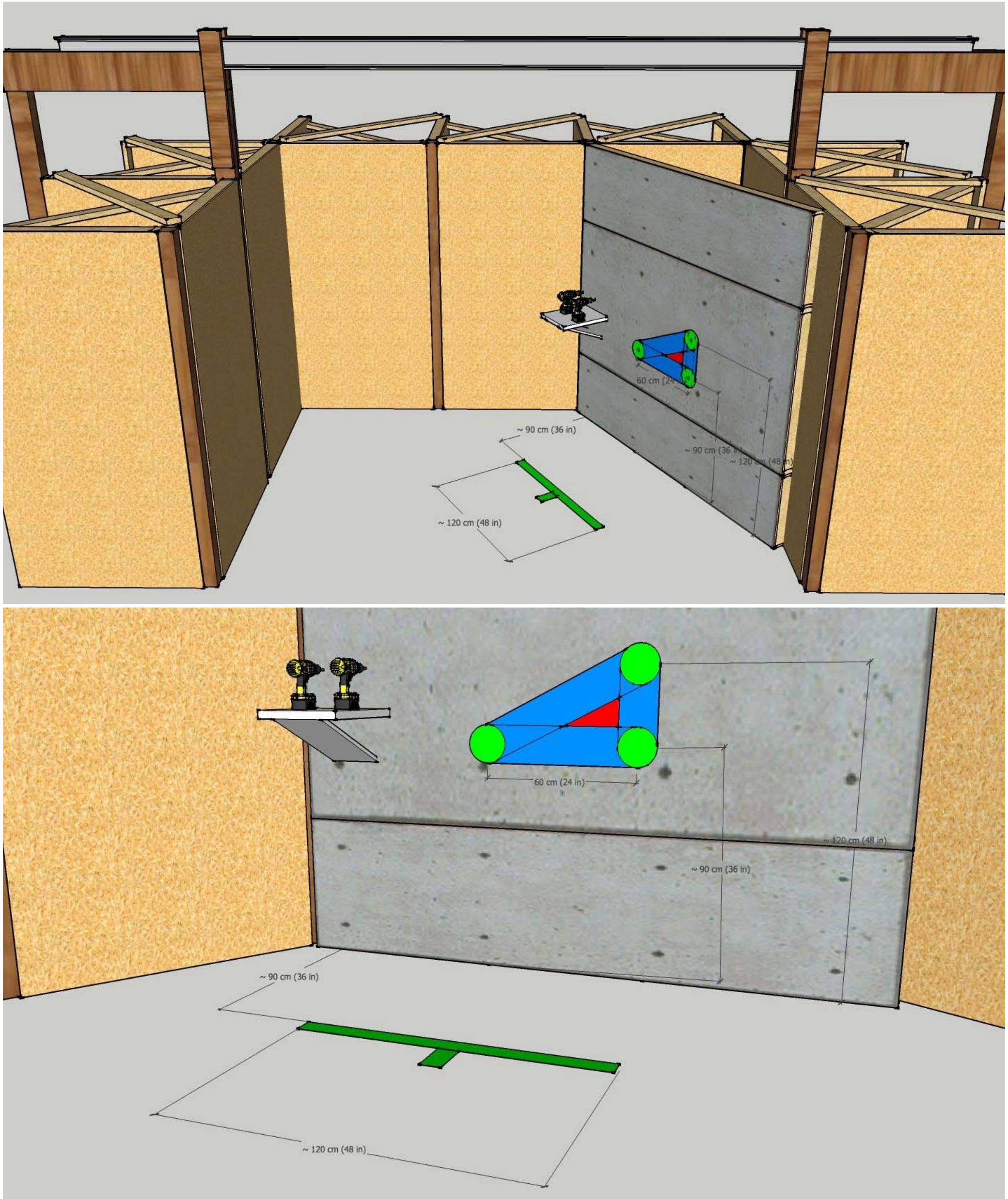


Figure 6. Course layout for Wall task

The Wall task will be scored as follows: (1) Cut one edge between two green vertices (1 point), (2) Cut a second edge (1 point), and (3) Cut a third edge and remove triangular piece from wall (1 point).

The wall material will be ½ inch thick drywall. There will be no obstruction or supports directly behind the cut pattern.

A single right triangle will be drawn on the wall as the shape to cut. The three vertices will be six (6)-inch diameter circles colored green. Two of the vertices will have a height of 36 inches, and the other vertex will have a height of 48 inches. The edges connecting the vertices will be six (6) inches wide and colored blue. The vertical edge will be 12 inches long, and the horizontal edge will be 24 inches long.

The task is to cut exclusively within the area colored green or blue to remove the red area, while not cutting into the area outside the area colored green, that is, not cutting any gray area. Once all green areas are connected with cut lines, the robot may push the drywall in an attempt to remove the red area. If the drywall is removed in this way, all breaks in the drywall must be within the margins described above. If the cracks extend into the gray area, the final task will not be considered complete. There is no requirement regarding the order or number of cuts necessary to remove the inner triangle.

For an intervention during any of the sub-tasks, the robot will be returned to the start.

Teams may choose between two drills:

- Dewalt DCD980M2 cordless drill or similar, and an additional side handle. The DCD980M2 has a trigger; to operate, the robot must grasp the drill and squeeze the trigger. This drill has a side handle, which the teams may set in any orientation or removed. The drill only runs for approximately five (5) minutes before it must be re-triggered.
- Dewalt DC550 cordless drill or similar, The DC550 has an on/off switch, not a trigger. To operate this drill, the robot must grasp the drill and press the on/off switch. (Note that the on/off switch is guarded by a piece of yellow plastic that prevents accidental switching. Some robot “fingers” might have trouble making contact with the switch. Teams might consider adding a “bump” on the finger that improves access to the switch.)

Teams may choose between two drill bits:

- Morris13042 bit or similar. Typically, this would be used with the DCD980M2.
- DW6603 ⅛ inch bit or similar. Typically, this would be used with the DC550 drill.

Bits shall be installed in the drill chuck so that the bit is able to use all available cutting surfaces, while remaining firmly secured by the chuck.

Two fully-charged drills of the type selected will be provided on a shelf in the workspace, both set to the highest speed. Drills will be OFF. Bits will be pre-installed. Drills will be standing upright on their batteries (as opposed to lying on their sides on the shelf), located approximately one foot apart. If one of the tools ceases to function (for example because the robot dropped it, or the bit broke), the robot may use the second tool. If both tools cease to function, the team may call an intervention, and the robot will be returned to the start and two new tools will be provided on the shelf.

Task 7 Valve

Figure 7 shows the course layout for the Valve task.

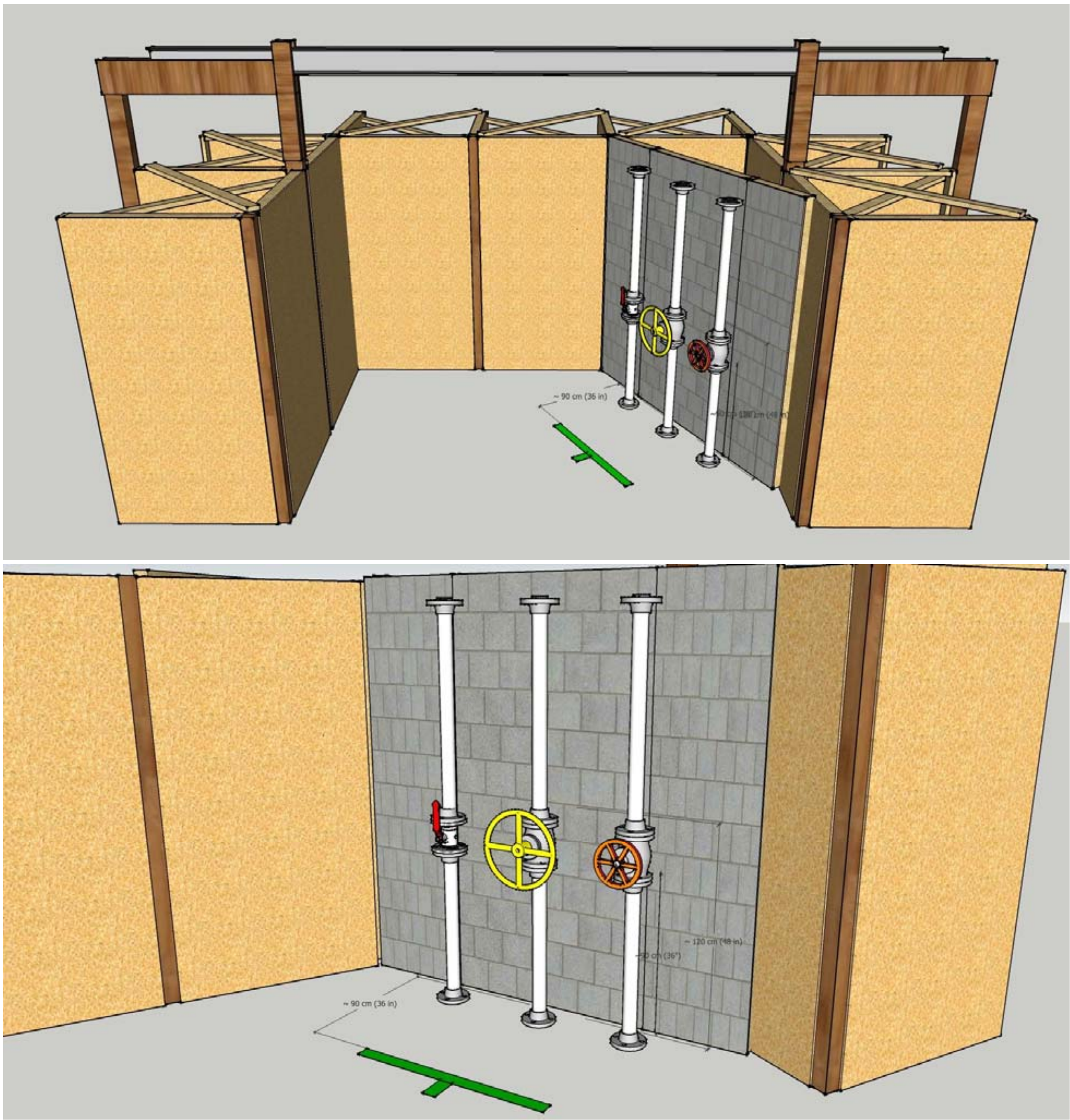


Figure 7. Course layout for Valve task

The Valve task consists of three sub-tasks: (1) Close a first valve (1 point), (2) Close a second valve (1 point), and (3) Close a third valve (1 point). Valves may be closed in any order.

The valves will control air flow in pipes, with indicators that visually show air flow. For each of the three sub-tasks, completion requires turning the valve until the flow of air stops.

One valve will be a 90 degree ball valve, with a 13 inch handle, that requires a rotation of 90 degrees to close. The DRC Trials will use the "CS Ball Valve 3 Inch" (Grainger Part Number 1PRB9, or similar). The valve will move upon application of no more than five pounds of force (5 lbf) to the tip of the handle.

Another valve will be a mid-size rotary valve that requires one (1) complete clockwise rotation to close. The DRC Trials will use a "Gate Valve" body (Grainger Part Number 1WPD6, or similar) that comes with a 9-inch diameter hand wheel. The valve will move upon application of no more than five pounds of force (5 lbf) to the edge of the hand wheel.

Another valve will be a large rotary valve that requires one (1) complete clockwise rotation to close. The DRC Trials will use a "Gate Valve" body (Grainger Part Number 1WPD6, or similar) with an 18-inch diameter hand wheel (available from Waterworks, Hyattsville, MD telephone 301-772-5845, part number 22639L hand wheel 10"-12" CLOW OL NRS 18") that is mounted on the gate valve. The valve will move upon application of no more than five pounds of force (5 lbf) to the edge of the hand wheel.

Initial positions for the rotary valves will be set by first closing them (so no air flows), and then opening them one (1) revolution.

The height of a valve center shall be approximately 40 inches above the ground, no less than 32 inches above the ground, and no more than 48 inches above the ground. The center-to-center distances between the valves is approximately two (2) feet.

For an intervention during any of the sub-tasks, the robot will be returned to the start.

The appearance of the wall may not be as visually "clean" as the wall shown in the figure, and may have a different texture.

Task 8 Hose

Figure 8 shows the course layout for the Hose task.

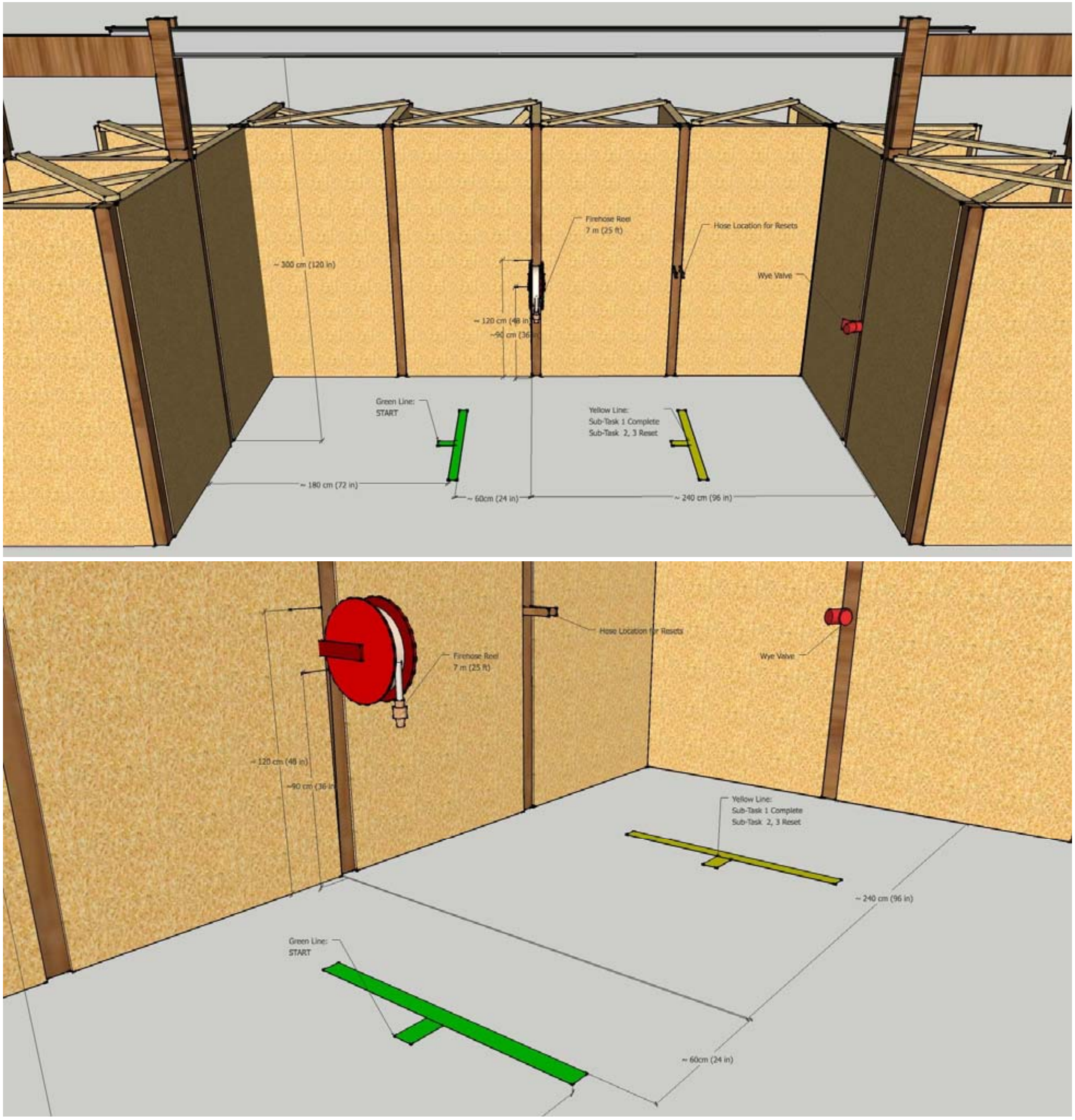


Figure 8. Course layout for the Hose task

The Hose task consists of three sub-tasks: (1) Hose nozzle moves past the yellow line (1 point), (2) Hose nozzle touches the wye (1 point), and (3) Hose nozzle attaches to wye (1 point).

For the first sub-task, the robot begins entirely behind the start line, travels to the reel, grasps the hose nozzle, and begins to unreel the hose. This sub-task shall be considered complete when the hose nozzle passes the yellow line.

For the second sub-task, the robot moves the hose nozzle to the wye.   This sub-task shall be considered complete when the hose end makes physical contact with the wye.

For the third sub-task, the robot attaches the hose nozzle to the wye. Typically, this would involve one hand holding the hose in place, and the other hand rotating the hose collar to mate with the wye. (If one rotates only the hose body, then the threads do not engage.) This sub-task shall be considered complete when the hose end remains in contact, unsupported by the robot, with the wye. There is no requirement on the number of turns of the collar or on the number of threads engaged.

The DRC Trials will use the following components:

- Wye: Plain Wye (1-1/2 inch NH Inlet x (2) 1-1/2 inch NH Outlet, Dixon brand, SKU PW15F15F, or similar)
- Hose: 1-1/2 inch hose (25 ft long, FireHoseDirect brand, SKU 15D850, or similar)
- Reel: Medium Fire Hose Storage Reel (Dixon brand, SKU HSR18, or similar)

The height of the center of the reel will be approximately 40 inches above the ground. In the initial state, the reel will be oriented approximately perpendicular to the wall. In the initial state, the hose nozzle will hang down from the reel as shown (Figure 8). It will be lightly secured in this position with painter's tape attached from the frame to the reel. The tape prevents initial breakaway if the robot bumps or brushes against the hose, without hindering the unreeling process once begun.

The height of the wye will be approximately 40 inches above the ground, no less than 32 inches above the ground, and no more than 48 inches above the ground.

If an intervention takes place during the first sub-task, the robot will be reset behind the start line, and the hose will be replaced on the reel, thus restoring the task to its initial state.

If an intervention takes place during the second sub-task, the robot will be reset behind the yellow line, and the hose will be placed in a hose-holding fixture mounted on the wall. The height of the hose-holding fixture will be approximately 40 inches above the ground, so the robot need not reach down to the ground to pick up the hose.

If an intervention takes place during the third sub-task, the same procedure will be followed as for an intervention during the second sub-task.