RoboCup Rescue Rulebook

Rapidly Manufactured Robot League/Mini Arena Edition
(as of 2016-06-07)
Version 1.3ma

This is a draft discussion document, based on the rules for the Major RoboCupRescue Robot League.

For the most up-to-date version of this document, please visit the website of the Open Academic Robot Kit, comp.oarkit.org. For inquiries and discussion, please visit and subscribe to the mailing list at list.oarkit.org .

New Concept for RoboCup Rescue

The main objective of our league is to conduct challenging and fair competitions that inform teams about the tasks necessary to be effective for responders. We also need to measure progress in our robotic systems to highlight breakthrough capabilities that responders can understand and appreciate. Ten or more successful repetitions begin to indicate a reliable capability. A series of trials across a suite of complementary tests begin to evaluate the system.

This year we transition the competition into a format that more closely resembles Response Robot Exercises. These have been effective in communicating capabilities between robot manufacturers and responders. Each robot will be evaluated in standard and draft standard test methods during Preliminaries to demonstrate functionality, reliability, operator proficiency, and autonomous/assistive capabilities. The resulting scores will qualify them for a "deployment" into a more complicated scenario in the Finals. This will enable concurrent testing opportunities for more robots to capture statistically significant performance. It will also encourage testing in more complex or difficult settings, challenging robots beyond their comfort level to compile more points.

The Finals will remain a comprehensive search and identification of simulated victims in the overall maze for the best performing robots. Each qualified team is allowed one robot. The maze will consist of all the same test apparatuses and tasks. As always, the search scenario will be conducted from random start zone and performed in any order of tasks the team chooses.

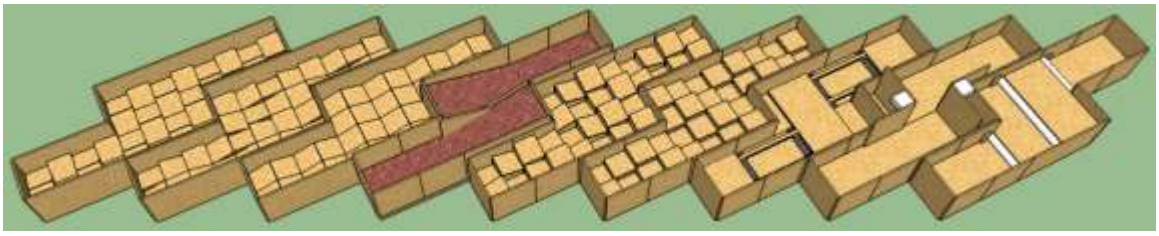
This year we will instantiate a rigorous, standardized process for practicing and measuring league capabilities throughout the year, with competitions being the public demonstration of those capabilities and sharing of results. So we encourage you to build

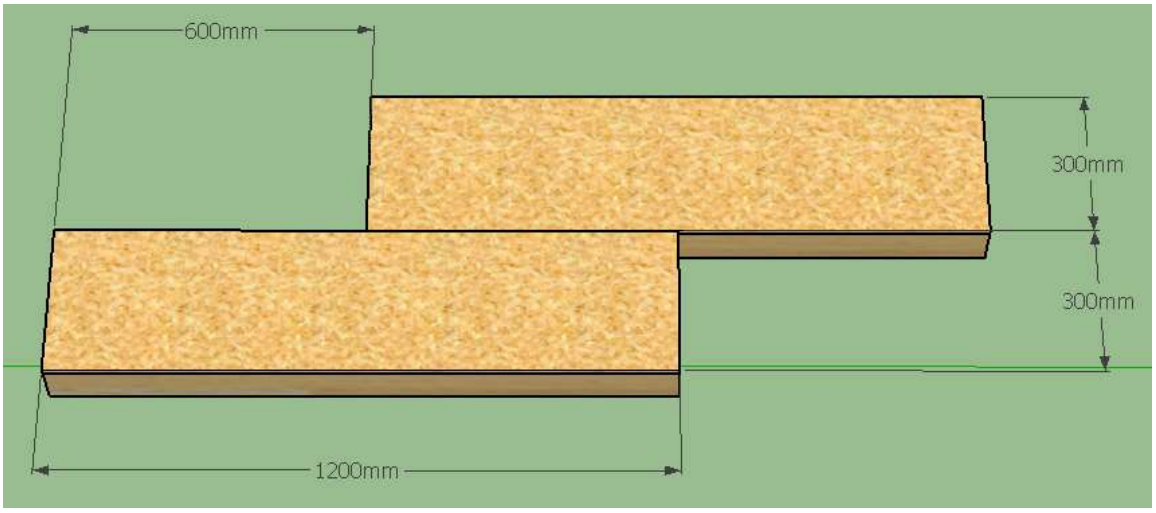
and practice these tests during your development. Then demonstrate your capabilities at competition time for scores.

This new structure will help our league communicate emerging capabilities to responders and allow them to guide such capabilities toward deployment. Local responders may come watch the competition and potentially demonstrate their own robots. This will familiarize them with the test methods and our emerging capabilities, making RoboCup Rescue a leading incubator for robots and test methods worldwide.

1 Test Suites

The new RoboCup Rescue League competition is designed around standard robot test methods that evaluate each robot's capabilities individually in a systematic way. The new competition consists of 20 ground robot tests which are structured into four suites: Maneuvering, Mobility, Dexterity and Exploration. **All bays are 1.8m (6ft) in length and minimum of 0.3 m (1ft) in width.**

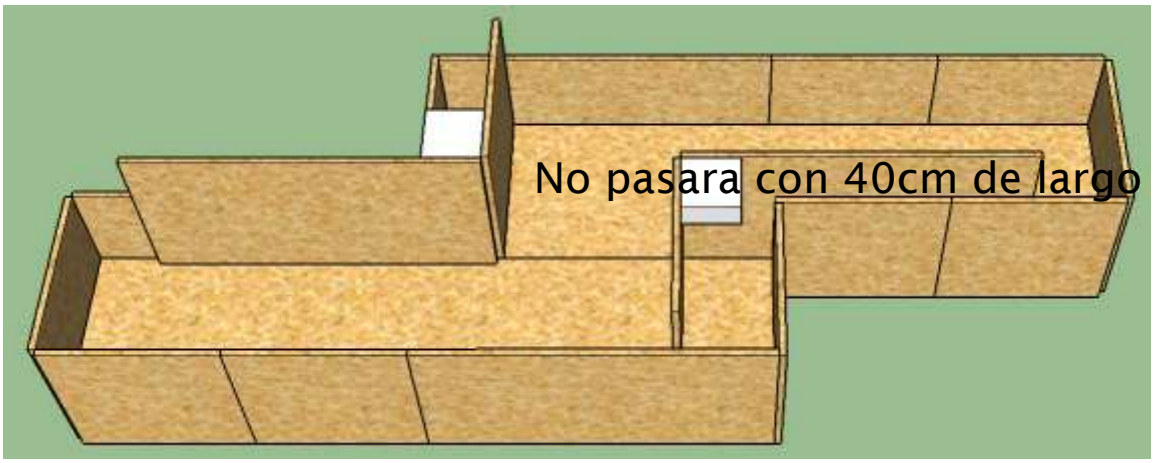




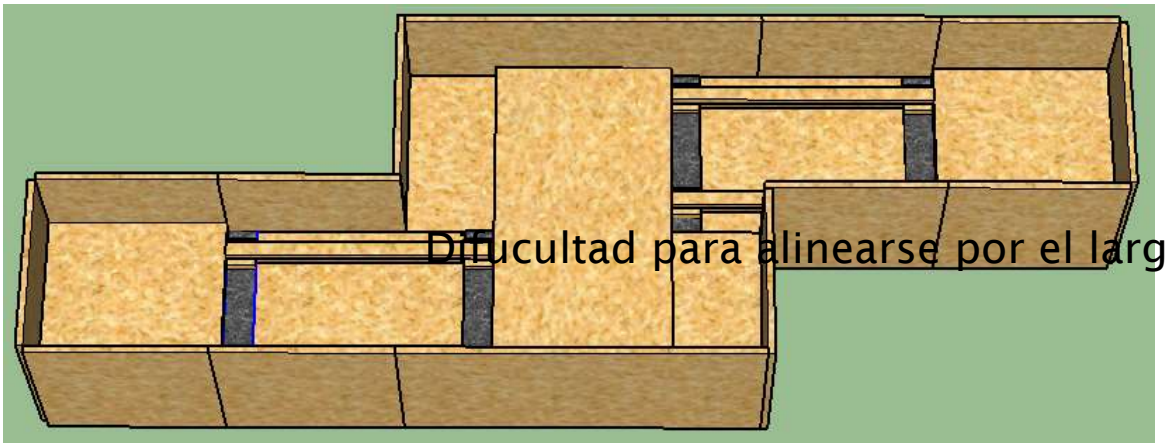
1.1 Maneuvering

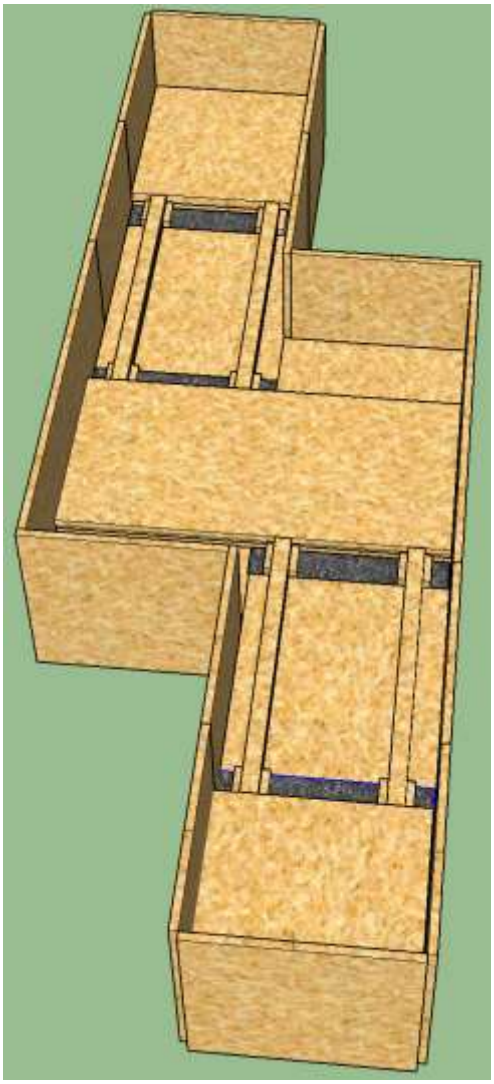
4 tests for basic driving over quite easy terrain completed in forward and (for non-autonomous robots) reverse driving orientations (all tests are mandatory for each robot):

- (MAN 1) **Center**: A slalom with turn width set to the robot's diagonal ground contact dimension, challenging a robot's awareness of interactions across it's width.

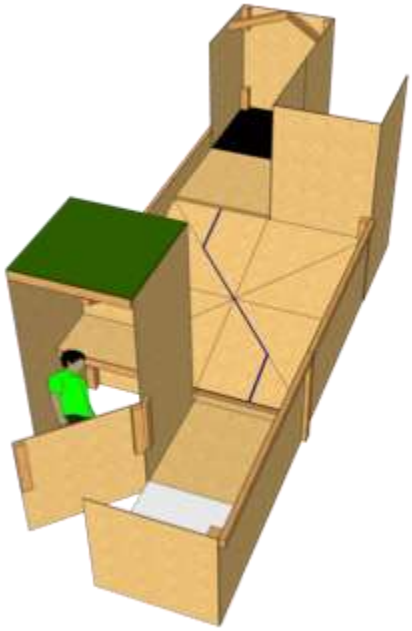


- (MAN 2) **Align**: Two bars (25 mm width) to cross which are set to the robot's outer ground contact dimension. The robot's tracks outer edges will be centered on each rail to limit left/right error similarly for various locomotion designs.



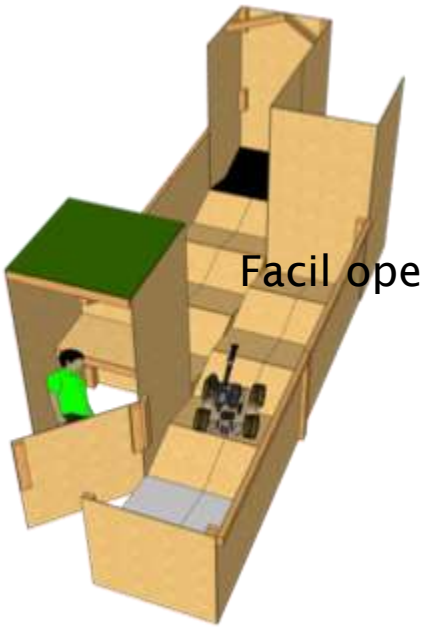


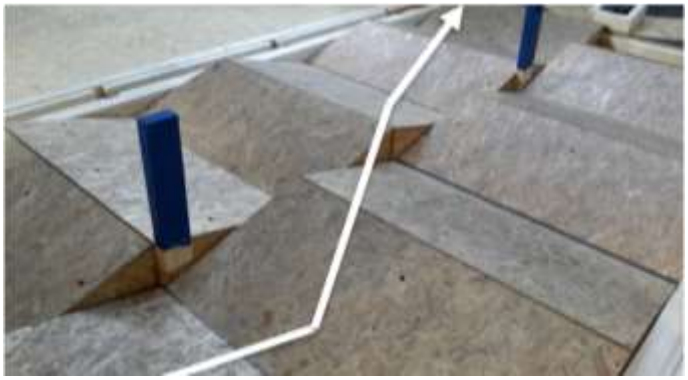
- (MAN 3) **Traverse**: A 30 degree inclined OSB surface to follow line in a zig-zag pattern both forward and reverse.
  (Full sized arena diagram shown.)



No entiendo bien si tiene que hacerlo autonomo o operado.

- (MAN 4) **Crossover**: A field of 15 degree ramps with a discontinuity to crossover. *(Full sized arena diagram shown.)*

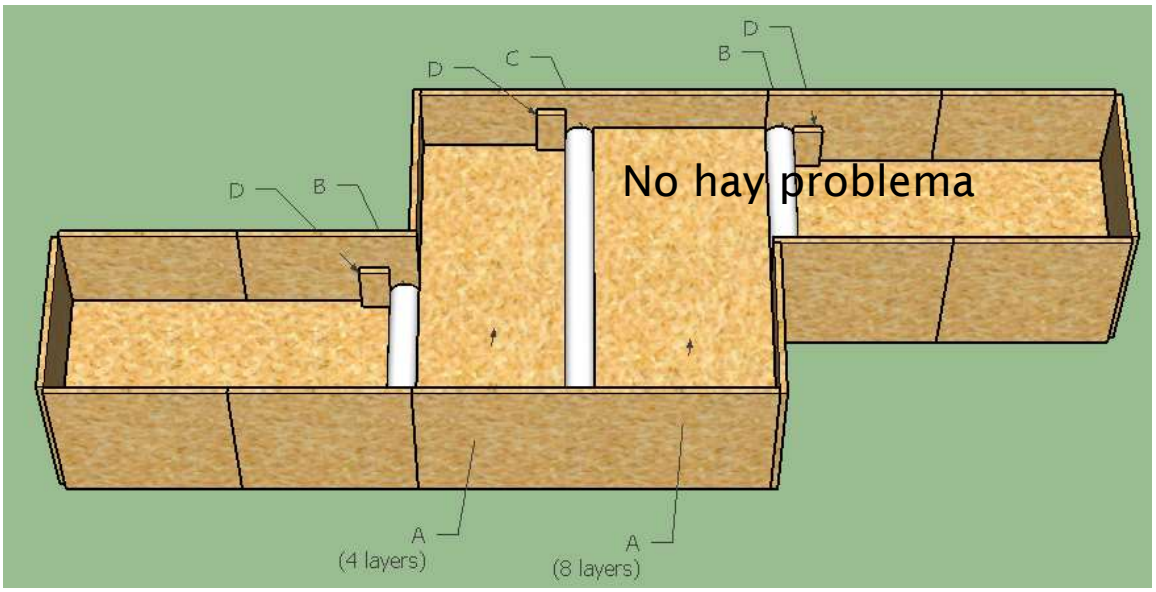


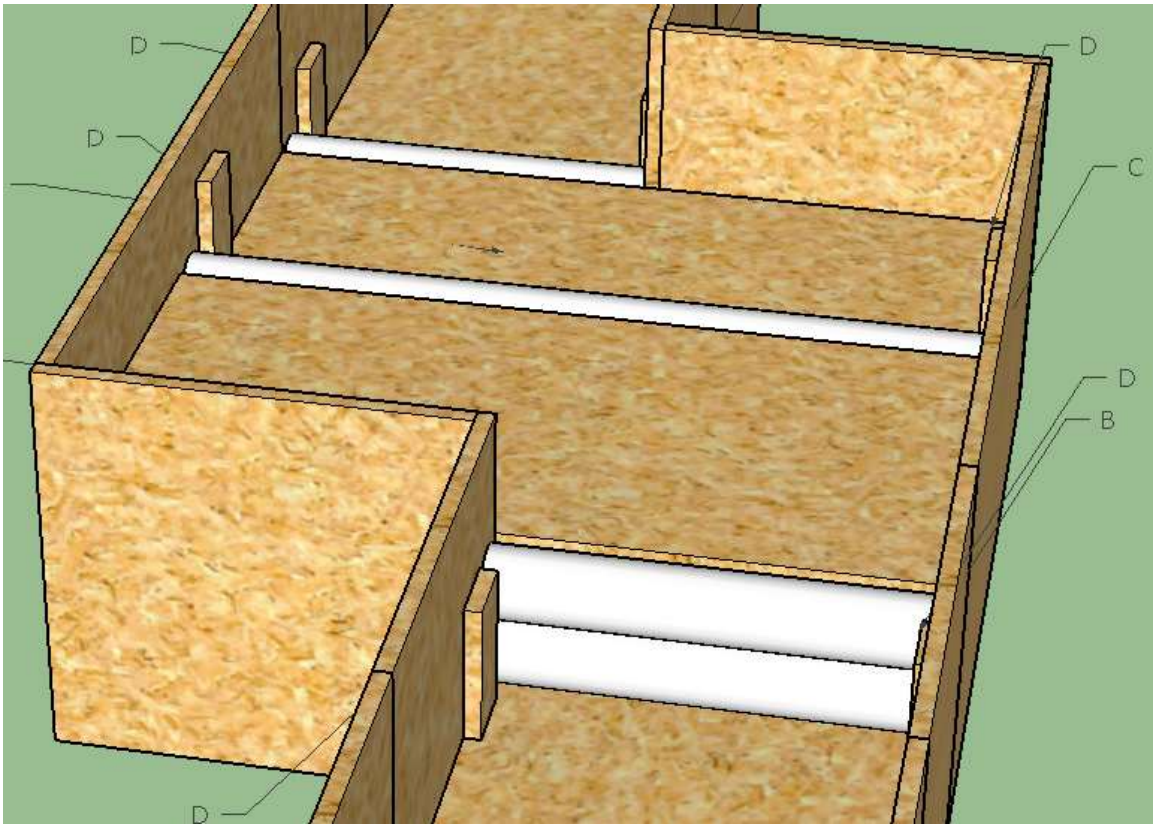


1.2 Mobility

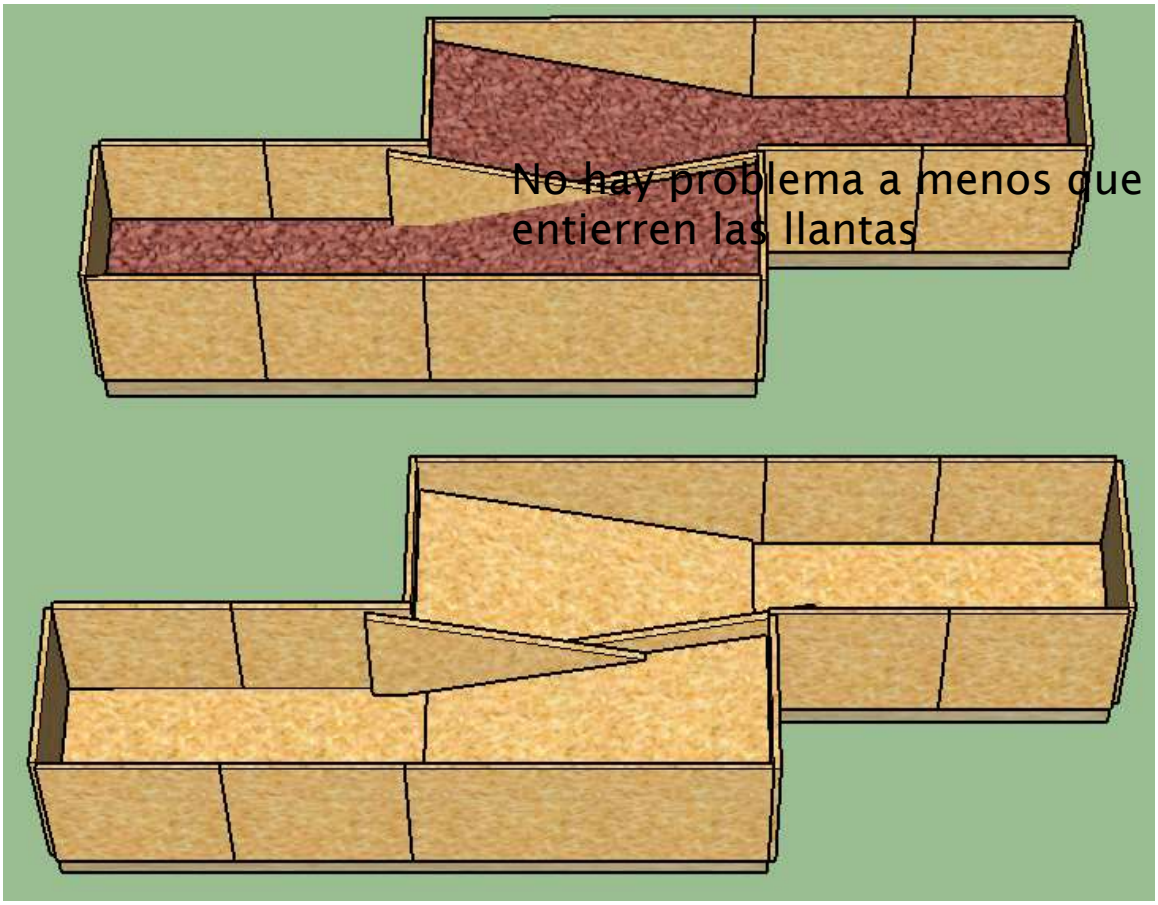
4 tests for driving over terrain with medium to hard difficulty (all tests are considered for a robot to win Best in Class Mobility). Robots are able to turn around.

- (MOB 1) **Hurdles**: A 5 cm tall rolling pipe obstacle to climb and descend.

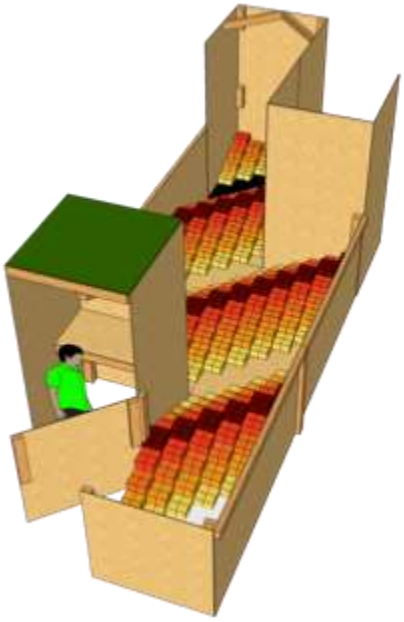


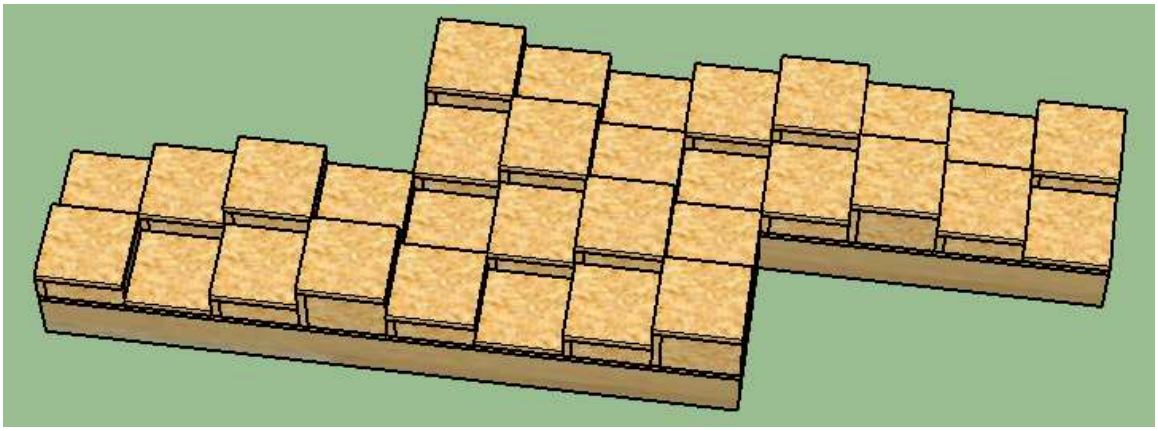


- (MOB 2) **Sand/Gravel Hills**: An alternating hill terrain with 15 degree slope.

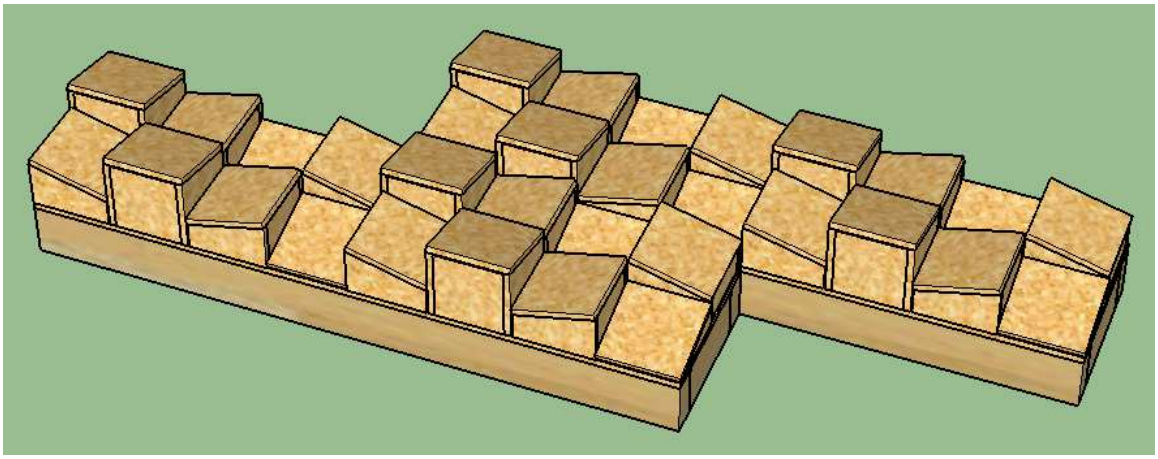


- (MOB 3) **Stepfields**: A diagonal hill terrain consisting of 15 cm square steps made from posts with flat tops.
  (Full sized arena diagram shown.)





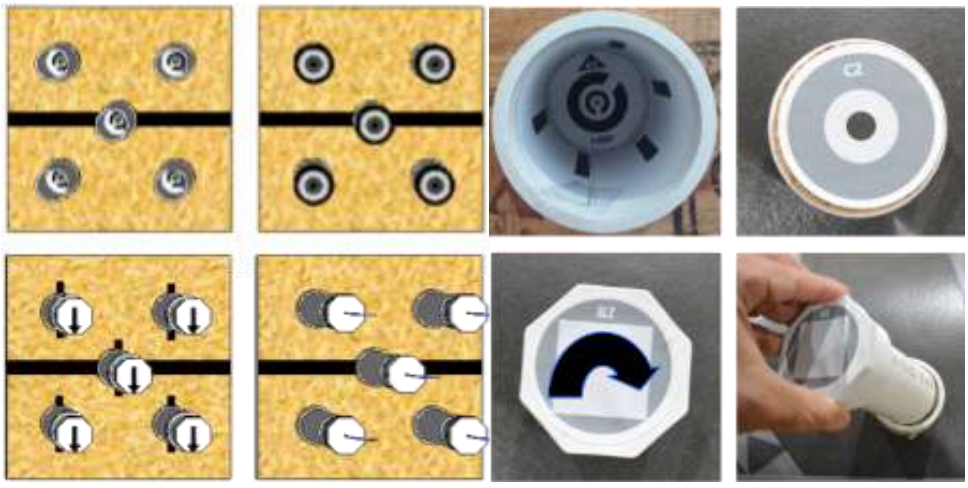
- (MOB 4) **Elevated Ramps**: A diagonal hill terrain consisting of 15 cm ramps with sloped tops (similar to the DARPA Robotics Challenge).



1.3 Dexterity

2 tests for manipulation and inspection (all tests are considered for a robot to win Best in Class Dexterity). **Pipes are 10 cm (4 in) in length and 5 cm (2 in) in diameter. Extract and rotate caps have 8 facets which are approximately 2 cm (1 in) wide.**

- (DEX 1) **Parallel Pipes**: Inspect, Touch, Rotate and/or Extract in total 20 parallel mounted pipes (mounted on 4 boards with 5 pipes on each board). This test is conducted within a terrain with ramps that requires mobility.



- (DEX 2) **Omni-Directional Pipes**: This is the Pipe Star variant of Parallel Pipes, but mounted in an omnidirectional orientation (tasks include Inspect, Touch, Rotate, Extract). This test is conducted on an inclined surface.

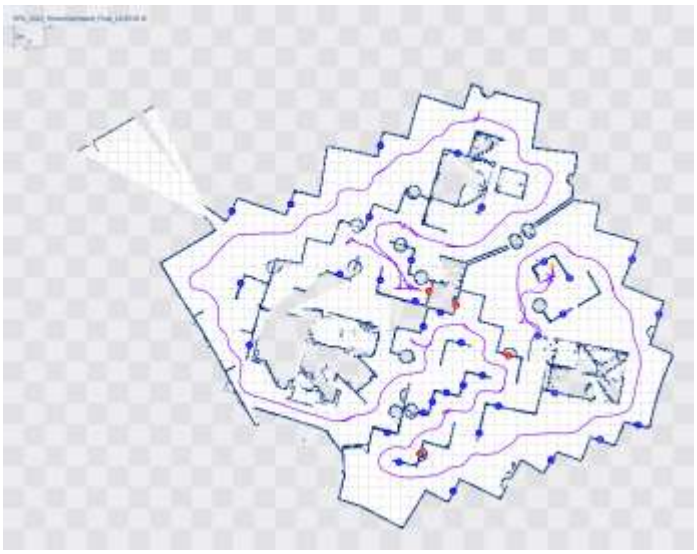
NECESITAMOS UN BRAZO MECANICO HECHO CON LOS SERVOS DE DYMEXT PARA TENER CONTROL PRECISO Y DOS CAMARAS, UNA PARA EN EL BRAZO Y OTRA EN UNA POSICION OPTIMA PARA OPERAR EL ROBOT (LA CAMARA DEBERIA SER ROTABLE EN ELOS TRES EJES PARA MAXIMO CONTROL)

1.4 Exploration (in the full sized arena)

DE AQUI EN ADELANTE CREO QUE YA NO TENEMOS TIEMPO

5 tests for mapping, object/terrain recognition and detection (all tests are considered for a robot to win Best in Class Exploration).

- (EXP 1) **Map on Continuous Ramps**: Create a 2D and/or 3D map of a dark Labyrinth while traversing modest ground complexity. This capability has to be an autonomous background service for teleop or autonomous robots.



- (EXP 2) **Map on Crossing Ramps**: Create a 2D and/or 3D map of a dark labyrinth while traversing increased ground complexity. This capability has to be an autonomous background service for teleop or autonomous robots.
- (EXP 3) **Recognize Objects:** Including QR codes, fire extinguishers, doors, simulated victims, and other items. This capability has to be an autonomous background service for teleop or autonomous robots.
- (EXP 4) **Avoid Holes**: Drive and map while avoiding amorphous negative obstacles along a robot's path - augmenting capabilities demonstrated in Align test method. This is for autonomous robots only.
- (EXP 5) **Avoid Terrains**: Drive and map while avoiding amorphous terrain obstacles without enclosing walls (e.g. stepfields, small obstacles). This is a test for autonomous robots only.

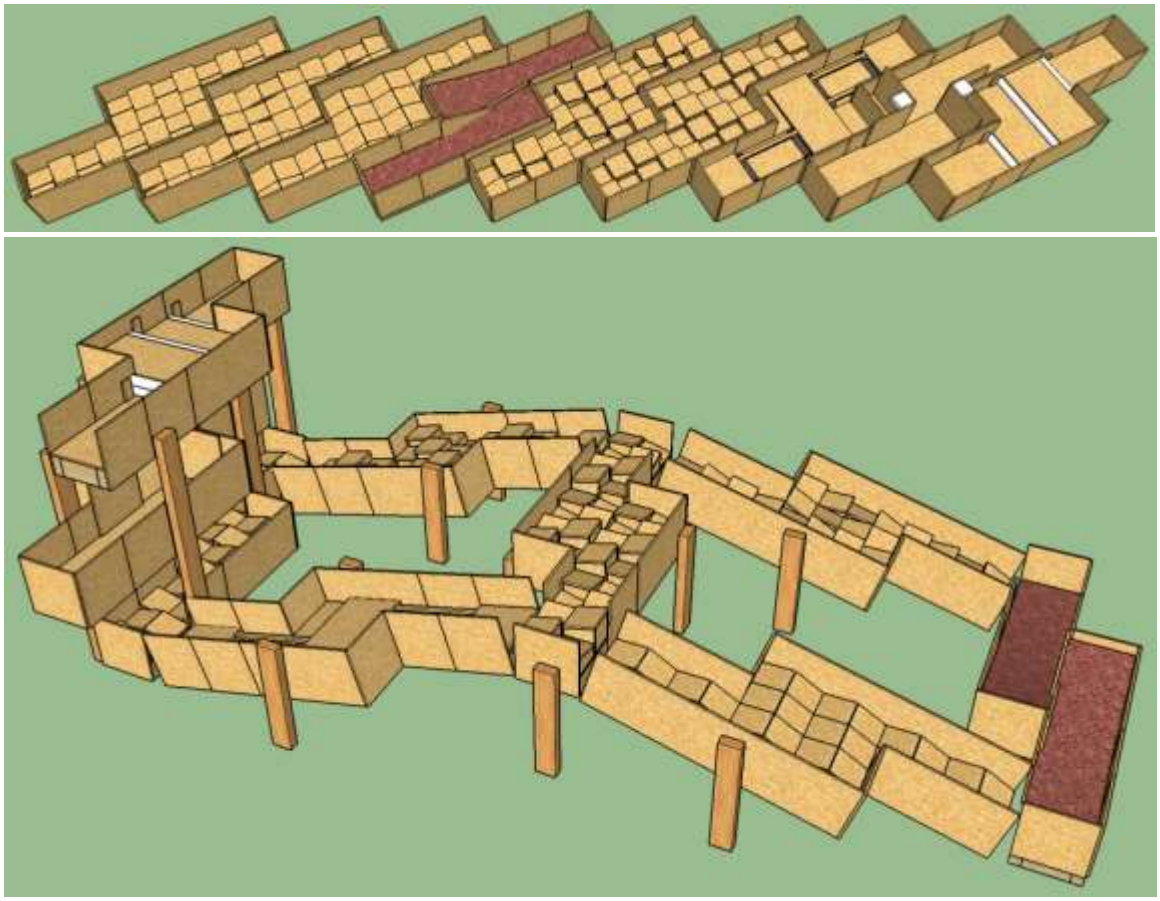


Figure 1: Sample arena layout showing locations of all the test lanes set up for concurrent operation (top) and as a maze arena (bottom).

2 Robot Configurations

Readiness check of system sensors and dexterity

The preliminary test trials have no victims. In order to reflect expected performance in the finals where robots are expected to locate victims, at the start of each trial, the robot will perform a set of 6 inspection and 4 dexterity tasks. The number of successfully completed tasks will form a multiplier on the test trial score. This encourages more capable systems toward the finals and expects less capable systems to be much more efficient in performing each task. Teams may trade off between spending longer on this task to yield an increased multiplier, or spending more time performing repetitions in the trial.

The 5 identification tasks, worth 1 point each:

- **Video Image Resolution:** Use any c*amera to either teleoperatively identify the middle concentric C gap relative to the center of the of the 4 square panel (answer shown = 0°), or autonomously identify the middle size QR code and display correctly on the OCU display*
- **Motion Detection**: Use any camera and integrated video processing to correctly identify the number of moving targets (1-4) automatically, not by operator. Highlight (e.g. draw a rectangle around the area) and track the identified motions in the OCU display and textually or audibly warn the operator about such motions. Teleoperatively initiating this capability for a stationary robot is permitted.
- **Thermal Image Resolution**: The operator identifies the concentric Landolt C with a 2 cm gap to evaluate thermal resolution (regardless of the robot being teleoperated or autonomous).
- **Audio Acuity**: Use system microphones and speakers to correctly identify 2 lines which consists of 5 random numbers for each line. Random number strings (5 single digits each) will be articulated by a computer voice in .
- **Color/Pattern Recognition:** Use any camera and integrated video processing to correctly identify 3 of 4 hazmat labels from a known set of 12 possible. Highlight and track the identified labels in the OCU display and textually or audibly warn the operator about such hazards. The labels can be found at http://wiki.robocup.org/images/2/27/Hazmatlabels.pdf


Thermal Image Resolution
Video Image Resolution
DANGEROUS WHEN WET
SPONTANEOUSLY COMBUSTIBLE
4
INHALATION HAZARD
2
OXIDIZER
Color/Pattern Recognition
Motion Detection

Figure 2: Identification Tasks.

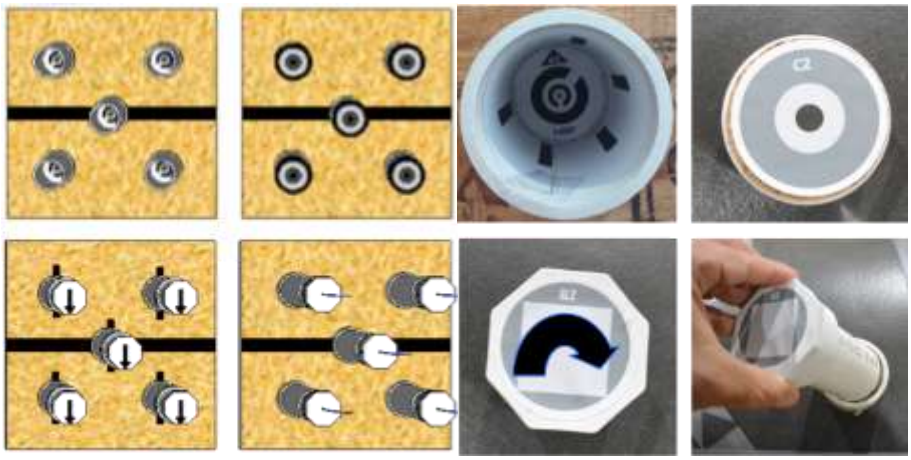


Figure 3: Dexterity tasks

The 4 dexterity tasks, worth 1 point each:

- **Inspect**: Identify the number of bars placed on the internal walls of a 5 cm pipe.
- **Touch**: Touch a 1 cm diameter circular target on the end of a pipe.
- **Rotate**: Grab a 5 cm octagonal pipe cap and rotate 180 degrees.
- **Extract**: Grab a 5 cm octagonal pipe cap and pull out of the pipe.

3 Robot Classes

Autonomous and Teleoperated Robots are compared together as they compete the exact same terrain, obstacle, or task repetitions. A repetition consists of successful completion of a terrain or obstacle from start zone to end zone, or a dexterity task.
A robot may be in more than one class. The classes are:

- **Autonomous Robot**: A robot that completes a repetition without intervention by a single operator in a remote operator station. Any repetition (which is a subtask such as driving from the start zone to the end zone or the other way) that requires operator intervention is considered a teleoperation repetition.
- **Teleoperated Robot**: A robot that completes a repetition with any intervention by a single operator in a remote operator station.

4 Primary robot / CarryBot / MicroAerial

(This section not relevant to the Rapidly Manufactured Robot League/Mini Arena.)

5 Trophies and Certificates

As 2016 is a demonstration year, there will be no formal trophies awarded. The criteria for the awarding of certificates will be determined at the start of the competition.

6 Competition Schedule

The competition is structured as follows:

- Preliminaries: At least 12 missions (time slots) per primary robot are assigned to the teams; up to 15 min each plus an additional 5 min for pure autonomy. The goal here is to score as many points as possible in the test methods. In general, you get one point for getting from the start zone to the end zone and another point for the way back from the end zone to the start zone (and so on). The result of the 5 maneuvering tests plus 5 other best test results are added up for the qualification. See Sec. 6.1 for details.
- Finals: Each mission lasts 30 min. The goal here is to score victims with the Primary robot. See Sec. 6.2 for details.

6.1 Preliminaries

Your team will select a certain subset (at least 10) of the 20 test methods and perform in up to 20 minute test runs. You will get at least 12 time slots to perform the selected tests, such that you have the chance to improve your score of two (or more) tests.

6.2 Finals

- The best teams qualify for the finals.
- Only a single robot (the qualified Primary robot) is allowed in the finals.
- Score is reset to 0 before the finals (i.e. points from the preliminaries do not count for the finals).
- Goal of the finals is to score as many victims as possible, and to gain as much information about each victim as possible (e.g. vision, heat, audio, mapping).
- If the robot is able to find all victim locations during the final run, it can start over the search to gain more points.

Test Execution:

The procedure for each test (each run that a team performs) is as follows.

- Each time slot is 30 minutes.
- Before your mission, move your robot to one of the provided waiting tables.
- **5 minutes Setup Phase**: place your robot at the start zone and establish the connection to the operator station. Do not start the readiness test or run. Your robot should point towards the open victim box, which is placed near the start zone.
- **15 minutes Readiness Test and Run Phase**.
- During the readiness test teams may obtain up to 10 points:
    - 5 for sensor tests:
        - Video Resolution (either manual Landolt C or automatic hazmat sign or automatic QR code detection)
        - Motion detection,
        - Thermal Image Resolution,
        - Audio Acuity,
        - Color/Pattern Recongition
    - 4 dexterity tests:
        - Inspect,
        - Touch,
        - Rotate,
        - Extract,

  These points serve as a multiplier for the results.
- A team can perform each repetition (i.e. move from the start zone to the end zone or move from the end zone to the start zone) either tele-operated or autonomously.
- Each successful complete repetition is counted as one point.
- Only if a repetition is done completely autonomously, it counts as an autonomous repetition.
- If the operator switches back within a repetition from autonomous mode to teleop mode, the repetition is still valid, but is considered as done teleoperated.
- **Extra 5 minutes Autonomous Operation only**. Teams can use extra 5 minutes to perform the same task autonomously to gain autonomously scored points. In that phase no switch to tele-operation is allowed; switching back to teleoperation mode would end the run automatically. At the start of this 5 minute time slot, if the robot is not autonomous since it left the start zone, the robot has to be driven back to the start zone and continue autonomous for the rest of the run.
- **5 minutes to clear the arena**.
- There will be a global clock, so all tests in all test lanes start and stop at the same time.

- If your robot has radio issues, you are free to use a tether / cable to communicate with the robot.

Scoring

- Every team can repeat a test, as often they want if it is available and the team has a free token to place. Only the best result will be kept for the task and team.
- All scores will be normalized per test method, so that the best team gets 100 points. This calculation is done after all teams have completed all tests in the preliminary round. The other teams get points proportionally. Example: For test method Dexterity 1: If team A scored 20 points and team B scored 10; then at the end of the preliminaries the score of team A will be set to 100 and the score of team B to 50. This way, for each test method the best team gets 100 points.

There is no multiplier for autonomous operation, but autonomous robots get extra time (5 minutes) in each test method in which only autonomous operations are allowed. Also robots that worked teleop during the mission get this extra time if they switch to autonomy.

6.3 Best in class

As 2016 is a demonstration year for this competition with an unusually small number of teams, there will be no formal Best-in-Class competition. Instead, this will be an opportunity to determine suitable Best-in-Class awards and how the Major competition Best-in-Class procedures may be adapted.

7 Remarks

- Resets: 2 min time penalty for each touching and/or moving of robot. After a reset, the robot has to start from the last start zone again. The robot keeps the points achieved so far.
- For some test methods, the robots have to drive in reverse mode. So make sure you are able to do that by either having backwards looking cameras or other sensors on the backside of the robot.
- The competing robots can be tethered.
- Radio regulations of the host country have to be respected.
- Rules and arena layouts are subject to change.
- The pictures of the test method in this document do not guarantee the actual implementation of this test method.