# 2015 IEEE R5 Conference

# Student Robotics Competition Rules

This document contains the rules for the 2015 robotics competition. The competition is open to teams of no more than 5 undergraduate students who reside within the IEEE Region 5 boundaries.

### Venue

The 2015 region 5 robotics competition will be held in the LaSalle ballroom at the Intercontinental hotel at 444 St. Charles Avenue in New Orleans, La, less than ½ mile from the historic French Quarter, on April 18th , 2015 starting at 8:00 AM. The venue will be available for robot practice starting on Friday April 17th at 2:00 PM. The venue is smaller than normal this year and we expect larger than normal participation so be prepared for congestion. Five practice fields will be installed starting at Noon on the 17th. These will be available when the venue opens. Teams will have access to the practice fields until 1 hour before the start of the competition on Saturday the 18th. Wireless communications with the robots is prohibited within the competition ballroom during both practice and competition.

### Events and Prizes

There are several events and meals scheduled starting Friday night. Registration is required for area entry and badges must be obtained at registration. The competition will conclude in the awards banquet on Saturday evening. Cash prizes and certificates will be awarded at the awards banquet to the top three teams. An additional "Perfect Score Prize" will be offered this year. Specific details of award values will be provided by the IEEE at a later date.

### Videotaping

Flash photography is prohibited during the competition. No light sources, external to the robots, can be used during the competition. The Organizing Committee will videotape the competition and display the live action on large screens in the ballroom during the competition.

Rules follow.

**2015 IEEE R5 Robotics Competition rules**

This year's competition challenges the sensing, navigating, learning and reading capabilities of an autonomous robot. The field is a simple maze. Scoring emphasizes rational search patterns, path learning, symbol reading, and speed.

**Playing field**: The playing field is a 7x7 array of 1 sq. ft. cells. Mazes will be built on the playing field in sizes ranging from 5x5 to 7x7. From a top view (see figure 1) each cell has ¾" black vertical and horizontal stripes to aid in navigation. The stripes are horizontally and vertically centered in each cell. The floor of the playing field is slotted (7/32") between cells for the insertion of wall segments (7.5"Hx11-3/4"W) or speed bumps (½"H x ¾"W x 10"L). The cells will be numbered for the judges' purposes

The mazes (see figure 2) shall be simple. They shall consist of a single central path from the start cell to the finish cell with dead end branches on both sides of the central "critical" path. There will be no closed loop paths. All paths except the critical path shall terminate in dead ends. There will be an equal number of dead end path lengths on each side of the critical path. There is only one critical path in any maze.

**Objective:** There are 3 qualifying rounds and a final round. The primary objective of the qualifying rounds is to score points by learning the critical path of the maze in a rational search pattern and then by running the robot through the critical path. The secondary objective of the qualifying rounds is to earn additional points by recognizing characters on the walls. The ultimate objective of the finals is to be the fastest (adjusted time) to the end cell. A robot's time is adjusted in the finals by achieving the solution to the character recognition problem.

**Challenge**: The challenge has two parts in each round. The robot must perform part 2 immediately after part 1. A team member shall have 1 minute to set their robot before each run.
**Part 1** - The robot searches the maze to find the shortest (critical) path from start to end within a fixed time limit for each round. During the search, the robot scores points by entering new squares and by identifying easter eggs. Easter eggs are symbols on the walls (see easter egg rules). They may be letters, numbers, or other special characters. Identifying and reporting easter eggs earns points in the qualifying and final rounds and additional time bonuses are also earned in the final round (see scoring).
**Part 2** - If the robot completes the maze in part 1 within the allotted time (i.e. the robot makes it to the end cell of the maze) and then lights a red LED, the robot will be allowed a critical path run. In the critical path run, points will be awarded for correct moves along the critical path and deducted for moving off the critical path.

**Qualifying**: Robots will advance to the finals by earning points in three qualifying rounds. In each round all robots will compete on identical mazes. There will be three scoring rounds with time limits. Scoring is cumulative throughout the qualifying rounds. Each scoring round will consist of both parts of the challenge. Each robot will have a fixed time period to move from start cell to

end cell. The time periods for each round are given below. Along the way, the robot must learn the critical path. If the robot completes the maze in the allowed time in part 1 it will be given a second run (part 2). Points will be awarded in all Part 1 runs each time a robot completely enters a new square or identifies an "easter egg". In Part 2 of each round points will be awarded for correct moves (unique moves along critical path) and deducted for incorrect moves (i.e. moving into a square which is not on the critical path (part 2) or repeating a path move (part 1 and part 2)). A path move is a completed motion, i.e. clearing the cell boundary, from one square to an adjacent square. A path move is described by its start cell and end cell, i.e. 26-19. Robots will automatically advance to finals if they complete the maze (i.e. execute a correct critical path run with no penalties – part 2) in any round. A minimum of 25% of competitors will advance to the finals based on cumulative scoring in the three qualifying rounds. There will be no speed scoring benefit in the qualifying rounds other than the speed of scoring points. "Easter egg" characters/symbols will appear on the walls in rounds 2, 3, and the final round. Identifying the characters/symbols during the search run (part 1) earns additional points (see Scoring:). Speed bumps (½"H x ¾"L x 10"W) will appear in round 3 and the final round.

**Size and timing – Qualifying Rounds** (see timing rules)

1. Round 1: 5'x5' maze – 3 minute search limit/1 minute critical path limit
2. Round 2: 6'x6' maze – 4 minute search limit/1 minute critical path limit – Easter eggs
3. Round 3: 7'x7' maze – 5 minute search limit/1 minute critical path limit – Easter eggs, speed bumps, and perfect score challenge

**Finals**: The finals will be conducted on a 7x7 maze. The finals format will be the same two part challenge with a modified scoring. The winning criteria for the finals will be the adjusted times of the critical path attempts (part 2). The adjusted time is the robot's start to end time (from the judges "go" signal till the robot completely enters the end cell) minus the "easter egg" time bonus the robot scores in the search phase (part 1). "Easter eggs" are symbols on the walls. There are numbers, letters, and others. To score the "easter egg" time bonus the robot must read the symbol during the search run, record its location and report it at the end of the run (see Easter egg rules). There will be more speed bumps in the finals.

**Easter egg rules**:

1. Easter eggs must be identified by character and which numbered square they are in.
2. Easter egg identifications must be made by downloading an ascii text file to a flash drive, provided by the judge, at the end of the search run (part 1). The text shall contain a list of square numbers and their associated "easter egg" characters. There will be no penalty for incorrect identifications.
3. Robots which attempt the character recognition problem must provide an accessible, i.e. top mounted, USB port for insertion of the judge's flash drive.
4. "Easter egg" characters:
    a. Letters - ABCDEFGHIJKLMNOPQRSTUVWXYZ
    b. Numbers - 1234567890
    c. Other characters - !@#$%^&*()

5. Easter egg characters shall be 1" high, uppercase, Calibri font, and black.
6. They shall be horizontally centered on their wall sections.
7. The tops of the easter egg characters shall be 1" from the top of the wall
8. Easter egg walls shall be painted pink for letters and blue for numbers. The "Other characters" shall appear on either pink or blue walls.
9. The maximum easter egg score in the finals shall be 35% of BTB (see scoring)
10. In each maze in which they appear there will be 20 easter eggs
    a. 8-ea - Numbers
    b. 2-ea- Letters
    c. 10-ea- Others
11. The easter eggs will be evenly distributed between the left and right sides of the maze.

**Ranking criteria – Winning criteria and successive tie breakers**

1. Lowest adjusted time for execution of critical path in finals
2. Highest scoring (points) of all critical path attempts in finals
3. Lowest adjusted time in finals search path run
4. Highest combined point total in finals round
5. Highest combined point total in all rounds

**Scoring - Qualifying rounds (1, 2, 3)**

| | | | |
|---|---|---|---|
| 1. | Entering new squares (part 1) | +1 | |
| 2. | Correct critical path moves (part 2) | +2 | |
| 3. | Lighting a correct light (red or green) | +1 | |
| 4. | Repeating a path move (both parts) | -1 | |
| 5. | Touching wall (both parts) | -1 | max penalty per square |
| 6. | Moving off critical path (part 2) | -1 | |
| 7. | Easter egg – numerical | +1 | |
| 8. | Easter egg – alphabetical | +2 | |
| 9. | Easter egg – other symbol | no score except "Perfect Score Challenge +1" | |

**Scoring - Final**

| | | | |
|---|---|---|---|
| 10. | Adjusted critical path (part 2) execution time | Winning criterion | |
| 11. | Search path (part 1) execution time | 2nd tiebreaker criterion | |
| 12. | Entering new squares (part 1) | +1 | |
| 13. | Correct critical path moves (part 2) | +2 | |
| 14. | Lighting a correct light (red or green) | +1 | |
| 15. | Repeating a path move (both parts) | -1 | |
| 16. | Touching wall (both parts) | -1 | max penalty per square |
| 17. | Moving off critical path (part 2) | -1 | |
| 18. | BTB – Bonus time base | Fastest critical path time in finals | |
| 19. | Easter egg – numerical | +1 plus 5% of BTB off critical path time | |
| 20. | Easter egg – alphabetical | +2 plus 15% of BTB off critical path time | |
| 21. | Easter egg – other symbol | no score | |

**Timing rules**

1. One team member shall be given three minutes to boot the robot prior to start (part 1).
2. All robots shall light a green ready light when they are ready to run (part 1 and part 2).
3. At the timing judge's direction, the team member shall have one minute to prepare to start the robot.
4. Robots shall be started by a push button on the top of the robot at the timing judge's direction to start. Timing will begin at the timing judge's direction to start.
5. The robots path time will stop when the robot clears the end square threshold.
6. In part 1, a robot's run may continue until the time limit (for that round) is expired; i.e. if the robot wishes to continue searching and scoring points after it reaches the end square it may do so with no search time penalty. This is only relevant for part 1.
7. In part 2, the path time for the run is recorded when the robot completely enters the end square and the robot must shut down.
8. In the Perfect Score Challenge, the robot must light the red light when the robot enters the end square in part 2 in addition to the requirement for part 1.

**Special rules**

1. All robot designs must be original. No kits.
2. Construction sets are permissible.
3. Touching a wall will result in penalty points.
4. Damaging a wall will result in disqualification.
5. Robots must be less than 7.5 inches tall at all times.
6. While an 8"Lx8"W robot may be able to maneuver, 7"x7" or smaller is recommended.
7. Robots may not split into separate parts.
8. Robots may not fly, or jump, or attempt to climb walls.
9. The playing field squares shall be numbered horizontally and vertically from 1 to 49.
10. 5x5 mazes shall start in cell 48 and end in cell 9. 6x6 mazes shall start in cell 48 and end in cell 1. 7x7 mazes shall start in cell 49 and end in cell 1.
11. The start cell will be outside the maze area where possible, directly below the bottom right cell of the maze area (see figure 2).
12. The end cell shall always be within the square maze area (ignore figure 2).
13. Smaller mazes will start below the maze area.
14. Robots shall be sequestered prior to all rounds.
15. All robots shall be powered down when sequestered.
16. A robot's run will end if the robot stops moving for more than ten seconds.
17. Upon reaching the end square (part 1) the robot must light a red success light
18. All robots must have a stop button. Teams will terminate runs by pushing the stop button. Teams must terminate at judge's direction or by team choice.
19. Critical path attempts (Part 2) must be made immediately after searches (part 1).
20. Critical path attempts shall be initiated by pushbutton at judge's direction.
21. No wireless communication, control or telemetry, is allowed with the robot in the competition venue.

**Perfect Score Challenge**

To win the perfect score challenge a robot must obtain a perfect score in the third qualifying round. To obtain a perfect score the robot must complete the following tasks, in the order specified, within the stated time periods.

1. Light the green light before starting the search path run.
2. Visit every square on the maze at least once within 5 minutes in the search phase (part 1).
3. Light the red light when the end cell is entered (part 1).
4. Locate, decode, and correctly report all 20 easter eggs (part 1).
5. Light the green light before starting the critical path run.
6. Execute a correct critical path run within 1 minute (part 2).
7. Light the red light when then end cell is entered (part 2).
8. Avoid all walls.
9. Avoid repeated path moves.

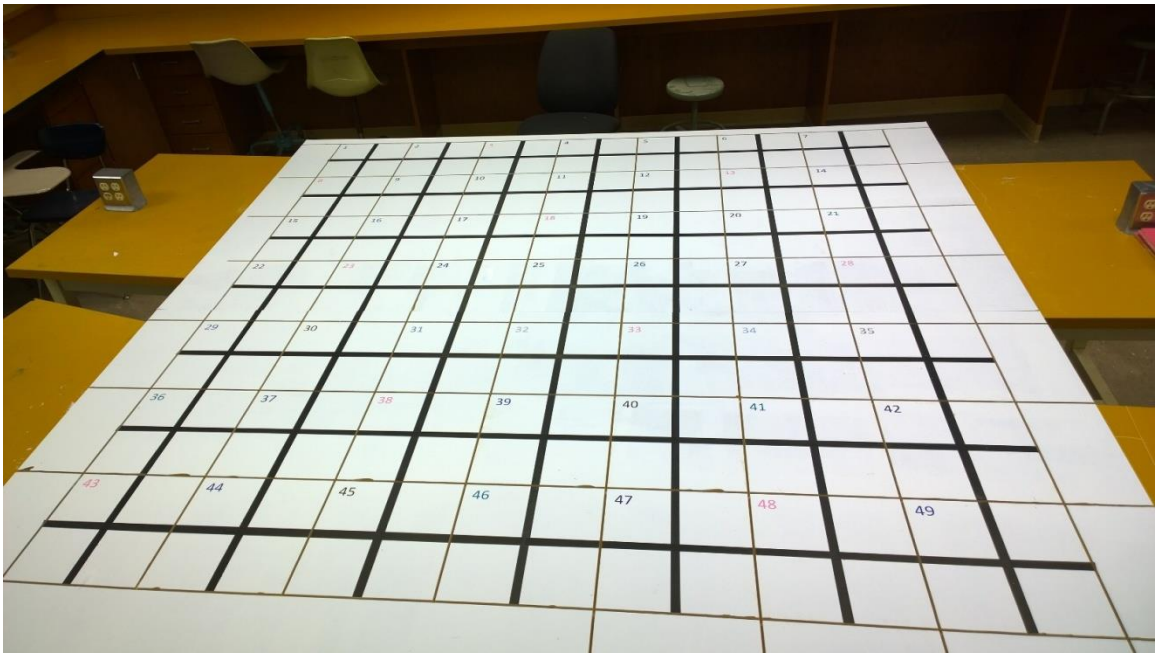


Figure 1 – Bare playing field (see attached JPEG for better detail)
The bare playing field is shown. The wide black lines are the painted stripes. The smaller grey lines are the slots in the playing field. The cell numbers are below and to the right side of the intersecting slots.

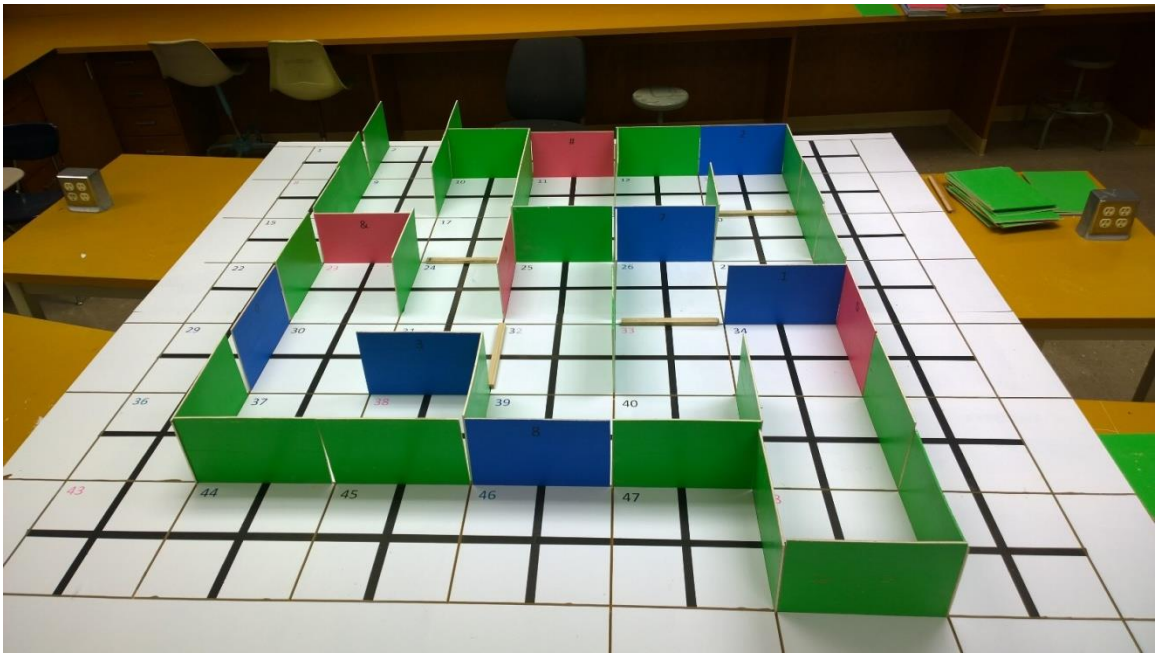


Figure 2 – 5x5 Maze with speed bumps (see attached JPEG)
The start cell is seen in the lower right of the picture (cell 48). The colored walls are visible as are the Easter egg symbols and speed bumps (light brown such as between cells 33 and 26). The end cell (cell 9) is not properly closed.

# Itinerary

Practice field (Corpus Christi Ball Room) opens at 3:30pm and will be available all night, 4/4 (Friday)
Registration confirmation start at 7:00am, 4/5 (Saturday)
First round competition for Semi Final starts at 9:00am
Lunch starts at 12:00pm
Second round competition for Final starts at 1:00pm

This schedule is subject to change depending on how many teams show up and if we can squeeze in more rounds. Your team number for the schedule will be decided at random on the day of the competition.

# Venue

The IEEE 2014 Region 5 Robotics Competition will be held at the Omni Bayview Hotel in Corpus Christi, Texas. Tables will be available for teams to work on their robots. The competition space will be limited to contestants and spectators throughout the event. Practice fields will be made available a day before the competition, and will be accessible from *3:30pm*. Flash photography will not be permitted during the course of the competition runs.

# Eligibility

This competition is open to all IEEE member undergraduate students attending IEEE Region 5 educational institutions. All involved contestants are required to register appropriately for both the regional conference and student activity. Registration fees per student for the event will be $160. At this time, team registration is not open yet.

# Contact Info

For questions regarding the rules and all other matters related to the robotics competition, please contact the robotics chair, **Dr. Dugan Um**, at *dugan.um@tamucc.edu*, or **Cruz Monrreal**, at *cruz.monrreal@gmail.com* with the subject **[2014 IEEE Region 5 Robotics]**. Be sure to check the forum and FAQ frequently, as submitted questions will be answered online as well as via email.

**Last Updated: Jan 29, 2014**

# Revisions

| | |
|---|---|
| Apr 3, 2014 | Updated Itinerary<br>Updated Gameplay |
| Mar 27, 2014 | Minor change in scoring rule. |
| Feb 4, 2014 | Updated FAQ<br>Created Oil Rig Request Form |
| Jan 29, 2014 | Corrected Oil Rig CAD Files and Diagrams<br>Updated Field Preview Image<br>Updated Field Diagram |
| Jan 28, 2014 | Updated Tools and Oil Rigs CAD Files and Diagrams |
| Jan 16, 2014 | Added <Update Needed> tags<br>Uploaded Flames CAD files |
| Nov 10, 2013 | Modified *End of Round* Cause #3<br>Updated *BoM* |
| Oct 23, 2013 | Moved *FAQ* to Google Group |
| Oct 20, 2013 | Google Group created<br>Demobot videos uploaded |
| Sept 30, 2013 | Updated *BoM*<br>Uploaded *CAD files and Diagrams* |
| Sept 25, 2013 | Linked *BoM*<br>Tentatively updated colors of elements |
| Sept 24, 2013 | Added to FAQ<br>Modified *Robot Restrictions*, *End-Of-Round Causes*<br>Added *Questions TBA* |
| Sept 17, 2013 | Typos... |
| Sept 16, 2013 | Added *Playing Areas*, *End-Of-Round Causes*, *Final Thoughts*<br>Modified *Scoring*<br>Added CAD of field and bird's eye view of field w/ markings |
| July 30, 2013 | Initial Draft |

# Competition Description

This year's competition will continue the tradition of using compact, mobile, and autonomous robots operating on a predefined field. The challenge will be to extinguish a fire that has been identified on a distant oil rig. The winner will be determined by the robot that is able to put out the fire the quickest.

## Robot Restrictions

The Robot will be screened by a judge before each round of the competition. Entries not meeting the requirements will be disqualified for the round. These requirements take into account the scope and spirit of the competition.

1. Entries must be completely autonomous.
2. The robot is not allowed to communicate with *anything* outside of the field during the round.
3. The maximum dimensions of the robot are 1'x1'x1'. This only applies during the *beginning* and *end* of the round. The robot is allowed to extend beyond these dimensions during the round.
4. Robots must not exceed a generous weight limit of 50 lbs at any time.
5. **The robot must be deemed safe in the eyes of the judges.** The possibility of harm towards humans and/or property will be the deciding factor. If you have concerns, contact us.
6. An easily *accessible*, easily identifiable "start/stop" button must be provided for the judges to initiate the round.

## Objective

An **oil rig**, (**offshore platform** or colloquially **oil platform**) is a large structure with facilities to drill wells, to extract and process oil and natural gas, and to temporarily store product until it can be brought to shore for refining and marketing. In many cases, the platform contains facilities to house the workforce as well. Due to the nature of process and dangers innate by gas/oil product, oil rigs are prone to fire that can lead to a maritime disaster. Robotic rescuers are in need of deployment in such occasions of oil rig fire to extinguish fire as soon as possible.

This year's objective is to create a robot that can not only identify the oil rig on fire, but to also put it out using the correct 'tool'. On the field, there are three oil rigs, three 'tools', and a vast body of water. Because of the logistical issues that involve open flames and large bodies of water, the oil rig on fire will be indicated by a cutout of a flame located behind the oil rig. In this competition, water will be represented as semi-circles cut out of pieces of wood. Also, because the ocean is vast and unpredictable, before the beginning of the round, the waves will be changed such that the path to the oil rigs will change each round.

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# Playing Field

The playing field will be based on an 8’ x 8’ surface constructed out of MDF or equivalent (ie: two 4’ x 8’ sheets of plywood), and remain white. Before the round begins, the ‘waves’ will be randomized, along with the ‘tools’.

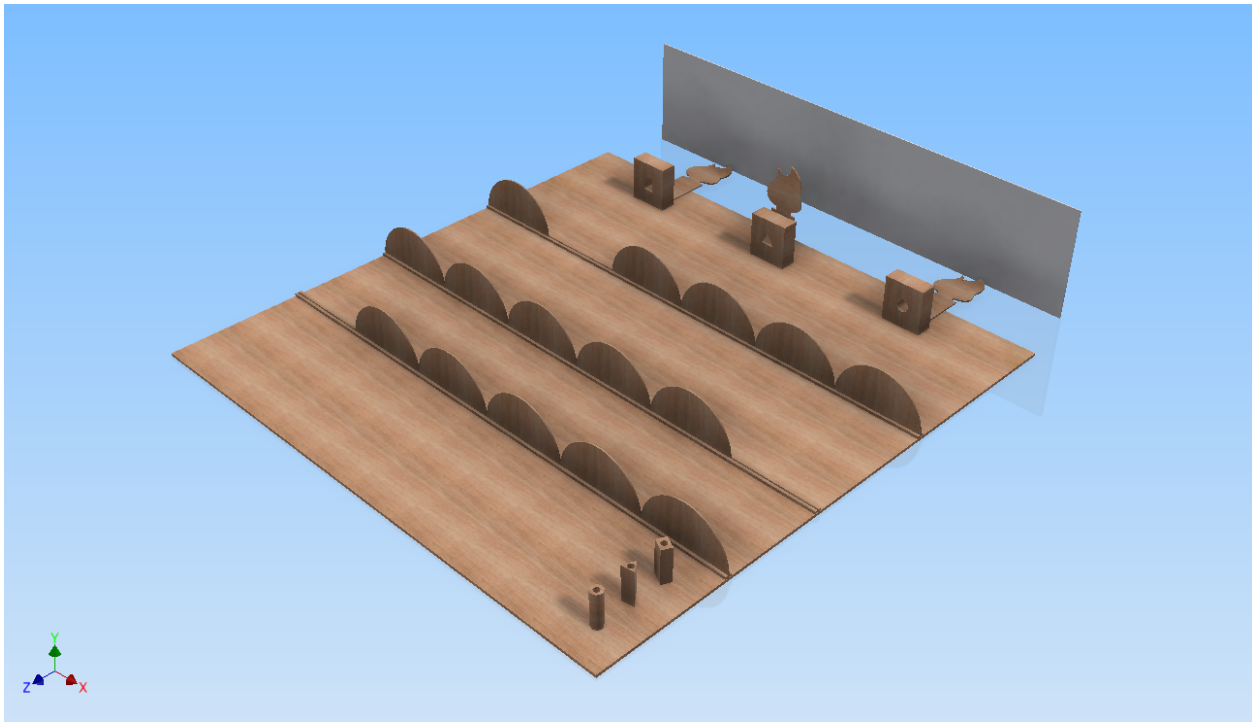

**Fig 1:** 3D CAD of Field

## Playing Areas

The playing field is divided into three areas: the loading zone, the ocean, and the oilfield:

1. The loading zone is comprised of the bottom ¼ of the field (8’ x 2’), and contains both the starting area and the ‘tools’. The robot may start anywhere within the left-most 2’ x 2’ area of the loading zone, but must still adhere to the starting conditions. The ‘tools’ are located on the right side of the loading zone, randomized among the three dots, which are spaced 6” apart from each other, and are 6” away from the field edge.
2. The ocean is the largest part of the field, encompassing an area of 8’ x 45.5”. In the ocean, there are three rows of waves, constructed out of a ¼” plywood, with each wave being a semicircle with a diameter of 16”. Each row of waves is held in place by a ½” x ½” x 8’ piece of wood, such that the waves are free to slide. In each row, there are 5 of these waves, leaving a gap of 16” to maneuver the robot through. This gap will always be continuous, and the robot is not allowed to move the waves or physically damage them.
3. The oilfield, is 8’ x 26.5”, and contains all three ‘oil rigs’. It will be the robot’s job to

determine which ‘oil rig’ is on fire, and insert the corresponding ‘tool’ into the ‘oil rig’ to put out the fire. The ‘oil rigs’ will be made out of two 8” pieces of 2x8 lumber, with holes large enough to insert the ‘tools’, but small enough that the robot cannot insert a different ‘tool’. The ‘flame’ is made out of a ¼” piece of plywood and is attached to the ‘oil rig’ by a hinge. It will only go down upon the insertion of the correct ‘tool’.

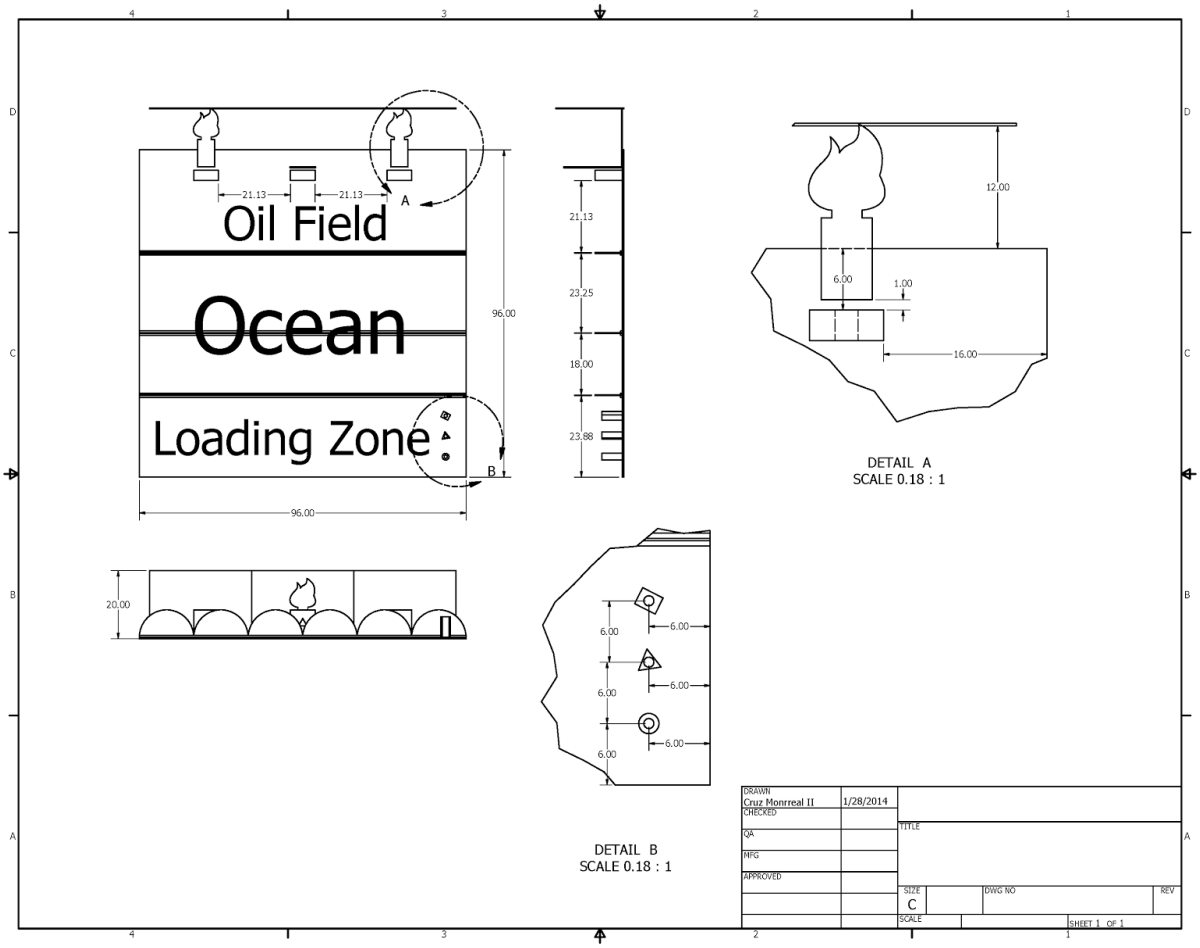


**Fig 2**: Field Diagram

## Color scheme of the playing field

**Yellow Paint (Oil Rigs)**
**Black Paint (Tools, Flames)**
**Blue Paint (Waves)**
**White Paint (Field, Rails)**

# Gameplay

Each team will get as many rounds of play as possible. One final round to determine placing will be played by teams that are able to complete a minimum score of 1 point. The judge will randomize the 'waves' and set an 'oil rig's 'flame' at the beginning of each round. 'Tools' will be randomized after every team.

Rounds will proceed as follows:

1. Judge requests teams on-deck.
2. Students have two (2) minutes to set up their robot in the starting area and step back from the field.
3. The judge will place the 'tools' on their locations, randomly.
4. The team leader will press the 'start' button on your robot and the judge will start timekeeping.
5. The robot will have to identify which oil rig is on 'fire', pick up the required 'tool', go to the 'oil rig', put out the 'oil rig's 'flame' with the 'tool' and return to the starting area.
6. After ten (10) minutes of gameplay, the robot will be stopped.

## Scoring

Total point a team can possibly earn is 5 points. The tasks at hand for the competition are as follows (each task earns 1 point):

1. Identify which 'oil rig' is on 'fire' and pick up the correct 'tool' to extinguish 'flame'
2. Navigate 'ocean' to extinguish 'flame'
3. Stop at the correct 'oil rig' within 3"
4. Insert 'tool' to extinguish the 'flame' in correct 'oil rig' and leave 'tool' behind (the flame must fall down due to the 'tool')
5. Navigate 'ocean' back to the start area

Time of completion of each task will be used as tie breaker. Therefore, the robot that can complete the most tasks with the fastest time will end up the victor.

## Tentative Schedule (4/5/14)

| IEEE R5 Robotics competition - tentative schedule | | | |
|---|---|---|---|
| | | | |
| First round | (Qualification) | | |
| 9:00 AM | Team #1 | Team #2 | Team #3 |
| 9:15 AM | Team #4 | Team #5 | Team #6 |
| 9:30 AM | Team #7 | Team #8 | Team #9 |
| 9:45 AM | Team #10 | Team #11 | Team #12 |
| 10:00 AM | Team #13 | Team #14 | Team #15 |
| 10:15 AM | Team #16 | Team #17 | Team #18 |
| 10:30 AM | Team #19 | Team #20 | Team #21 |
| 10:45 AM | Team #22 | Team #23 | Team #24 |
| 11:00 AM | Team #25 | Team #26 | Team #27 |
| 11:15 AM | Team #28 | Team #29 | Team #30 |
| | | | |
| 12:00 PM | Lunch | | |
| | | | |
| Second round | (Final) | | |
| 1:00 PM | Team #1 | Team #2 | Team #3 |
| 1:15 PM | Team #4 | Team #5 | Team #6 |
| 1:30 PM | Team #7 | Team #8 | Team #9 |
| 1:45 PM | Team #10 | Team #11 | Team #12 |
| 2:00 PM | Team #13 | Team #14 | Team #15 |
| 2:15 PM | Team #16 | Team #17 | Team #18 |
| 2:30 PM | Team #19 | Team #20 | Team #21 |
| 2:45 PM | Team #22 | Team #23 | Team #24 |
| 3:00 PM | Team #25 | Team #26 | Team #27 |
| 3:15 PM | Team #28 | Team #29 | Team #30 |

In qualification round, team must earn at least 1 point to be advanced to the final round.
Only the points earned at the final round will be considered for awards.

## End-Of-Round Causes

Throughout the match, there will be several conditions which cause the round to come to a close:

1. The robot successfully completes all tasks and stops at the starting area.
2. Elapsed time is over 10 min.
3. The robot falls off the playing field.
4. The ‘tool’ required to put out the ‘flame’ falls off the playing field.

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5. The robot interacts with a ‘wave’. The robot is not allowed to move ‘waves’.
6. The robot puts out a ‘flame’ by other means aside from the ‘tool’.
7. The team lead tells the judge to end the round.

Every time a round is ended, the time will be recorded with the last scoring task that was completed. IE: If the robot falls off of the field while going back to base (task 5), the time will be stopped and scored for task 4.

# Final Thoughts

This game is meant to touch on three aspects of robotics: mobility, manipulation, and vision. It is in our opinion that technology has advanced to such a point that this type of challenge is within the ability of current university students. However, this does not mean that there does not exist simple solutions to difficult problems. Search for them, think outside of the box, and don’t be afraid to try out new things.

CAD files and all dimensions for each part have been meticulously provided for your benefit. *However*, in all of engineering, everything has tolerances. At the end of the day your robot must be able to complete the challenge with these tolerances in mind. Do not expect a picture perfect field with what was provided in the CAD.

Good luck, and have fun!

# Appendix

**Bill of Materials**

**CAD Files (Autodesk Inventor)**

**CAD Diagrams (PDF)**

**Google Group**

### Past Game References

- 2013
- 2012
- 2011
- 2010