2010 IEEE Region 5 Conference Robotics Competition

Official Rules - Version 1.4

I. CONTEST VENUE

The IEEE 2010 Region 5 Robotics Competition will be held at the Gaylord Texan Resort and Convention Center in Grapevine, Texas. Tables will be available for teams to work on their robots. The competition space will be open to contestants and spectators throughout the event, in a Convention Center Room to be determined. Lighting and other details will be mentioned as more information becomes available. In order to minimize ambient lighting, flash photographs will not be permitted during the course of the competition runs.

II. ELIGIBILITY

The Student Robotics Contest has been designed, over the years, as an event for undergraduate students. Undergraduate teams may NOT include any non-undergraduates. In any case, all team members must be properly registered for the regional meeting.

III. THEME OF THIS CONTEST

In concert with this year's Region 5 Green Technology Technical Conference, the task this year is to construct a land-based robot which can autonomously transport expended nuclear fuel rods from a central location to remote processing areas. Due to the high risk of human exposure or environmental damage, it is desirable to transport spent fuel rods from the power plant to remote processing locations via autonomous unmanned transport. In the power plant environment, there are wind turbine obstacles that must be avoided. Efficient use of power is also encouraged (see power efficiency challenge).

IV. CONTEST GOAL

Each team must design and build an autonomous robot that can detect and transport containers from 4 central locations to the assigned square areas in the corners of the course. The robot must deliver the rods from 4 central locations to their specified delivery areas in any order. In addition, an optional energy efficiency challenge will award teams who complete course objectives using the least amount of electrical power (see energy efficiency challenge section for more details).

V. ROBOT CONSTRUCTION

The only limitations to the construction of the robot are:
1. It must be <u>autonomous</u>,
2. Meet the <u>size and weight</u> requirements,
3. Contain a <u>"kill/safety" switch</u>, and

4. Be safely designed and <u>safe to operate</u>
5. The robot must not communicate with any device outside of the course while in play.

Each team can enter only 1 autonomous robot into the competition. No human interaction with the robot is allowed once the robot starts running after pre-programming. The single robot may expand or split up into multiple robots as long as the robot at the end of the competition meets the size requirements. Any robot not meeting the size requirements at the end of the competition will incur a penalty. A physical connection between multiple robot parts is not required as long as the combined system meets the size requirements at the start and finish of the run.

The maximum starting and ending size of the autonomous robot must not be greater than 1 foot in length, 1 foot in width and 2 feet in height. The robot cannot exceed 50 pounds in total weight.

Each robot must have a visible and easily accessible “kill” switch or emergency stop safety button to turn off all power to the robot in case of malfunction or improper activity.

A ‘safe’ robot is one that has a low potential to catch on fire, destroy/damage the field, or injure humans. For this reason, no robot may use a combustion engine power system. Care must also be taken to ensure that batteries are enclosed in a manner that will prevent any danger to humans, the course, or the facility.

In order to compete in the optional energy efficiency challenge, a specific set of construction guidelines must also be met (see energy efficiency challenge section for more details).

VI. THE COURSE

A. Field

The entire field will be set up on 2 pieces of MDF (0.75” medium density fiberboard) measuring 8’ by 8’ in total. The field will be painted white with a 0.75“ wide flat black lines (all lines will be 0.75” wide). Each corner of the field will have a square with a painted black border. Each corner square will measure 0.5 feet in length and width from the outside edge of the field. There will be additional black lines extending from the corner squares toward, but not connecting to the center.

There will be wind turbine obstacles on the field, randomly located during the final round of competition. Each collision with a turbine will result in a time penalty (see obstacles section for more details).

There will also be a square in the center of the field measuring 1’ by 1’. The center square will be divided into 4 equal quadrants with black lines. Additional lines will extend from the central division lines toward, but not connecting to a boundary line along the edge of the MDF.

The paint used for any part of the course will be as follows:

Primer:	White Pigmented	Kilz™	Kilz2 Latex
White:	Flat White	Rust-Oleum™	1990
Black:	Flat Black	Rust-Oleum™	7776

See Figure 1 below for an aerial-view plan of the field. The dots in the 4 corners of the field are explained further in the lights section below.

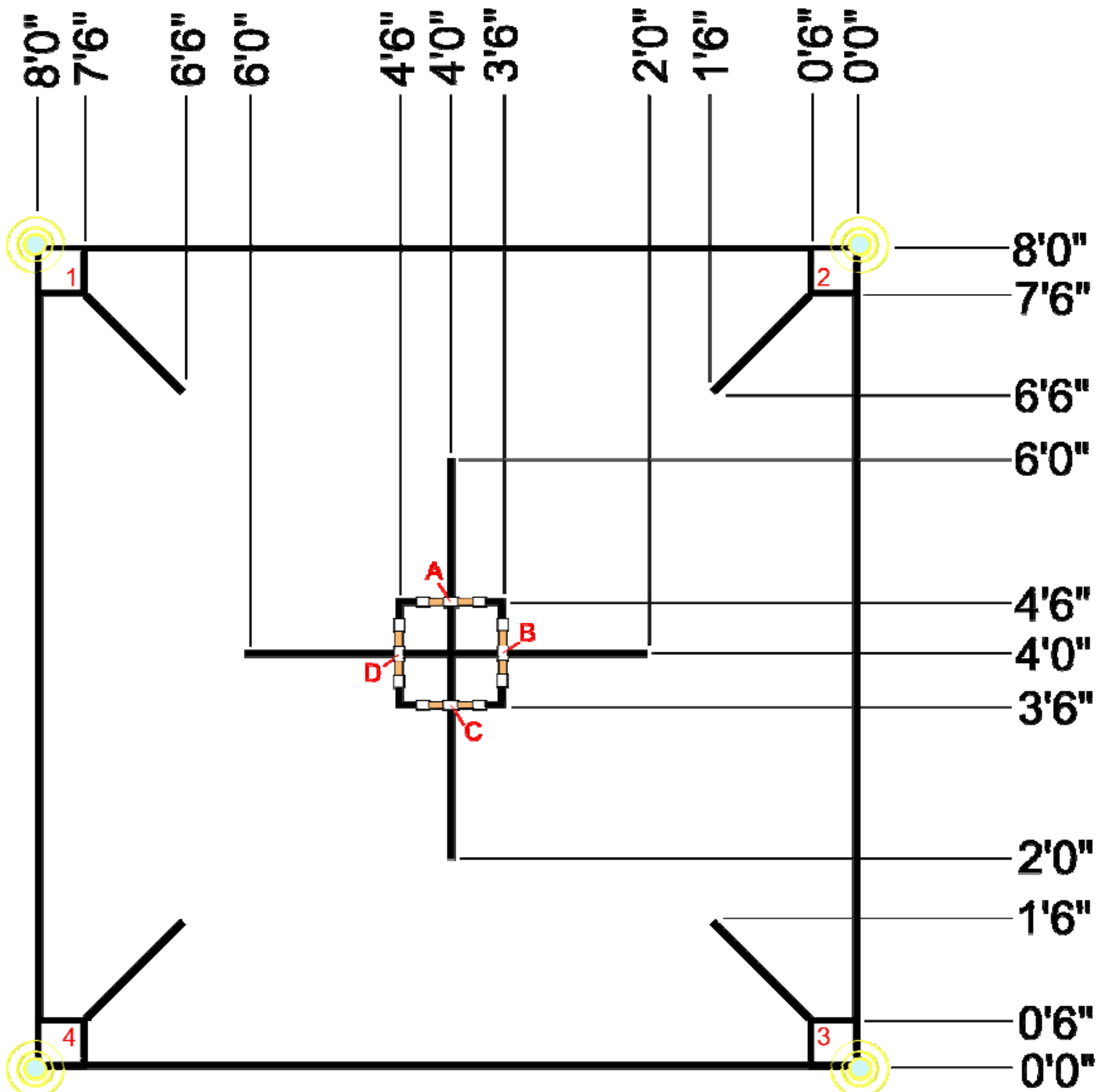


Figure 1: Aerial-View plan of Field [Measurements are in feet/inches]

All lines, except for the outer boundary, are centered on the measurement. The outer boundary is drawn flush against the wooden edge. The origin of the measurements starts at the bottom right corner of the board. The position of each measurement will have a maximum error of +/- 0.5 inches.

Fuel rod containers will be initially placed on the intersections of the central square and center lines as shown above. The central locations are lettered clockwise A through D beginning with the top location. The corner delivery locations are numbered clockwise 1 through 4 beginning with the top left location. Note that the red text in the diagram is not present on the actual course.

B. Lights

On every corner of the field, there will be a side-emitting white light (Luxeon LXHL-FW3C) flashing at a certain specified frequency. Each corner light will be positioned at a height of 8 inches and will have a light frequency different from that of the other 3 corners. The frequencies are as follows: 20 kHz, 40 kHz, 60 kHz, 80 kHz. The corner lights will be mounted on 0.75” diameter white PVC pipe posts that will be affixed to the corner of the board with double sided tape. Directly below the light will be a white 3”x 5” note card mounted horizontally for spectator reference. The note card will display the corner number and the resistance value of the container to be delivered.

The frequency of each corner will change between runs to indicate the value of the container at the matching central location (#1 indicates the value at A, #2 indicates the value at B, etc). For example, a 40 kOhm container initially located at central location A would result in a frequency of 40 kHz at the top left corner (position #1). Note that the corner frequency indicates only the resistance value of a container at a starting location, not the resistance value of the container to be delivered to that corner. Each container is always to be delivered to a set corner location, regardless of its initial starting location (see Cargo Container section for the resistance value to delivery location mappings).

The corner lights will be driven with a current of 700mA to produce 58 lm of light output. The competition will use the LXHL-FW3C LEDs, but any white LED configured for 58 lm of output will suffice for testing (The LXHL-FW3C is being replaced with the LXML-PWC1-0080, which can produce 58 lm at a lower current).

C. Cargo Container

At the start of the competition, each of the 4 central locations will contain 1 cargo container. Each cargo container will be a 0.75” diameter copper pipe with a 0.75” CPVC coupler in the middle and a 0.75” diameter CPVC “T” fitting on each end. Each container will have a unique resistance when measured from the copper sides across the middle insulating coupler. The resistances are as follows: 20 kOhm, 40 kOhm, 60 kOhm, 80 kOhm. The containers are to be delivered to the corners as follows: 20 kOhm to corner #1, 40 kOhm to corner #2, 60 kOhm to corner #3, 80 kOhm to corner #4. The overall length of each container will be 8” total. Each resistor will have a tolerance of +/- 10%.

Any method may be used to transport the cargo containers to its final destination. Lifting, pushing, dragging, rolling or even throwing are all acceptable methods of movement, as long as the cargo container is not damaged or completely destroyed.

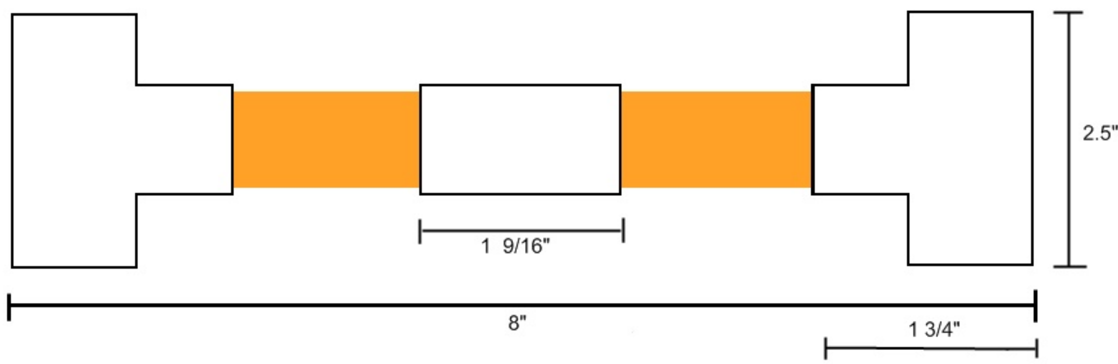


Figure 2: Side-View of cargo [Measurements are in feet/inches]

The cargo containers will be placed in their initial locations such that the holes in the “T” fittings will be oriented vertically, creating an open space between the copper pipe and floor. Figure 2 shows the initial container orientation when viewed from the side at the floor level.

D. Obstacles

The obstacles appearing in the final round will be wind turbines with operational spinning blades. The blades will be mounted on top of a 0.75” diameter white PVC pipe that will extend from a cylindrical base with a 4”-6” diameter and 4”-6” height. The spinning blades shall not come closer than 24” to the course floor.

VII. RUNS

Each team will be allowed 1 minute to place their robot on the course and prepare their robot for the run. Since lighting may play a factor in color and frequency determination, teams are welcome to calibrate to the conditions of the course during the preparation time (1 minute). There will also be an opportunity to perform this calibration on the day prior to the competition day during the practice session.

The initial placement and orientation of the robot is up to the discretion of the competing team as long as no part of the robot is within the center or outside squares or over the lines defining these squares (In other words, the robot must start inside of the outer boundary AND not touch the 4 middle or 4 corner squares). This constraint does not apply to any other line. In addition, no part of the robot may initially extend outside of the boundary line.

Once the robot has been positioned in its initial starting location the team will clear the field and the cargo containers will be placed on their starting locations. The matching of cargo resistance values to starting positions (A,B,C,D) will be randomly generated. Once the cargo containers are placed by the judges, the light frequency of the corner lights will be set to correspond to the resistance value of the container at the matching start location. Once the containers are placed and the lights are set, the judges will give a “go” command after a countdown. Time keeping will begin once the “go” command is given. One member from the team may be present on the competition field to activate the robot if a wireless start is not used. This team member must immediately exit the field once the robot begins to move.

A cargo container will be considered to be in the correct area if <u>any</u> part of the container is within or directly above the line defining the correct destination area when viewed from above at the end of the run.

There will be 3 rounds of competition. All teams must compete in any 1 or both of the first 2 rounds. Teams have the option to sit out either of the first 2 rounds if they choose to do so. The highest score from the first 2 rounds will be used to determine eligibility for the final round. The top scoring teams will advance to the finals.

The 3rd and final round will have up to 4 wind turbine obstacles randomly located at least 6” away from any line or other obstacle. There will be at most 1 obstacle located in each quadrant of the board (where quadrant boundaries are defined by extending the middle lines to the course outer boundary lines, not the diagonal lines extending toward the center from the corners). Any collision will result in a penalty, where knocking over the turbine entails a collision. Any contact with the turbine that does not result in the turbine falling over will not result in a penalty.

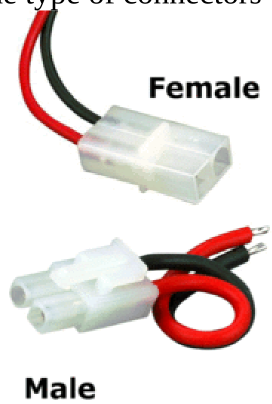
Each run will be limited to 4 minutes of run time, beginning when the ”go” command is given by the judges. A signal will be provided to the team to stop the run and have all progress up to that point scored (the signal will be a physical object such as a button or flag). After 4 minutes of run time, the run will automatically stop and no further progress will be factored into the final score.

VIII. ENERGY EFFICIENCY CHALLENGE

In order to promote green technology, bonus points will be awarded to teams for teams that minimize their power consumption while completing the challenge objectives. To compete in this challenge, teams will be given a small energy measuring device to install on their robot before the beginning of the round. This device will integrate the robot's power usage over the course of the run. In order to ensure compatibility with this device, and therefore to compete in this optional challenge, the team's robot will have to conform to some specifications:

- The device must be connected between the team's battery pack(s) and the robot such that all energy consumed by the device must go through the power monitor. If your robot has multiple power sinks, your power distribution system must be designed so that all power can be routed through the measurement device. The leads to connect the power monitoring device should be readily accessible. Each time will only have 1 minute before each round to connect the device.

- The device will have a Tamiya male connector on the battery input side and a Tamiya female connector on the output side that connects to the robot (the gender is determined by the plastic housing, NOT the metal pins within the housing). As such, it should connect directly inline between any robot that uses standard NIMH/NI-CD packs with Tamiya connectors (the same connector is found on 7.2 and 9.6 volt battery packs). If you use another battery type, you must ensure that your power source is compatible with this connector arrangement. Tamiya connectors can be easily found online and at RadioShack. The conventional polarity of these connectors must be used. The image below shows the type of connectors used in the device.



- The team's battery pack must have a nominal voltage of 24 volts or less. The battery pack will be measured (with no additional load) with a digital mulitmeter before being connected to the device. If the voltage is greater than 24 volts, the team will not be allowed to compete in this challenge.
- The team's robot must never draw beyond 10 Amperes. This cannot be easily verified before the round, but it can be detected by the device. If the device is damaged because of excessive power draw, the robot will receive a disqualification for the round. If an overcurrent condition is detected without damaging the device, the team will not be disqualified, but the team will not have the possibility of winning the energy efficiency challenge.
- The device will not count against the team's weight limit. The device, when connected to the robot, must still fit within the spatial limitations. The device must be securely attached to the robot such that it will not sustain damage during the round. If the device is damaged due to improper installation, the team will be disqualified for the round. The device is designed to be quite robust to both electrical and physical damage. That said, teams should make some provision to install it in a reasonable manner on their robot in such a way that it will not be subjected to unnecessary danger.

Each team that competes in the energy efficiency challenge will receive an energy score that is based on a ratio of the score earned from completing the tasks to energy consumed during that period. To achieve the maximum energy score, the team must complete as many tasks as possible while minimizing total energy consumption. The 3 robots with the highest energy scores for each round will receive a bonus multiplier for their score.

The schematic and firmware for the energy measurement device will be released under and open license as soon as it is completed. The device will be a microcontroller based system that samples battery voltage and current draw and integrates those measurements over time. The device will have its own small current draw of under 30mA, but the circuit will be designed such that the current measurements only consider power supplied to the robot and not to the power measurment circuit.

IX. SCORING

Scores will be assigned based primarily on the completion of detection and transportation of cargo containers. The speed at which the robot accomplishes the assigned tasks is of secondary importance. Points will be added and subtracted based on the state of the course at the end of the run as defined below...

- +250 points for each container delivered to the correct delivery location
- +125 points for each container delivered to the incorrect delivery location
- +25 points for each container that is moved entirely off of the middle black lines (any line that cannot be traced back to the outer boundary lines without crossing a white area. Any container that is over any of the middle lines when viewed from above will not receive any points, nor will a container that is knocked off of the playing field.
- -200 points for failing to meet the size requirements at the end of the competition run. A team that uses multiple robots will incur this penalty if the robots do not return to a formation that meets the size requirements.

In addition, the 3 teams with a score of at least 500 points who perform the best in the energy efficiency challenge will receive a bonus multiplier of 1.20. For example, a team successfully delivering all 4 containers to the correct locations, not incurring any penalties, and finishing in the top 3 of the energy efficiency challenge would have a maximum final score of (250 + 250 + 250 + 250)*(1.2) = 1200.

Any ties will be broken using the time of the run, but no points will be awarded for finishing the course before the maximum 4 minutes.

Scoring for the final round will be identical to the first rounds with an additional penalty for obstacles.

- -100 points for each windmill obstacle knocked over

As above, a robot delivering all containers to the correct location, finishing in the top 3 for the energy efficiency challenge, but knocking over 3 windmills would receive a score of (250 + 250 + 250 + 250 – 100 – 100 – 100)*(1.2) = 840.

The following scenarios will result in immediate disqualification:

- Robot does not meet the size or weight requirements at the start of the run.
- Robot does not have an emergency stop button ("kill" switch).
- Robot damages or destroys the field, lights, or cargo containers.
- Robot is not safe (based on the decision of the judges).
- Robot touches the floor outside the defined 8' x 8' field.

Please note that every effort has been made to prevent complete disqualification. The goal is that all teams will receive a score to show for their hard work. Please take advantage of the information in this document that will help you avoid any disqualification.

X. JUDGING

All decisions made by the judges during the course of the competition are final.

XI. QUESTIONS & COMMENTS

Competition chairs are Dan Popa, Chris McMurrough, and Matt Middleton. Questions should be sent to region5robotics@gmail.com (this email address will be forwarded to all competition chairs). Be sure to check the competition website and FAQ frequently, as submitted questions will be answered online as well as via email.