

IEEE, Region 5 2007 Conference Robotics Competition Rules and Course Description

Revision: 3 (These rules will be updated as necessary)

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Notice of major changes: Please note the major changes to the competition rules. These include size of the course, method to enter instructions to robot, and addition of emergency stop button.

- 1/12/07 Complete description of competition area has been added in section 4
- The initial size of the course (12'x12') became impractical for physical constraints of the facility for many competing teams. It also became an issue with quality construction and conference facility limitations. The size has been reduced to (8'x 8').
- There is still a priority that must be entered into the robot. However, the team can choose any method to enter the priority list.
- An emergency stop button has been added in the event of rogue robots. Robots with out some emergency stop method will not be allowed to compete. Please place the button/mechanism in a manner that it can be accessed easily as the robot is making random turns at max speed (just kidding). But, please provide some emergency stop method similar to but not limited to a pull-wire emergency stop switch, where the wire is accessible but completely contained on the robot.

At this point, I would like to mention John Glover from the University of Houston. This rewrite could not have been finalized so soon with out his assistance and his knowledge of past competitions. Although I hold him responsible for nothing in these rules (for which he is thankful), I thank him for his help.

1.0 Concept

The Robotics Competition at the 2007 Regional Conference is designed to be challenging to a broad base of experience levels. Schools with low budgets and resources can construct a robot that can compete, while those with greater resource levels will still find the problem challenging. Designing a robot to run on a course is one thing, but any design will always need thorough testing. For this reason, the course is designed to be easily reproduced by competitors at their respective home site.

In general, the competition is a mock-up of a transportation system for a solar system. Cargo must be moved from a distribution location to a delivery location. The location where the cargo must be delivered depends on the product color. The following systems would be helpful to the robot in accomplishing this task:

- Drive system for motion.
- Navigation sensors or cameras to assist in locating position, cargo, and navigation lines.
- Manipulator to handle cargo.
- Method to input priority of cargo.
- Emergency stop button.
- Processor/software to coordinate all of these elements

There will be two early rounds of competition, followed by a final round. The top 4 teams or the top 10% of teams, whichever is larger, from each of the first two rounds will go to the final round. In each of the first two rounds, each team gets a single run of the robot. The locations of the containers will be changed between the two rounds. The cans will be placed in different locations for each team within each round, and the distance to move each can will be similar for each run. Rounds one and two will not necessarily be the same set of combinations of can placements. Robots will be quarantined just before the start of the final round. Since everyone will have the same can placement on the final round, no one will be allowed to make changes after the final round begins. In the final round, each team will get two runs, with the container locations changed between runs. In other words, in the final round every team will have the same container placement, but the container placement will be different for the two runs. The team's best score will be taken to decide the winner of the final round. Scoring of each run is described below.

2.0 Details of the “Solar System” Course

2.1 Course Description

2.1.1 Course layout: Figure 1 shows the layout of the course, a “solar system” having four (4) large concentric circles and six (6) smaller circles. The six smaller circles represent cargo areas. Three of the cargo areas are labeled 1, 2, 3 while the other three areas are color coded. The robots must pick up the cargo from one of the numbered areas and place it, based on color, in the appropriate colored area.

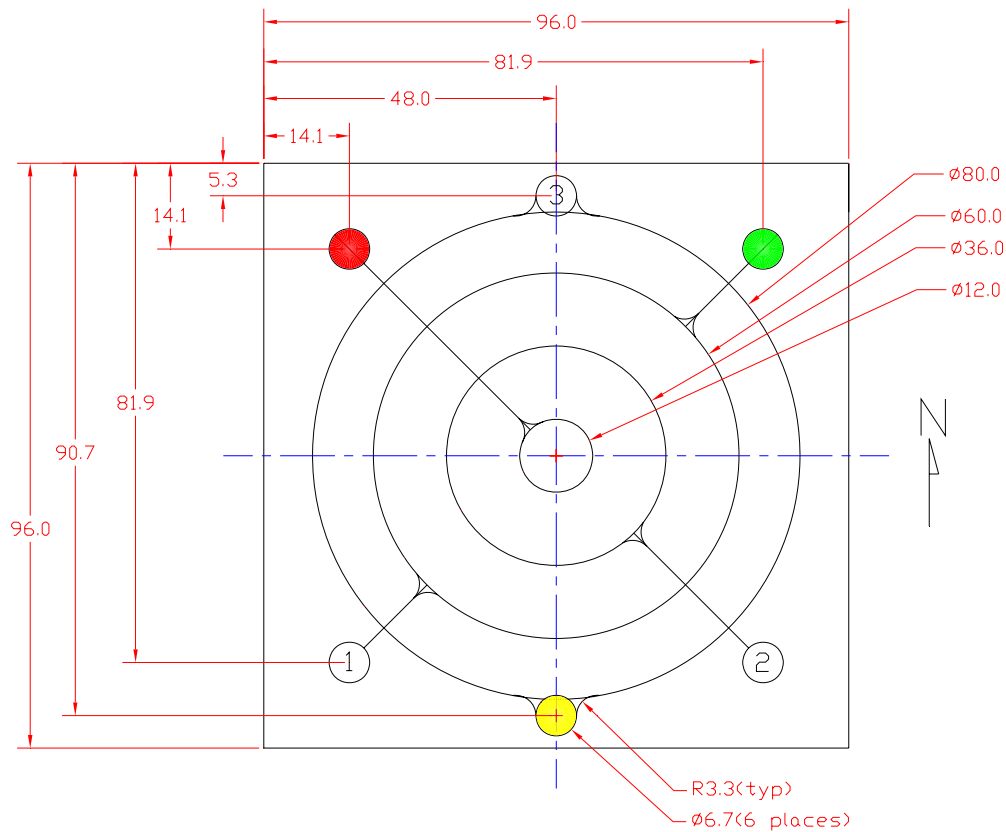


Figure 1 “Solar System” course layout (dimensions in inches).

2.1.2 Course details: One cargo container will be somewhere inside each of the numbered regions. The robot should retrieve the container and deliver it to the appropriate colored area based on the color of the container. As an example, if red cargo container is picked up from area 3 it must be placed inside the red cargo area. The robot can place the container anywhere inside the appropriate colored area, so long as the entire container is inside the circle.

2.1.3 Starting point: The starting point for the robot is anywhere within the concentric circles. The placement and orientation of the robot is up to the discretion of the competing team so long as the entire robot fits entirely inside the outermost ring

and entirely outside the inner most ring. The robot must not touch the inner or outer ring but, may touch any other ring. The robot must meet the size and weight check before being placed on the course (16" x 16" x 36" tall, 50 pounds, see section 2.4.1 for full details).

2.1.4 Starting time: Each team will be given up to two (2) minutes to move their robot onto the course and do any preparation necessary. At the end of this two minute prep time, the judge will announce "Clear the course". At this point, the order in which the cans are to be retrieved will be given to the team and the size of the robot will be checked. After the robot checks out as OK, one team member will be given 30 seconds to program the order into the robot. At the end of the 30 second period, the cans will be placed in the numbered cargo areas, and the judge will announce "Activate your robot". This will be the signal for the competitor to activate the robot and step off of the course. When the "Activate your robot" announcement has been made, a start clock will begin counting down thirty (30) seconds. The course time will begin from the time the robot starts moving after being told to activate. If a robot fails to move within the 30-second start time, the robot will be declared immobile and the run time will end at that point. This is to prevent a robot that is not working from taking up unnecessary time. In the event this happens the team will be given a time equal to twice the completed run. If no runs are completed the robot will be disqualified.

2.2 Course Navigational Aids

2.2.1 Black lines: The black lines will be used to aid in navigating within the solar system between cargo areas. Four of the cargo areas have straight line segments directed radially toward the center, which end within the solar system at the concentric rings as determined by the map above. The intersection at the end of each straight line with its given concentric circle will have two arcs as shown in the figure above. These arcs are tangent to the straight line as well as the concentric circle. Two of the cargo areas are placed tangent to the outer circle. All lines will be 3/4" ($\pm 1/8$ ") wide and all dimensions shown are to the center of the black line. All black markings will be painted in a matte or flat finish. The other two cargo areas are placed tangent to the outer circle.

2.2.3 Cargo areas: All of the cargo areas are 6.7 inches in diameter as measured from the center of the black outline. Three of the cargo areas are filled with color (sunrise red (Rust-Oleum™ 7762-830), Hunter Green (Rust-Oleum™ 7738-830), Sunburst Yellow (Rust-Oleum™ 7738.830)). The other 3 cargo areas will be outlined with black and marked with numbers (1, 2, 3). All cargo area markings are fixed.

2.3 Storage Containers

2.3.1 Dimensions and weight: The storage containers will have the same form factor as a common soda can with some ballast in the bottom to give it stability. This will allow anyone in Region 5 to easily build a mock up of the course and test their robot's manipulator and object location system. Height of a standard soda can is 4.8 inches (122 mm). The outer diameter of a soda can is 2 1/2 inches (+/-

1/8") or 6.4 cm (+/- 3 mm). The weight of an empty soda can is 0.5 oz (14 grams). The weight of the ballast shall increase the total weight of the can and ballast to be 2.5 oz (+/- 0.1 oz) or 72 grams (+/- 3 grams). The ballast used in the competition containers will be common sand. The can will be sealed in such a way that the ballast cannot fall out.

2.3.2 Notes about damage to containers: The robot's manipulator may crumple the container. A container that is damaged or excessively crumpled will not be reused in the competition. The idea of the container is that it is designed to withstand damage in order to protect the contents.

2.3.3 Color: Each soda can will have a different color: The cargo containers that must be moved will be red, yellow, and green. The cans that will be used as interference for the final round will be blue. Lighting conditions contribute greatly to RGB sampling value drift; therefore teams should design to calibrate to the course conditions beforehand. Opportunities to do so will be afforded the day before the competition during the practice session; as well as during the 2 minute prep time at the start of a run. Also, the soda cans will be painted with flat or matte spray paint as to limit the amount of reflection and interference from stray light.

2.3.4 Movement of containers: The robot may move the container by any means. Note that gripping a container is not required. When a container ends by resting upright for 5 seconds in the corresponding colored circle, the robot has accomplished delivery the container. Lifting, scooting, rolling or even throwing are legal methods.

2.3.5 Order of delivery: Each of the 3 cans will be in one of the starting circles (marked 1, 2, 3 on the figure), with only one can per circle. The robot must retrieve the cans and place them in the appropriate safe areas based on their color. The order the cans are retrieved and delivered will be given to the team after the placement of the robot. The order will be given as a series of numbers representing the starting circles. For example, if the order required is "3,1,2," then the cans must be retrieved from those starting circles in that order. The robot should be able to judge from its present location and execute the required task. Only one set of cans is setup at the beginning of each run. Run time ends either when the robot has successfully delivered all three of the cans to their appropriate rooms or when the 3 minute time limit has expired. The starting locations of the cans will vary from run to run.

2.4 Robot Design Restrictions

This competition is intended to encourage creative and improvisational design. The only hard restrictions are the size, weight, autonomous control and safe. By autonomous, the robot must not need or have any human control or intervention once the "Activate your robot." command has been issued. By safe, the robot must not pose a hazard for those at the competition or be able to damage the course. Specifically, the rules for the competition are as follows:

2.4.1 Size and weight: The maximum starting and ending size must be 16 inches wide,

- 16 inches long, 36 inches tall and cannot weigh more than 50 pounds. It is legal to have multiple robots which separate or to have a robot expand once activated. However, the size and weight requirements must be met before and after the run. Any size or weight violations before the run will disqualify the robot for that run. Any size or weight violations after the run will result in time penalties.
- 2.4.2 Sensors:** Any sensor or combination of sensors is legal within the restriction that the robot must be autonomous.
- 2.4.3 Power:** The robot must be self powered and self contained. For safety purposes the power source must be electrical. No combustion engine power system is to be permitted. Batteries must be enclosed in a manner that will prevent fire or liquids from becoming a hazard to the course or the facility.
- 2.4.4 Locomotion:** Safety is the only restriction. Wheels or legs or arms or anything else conceivable is legal. DC motors, pneumatics, air muscles, muscle wire (Nitonol), etc are all acceptable. Flying is acceptable as long as it is demonstrated as safe.
- 2.4.5 Controller/Processor:** No restrictions.
- 2.4.6 Manipulator:** (Gripper, lifter, etc) Safety is the only restriction.
- 2.4.7 Safety is the golden rule:** Any robot that is deemed to be unsafe by the judge(s) can be disqualified until it is modified to be safe. This rule is to ensure the people attending this event, the property where the conference is held, the course will not be harmed. Robot must also contain an Emergency stop button that is accessible from the outside for the robot in case of robot malfunction. A robot that does not contain some type of emergency stop will not be allowed to compete.
- 2.4.8 Multiple robots:** A competing team may enter a robot that divides itself into smaller robots to complete the task, subject to the total size and weight restriction of section 2.4.1.
- 2.5 Communication:** Once the robot is placed on the course the team will be given the opportunity to communicate the container priority to the robot. The team may use any method to accomplish this task. Including but not limited to keypad, rf, ir, microwave, cell phone, satellite, signal flags.
- 2.6 Final Round:** The top competitors as defined above will advance to the final round, which will introduce a new challenge to the course: Different containers will be placed in the numbered circles along with the containers to be moved. The container to be moved (red, or green, or yellow) will be standing as before, and a different container with a different color (Sail Blue (Rust-Oleum™ 7724-830)) will be in the circle. Both cans will be contained entirely inside the circle. All containers will be similar in size and shape and will be separated by the maximum distance allowed by the course. The Sail blue container will be standing but, will not be completely blocking the container of interest. This is view from the line radiating from the circle. No penalty is given for moving or interacting with the container that is not to be transported.

3.0 Scoring and Time Penalties

- 3.1 Score Calculation:** The score for each run will be the total time to complete the course (180 seconds max) plus any penalty time. For qualifying in the final round the best time of the early round will be used. The time for the final round will be the best time of the two runs.
- 3.2 Penalty for container that does not remain upright:** A container that is placed in a cargo area but that does not remain upright for at least five (5) seconds will receive a time penalty of five (5) seconds per container.
- 3.3 Penalty for container not moved to correct cargo area:** Any container that is placed and remains at the end of the round in an incorrect colored cargo area is penalized using the equation $(5^n + 5)$ seconds, where n is the number of containers not in the correct cargo area.
- 3.4 Penalty for “dropped” containers:** A container that is dropped outside the appropriate cargo area and left in an area other than a colored area is penalized using the equation $(5^n + 10)$ seconds, where n is the number of containers not in a cargo area.
- 3.5 Penalty for deviation from black navigation line:** There is no deduction for a robot that does not use the black lines for navigation or crosses the center of the course.
- 3.6 Penalty for leaving course boundary:** If any portion of the robot leaves the boundary of the course as defined in Figure 1 the robot will be disqualified for that run. No score will be given for that robot’s run.
- 3.7 Provision for unsafe robots:** A judge may at anytime declare a robot to be unsafe and disqualified for that run. No time is recorded for disqualification of this type.
- 3.8 Penalty for unmoved containers:** For all containers that are not moved from the initial starting position, a penalty colored area is penalized using the equation $(5^n + 15)$ seconds, where n is the number of unmoved containers. If a robot attempts to capture the container and causes the container to move, this time penalty will not be issued for that particular can.
- 3.9 Penalty for size restriction:** A robot that does not meet the required size at the beginning of each run will not be allowed to compete. A robot that extends beyond the size restriction and fails to meet the restrictions, once the run has been completed, will be penalized fifteen (15) seconds.
- 3.10 Penalty Weight restriction:** A robot that does not meet the weight requirement at the beginning of each run will not be allowed to compete.

4.0 Other Considerations

4.1 Course lighting: The lighting in the Facility where the competition is taking place is fluorescent lights with high ceilings. The ceilings are 14 foot high. Figure 2 is a picture of part of the area where the competition and practice tracks will be set up. There are no windows in the area where the competition is taking place. Figure 3 shows the floor plan where the competition will be held. The rooms available to the robot competition are rooms 402-407. Figure 2 shows Rooms 405-407 with the partitions removed.



Figure 2. Competition Area.

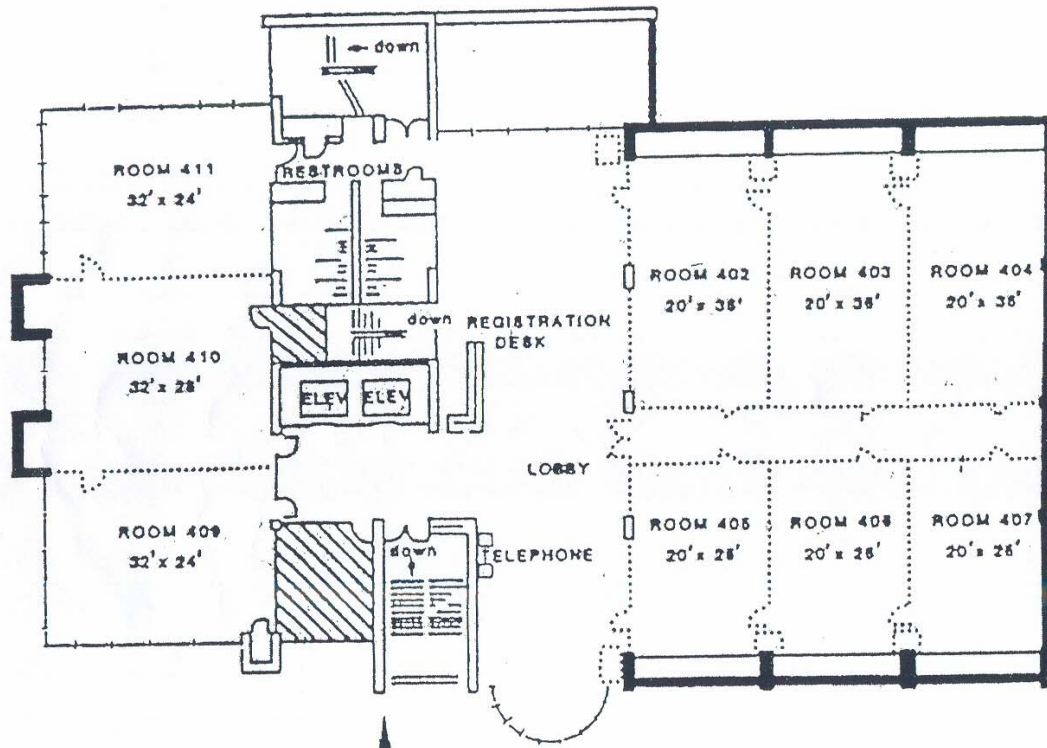


Figure 3. Competition Floor Plan

- 4.2 Additional lighting sources:** They will not be provided and teams cannot use their own light source during competition. There is only one exception to this rule and that would be if the robot has its own onboard light source.
- 4.3 Course background:** This competition is highly dependent on vision and color recognition abilities and as such, background interference poses a problem. To alleviate the risk of background interference (bright colored clothing, objects, that are not a part of the course), the course will be roped off so that no personnel other than the judges and two members of the current competing team will be allowed within five (5) feet of the course perimeter.
- 4.4 Flash photography:** Since this competition relies heavily on the robot's ability to 'see' and recognize obstacles and cans, flash photography is prohibited during run times of the competition.
- 4.5 Number of team members:** The number of people involved in designing and constructing a robot is not limited; however, only six (6) people may be registered

per team and because of space restrictions there will be a limit of four (4) teams per school. Only two (2) members of a team will be allowed at the track during that team's run.

- 4.6 Practice tracks:** Practice tracks will be made available prior to the competition.
- 4.7 Construction of course:** The course will be constructed using 3/4" (or what ever the lumber industry deems 3/4" plywood is this week) tongue and groove plywood. The plywood seam will run east and west along the center of the course. All care will be taken to make the seam as smooth as possible. The plywood will be painted with semi-gloss white deck paint.