IEEE, Region 5 2005 Conference Robotics Competition Rules and Course Description
Revision: 9/6/2004

1.0 Concept: The Robotics Competition at the 2005 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 reproducible at least in part by any of the competitors for testing at their respective home site.

In general the competition is a mock up of an automated warehouse. Competitors are to construct an autonomous robot that will take commands from a dispatcher unit regarding the location of a stored object and to where that container is to be moved. For example, the direction could be to collect the container stored in room C and move it to room 2. The robot must then have the following features:

- Wireless Communication circuit to receive commands
- Drive system for motion
- Navigation sensor array to move from one room to another
- Manipulator to handle the container
- Processor/software to coordinate all of these elements

Each competitor will have 2 runs of the course, each run being limited to a period of 3 minutes. Each robot is scored during this time for how well it accomplishes its directions. Points are awarded for each container moved with penalties for movement from/to the wrong location, etc. The best score of the 2 runs will be taken. Each run will be separated by at least 2 hours in order to give the teams time to correct problems or make adjustments. Failure of a robot to leave the starting area within 30 seconds ends that robot's run, so non mobile robots need not take up the entire 3 minute slot unnecessarily.

The 5-10 highest scoring teams of the first two rounds will go on to the final round which will introduce other challenges to make the competition more difficult. However the new challenges should not make it necessary for the robots to have a separate set of software or any new hardware to handle them. See Final Round info below. Top 3 scores will receive awards. A tie must be resolved with another run with highest score taken.

There will also be additional categories for award based on subjective judgment. These will include but are not limited to: Most Innovative and Best Style

2.0 Details of the course. Note that for all linear measurements expressed in inches, there is a tolerance of +/- 0.5 inches. The ¾" black line has a tolerance of +/- 1/8". All other tolerances are noted where applicable.

2.1 Course description: Figure 1 shows the layout of the course. It is a "warehouse" of 8 rooms, each 2 x 2.5 feet in size with a single entrance/exit 2 feet wide. A corridor 3 feet wide will separate 4 rooms on one side from 4 rooms on the other. Note that the "walls" between rooms are shown in figure 1 as black lines for clarity. In actuality they are only 1 inch high dividers and are painted white like the floor.

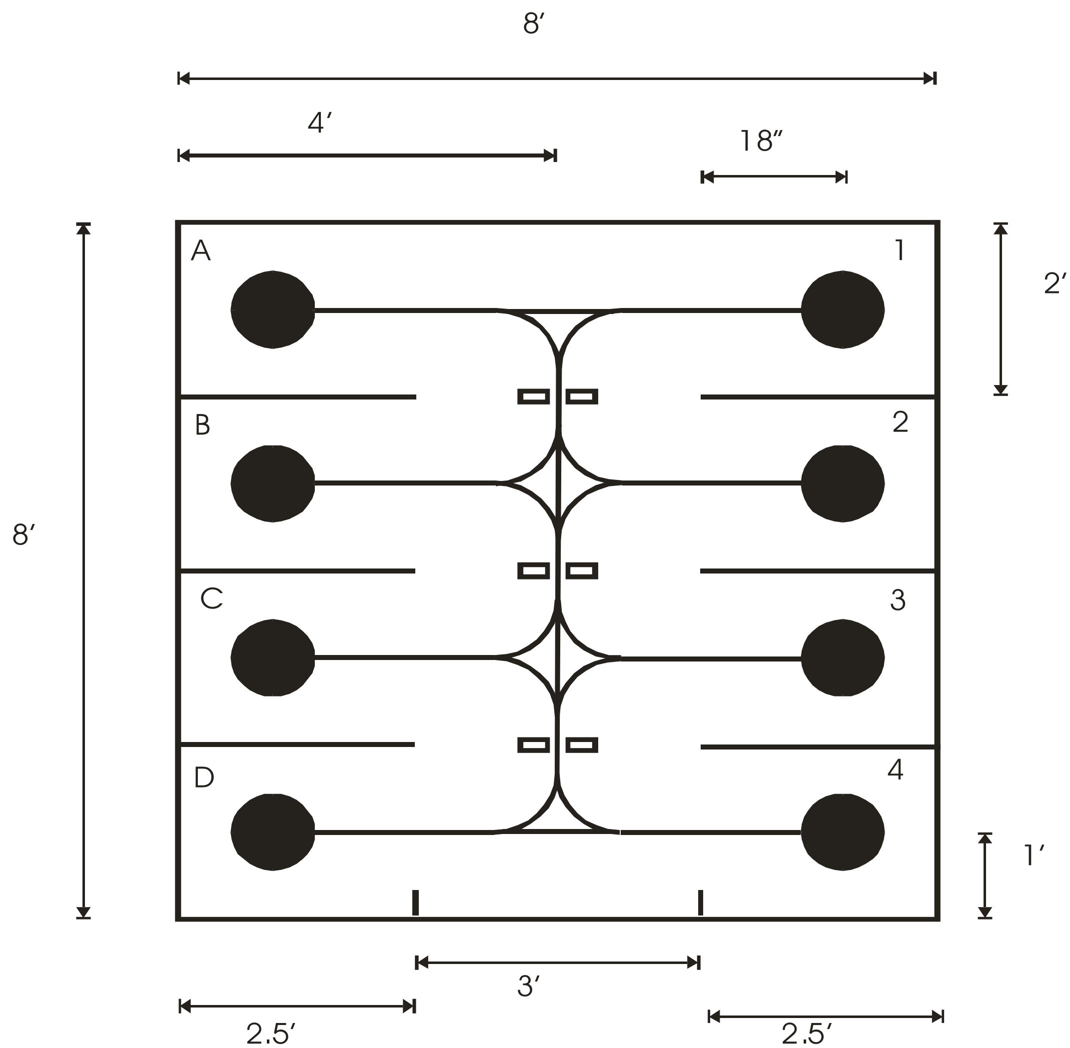

Figure 1: Course Layout

2.1.1 Plywood sheet construction. The course will be constructed of 2 plywood sheets joined together to make a relatively smooth floor. The floors will be painted flat white, with a ¾" wide black line running between the rooms and in the center of the corridor. The two 4' x 8' plywood sheets will be placed such that the central corridor line will cross the joint of the two sheets perpendicularly. (In figure 1 the top of the course will be one sheet and the bottom half the other).

2.1.2 Walls. Walls will be simulated with 1 inch square wooden molding strips. Robots cannot cross over the molding. There will be no ceilings on any of the rooms to afford viewing as the robot runs the course. The molding strips will be painted white like the floor. Molding that forms the walls of rooms B/C and 2/3 will be mounted to the top plywood sheet with no overlap, thus the walls for rooms C and 3 will be slightly (1/2" or less) wider than the other rooms. A robot is not to pass over the plane formed by the molding. Doing so results in a penalty. See 3.0 Points and penalties.

2.1.3 Room details. Each room is 2 feet wide by 2.5 feet long. Inside of each room the black line will end in a solid black circle that will be 10 inches in diameter. This black circle will be the place in which the storage containers will be stored. A storage container container be anywhere inside this circle when the robot goes to fetch it. Similarly, the robot can place the container anywhere inside the circle, so long as all of the container is inside the circle.

Rooms on one side of the warehouse are INCOMING (Rooms A, B, C and D) and the rooms on the other side of the corridor are OUTGOING (1-4). The dispatcher will give instructions to move containers from an INCOMING room to an OUTGOING room. The containers will be reset by simulated machinery (the judge/facilitator) as the containers are completely removed from a room. Outgoing containers will likewise be removed by judge after all containers have been placed and the robot signals for new instructions.

2.2 Storage containers:

2.2.1 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 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 pull tab will be removed and the hole plugged so that ballast cannot fall out.

2.2.2 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.

2.2.3 Color. Each of the storage containers will be painted bright red except on the top and bottom sections which are normally unfinished. The pull tab will be removed and the hole plugged so that ballast cannot fall out.

The red color is meant to allow a team to use a vision system for detection, but vision is not necessary to detect a solid cylindrical, metallic object that has a known height. Sonar or IR rangefinding sensors, IR proximity detectors, or even a simple "whisker" type sensor will suffice to make this detection and of course, the container must be inside the solid black circle.

2.2.4 Movement of containers. The robot may move the container by any means. Note that gripping a container is not required. So long as the container ends by resting upright for 5 seconds in the target black circle, the robot has accomplished its mission. Lifting, scooting, rolling or even throwing are legal methods.

2.3 Dispatcher: The dispatcher unit will be the source of instructions to the robot. The dispatcher will be a computer controlled radio frequency RS-232 format transceiver. This transceiver will be mounted on a column that is positioned at the intersection between room A and room 1, and 5 feet above the course.

2.3.1 Format. Communication format will be RS-232 data, 9600 BAUD, 1 start bit, 8 data bits, 1 stop bit, no parity bit. Communication protocol will be similar to XModem where both dispatcher and bot send data that is terminated with a checksum byte. The robot will initiate communication, requesting instruction. The dispatcher replies with the instructions and if the robot received them will acknowledge. If the transmission was faulty, the robot requests the dispatcher to resend. Protocol for communication follows:

Robot sends: Rr – Robot Ready (ready to receive command)
Dispatch sends: DA2B4C3D1 – Get object from room A, take to room 2, etc
Robot sends: Rok

The first byte is the source identifier (R for robot, D for dispatcher). Each data stream will be terminated with a checksum byte that will be the complemented XOR product of the bytes in the stream. If the robot does not receive a good data stream it signals

Robot sends: Rnr

And the dispatcher resends the data until a good transmission is received.

checksum = 1's complement of (byte0 XOR byte1…XOR byten)

Example of checksum calculation: Dispatcher is to send DA2B4C3D1. In ASCII this is

D	A	2	B	4	C	3	D	1
44h	41h	32h	42h	34h	43h	33h	44h	31h

XOR operation on all bytes gives 44h and 1s complement of that is BBh

So the full data stream sent by the dispatcher will be (in hex)

44 41 32 42 34 43 33 44 31 BB

The robot's response of Rok gives a checksum of : 1s complement of (52h Xor 6Fh Xor 6Bh) = A9h. So it sends (in hex) 52 6F 6B A9.

The dispatcher will only give a batch command to move all 4 INCOMING containers to 4 OUTGOING rooms. No partial commands will be issued.

2.3.2 RF Transciever information. The same brand and model of RF modem will be used by all competitors to ensure uniform transmission and receive quality. The Maxstream 9XCite 9600 OEM module was chosen for its ease of use, reliability and low cost. These RF Modems can be viewed at

http://www.maxstream.net/products/xcite/module/9xcite.php

Maxstream's part number for the standalone module is XC09-009WNC. This is for a 9XCite 915MHz, 9600 Baud, Integrated wire antenna, Commercial temp rating OEM module.

A development kit is available that will include all cables, power supplies and a circuit board that will do RS-232 voltage level translation for about $200. This kit is recommended to familiarize yourself with the modem's features, and allows the user to very quickly connect two devices together for serial communication. However the level translator board is a simple circuit that can be built for about $10, so it is not necessary to purchase the dev kit. If you wish to purchase the dev kit in order to save some development time, its part number is XC09-009-DK.

Maxstream offers an educational price for these products. Be sure to specify that for lowest cost.

2.3.3 RF Transceiver Address. The official competition dispatcher will have an address assigned of 0x7777. Robots must be able to select this address when running in the competition. On the day of the competition there will be many transceivers operating in the same room, thus during trial operation each robot's transceiver as well as a testing dispatcher unit must be set to some other address. Facilitators for the competition will circulate during the competition and check addresses, so design for the ability to change address of the transceivers.

2.4 Course navigational aids:

2.4.1 Black line: This will be used to aid in navigating from room to room. There are straight line segments joining adjacent rooms and curved segments to allow the robot or robots to make turns and maintain good tracking of the line. The line will be ¾" (+/- 1/8") wide with a radius on turns of 8 inches.

2.4.2 Floor reference markings: As figure 1 shows, there are 3 reference markings on each side of the line that a robot may use to orient itself. Figure 2 shows the 3 markings and their size relative to the main black line. These markings consist of 2 rows by 3 columns of black rectangles. Each individual rectangle field is 10 mm (+/- 1mm). This pattern occurs on both sides of the line at a midpoint between intersections. The markings are mirrored images of each other on each side of the line. This allows the markings to identify the robot's position and also in what direction the robot is traveling.

The reference markings are referred to as X, Y, and Z. X shall be placed at the midway point between rooms A and B. Y shall be at midway point between rooms B and C, and Z at the point between C and D. Note that because the plywood sheets will join at the midway point between rooms B and C, that the reference marking Y shall be 1 inch closer to room B.

2.4.3 Black circle in each room. Each room will have a solid black circle that is 10 inches in diameter. The center of this circle will be placed 18 inches inside the door and 12 inches from the walls.

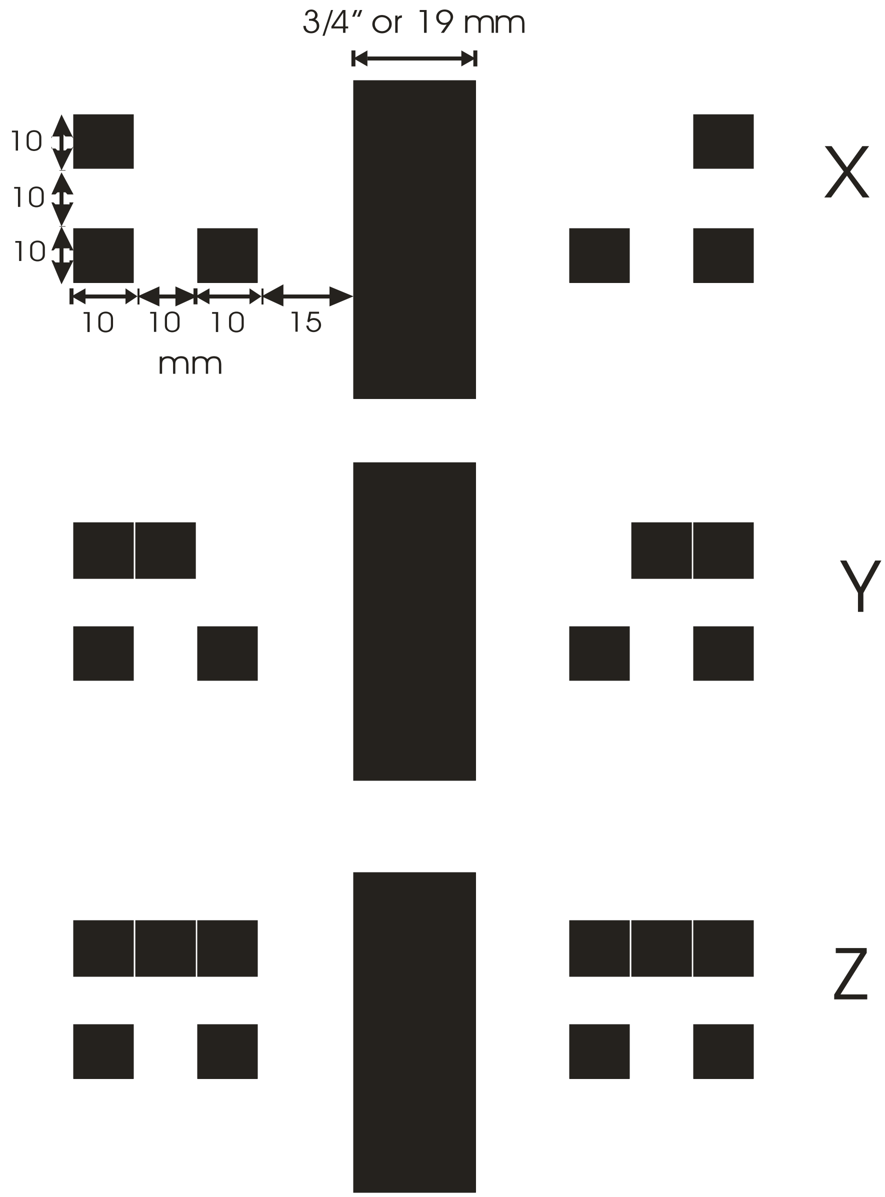

Figure 2: Black line and Floor reference markings

2.5 Robot design restrictions: This competition is intended to encourage creative and improvisational design. The only hard restrictions are that the robot must be autonomous (self acting) with no means of human control whatsoever and it must be safe for the course and the viewing audience. Specifically, the rules for the competition are as follows:

2.5.1 Size and weight: The warehouse is of a limited size and the specifications of the size of doors, turn radii, etc will in themselves be a limit to size. A maximum size is declared then to be 16 inches x 16 inches with a height limit of 3 feet. This is done to ensure that the course will not be damaged by a robot as it runs. Note that multiple robots that when combined all fit within the 16 by 16 inch x 3 feet qualifier are legal.

A weight limit of 50 pounds is as well imposed. Mobile robots by necessity are lightweight for battery power, so a limit of 50 pounds should not pose any real restriction to a team.

2.5.2 Sensors: Any sensor or combination of sensors are legal within the restriction that the robot must be autonomous.

2.5.3 Power: The robot must be self powered and self contained. For safety purposes power source must be electrical. No combustion engine power system is to be permitted. Batteries must be completely enclosed. Considerations are lead acid type batteries or lithium batteries that can pose a fire hazard under certain conditions.

2.5.4 Locomotion: Safety is the only restriction. Since the robot must be autonomous, a flying robot is impractical given the size of the course. Wheels or legs or arms or anything else conceivable is legal. DC motors, pneumatics, air muscles, muscle wire (Nitonol), etc are all acceptable.

2.5.5 Controller/Processor: No restrictions.

2.5.6 Manipulator: (Gripper, lifter, etc) Safety is the only restriction.

2.5.7 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 a catch all and is only placed here to allow for some very unreasonable design, or for a robot that is fabricated so poorly that it poses a threat to the course or audience. The competition takes place within a closed, painted, wooden platform and is housed inside of a hotel which IEEE does not wish to offend or move to legal action.

2.6.7 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 2.5.1.

2.6.8 *RF Transceiver Address.* The official competition dispatcher will have an address assigned of 0x7777. Robots must be able to select this address when running in the competition. On the day of the competition there will be many transceivers operating in the same room, thus during trial operation each robot’s transceiver as well as a testing dispatcher unit must be set to some other address. Facilitators for the competition will circulate during the competition and check addresses, so design for the ability to change address of the transceivers. Transceivers with the address of 0x7777 in the area of the competition will be required to be shut off.

2.6 Final Round: The top 5-10 competitors (depending on the number of total competitors) will advance to the final round which will introduce new challenges to the course. Main differences for the final round:

The time limit will be extended to 5 minutes.
All dispatcher directions will be random
"Human workers" on the course must be distinguished from containers.

2.6.1. Additional time. Each robot will have 5 minutes to compete in the final round, thus greater reliability is required.

2.6.2. All dispatcher directions are random. The first set of directions will be completely random, thus the wireless communication system must work or the robot will be unable to complete a mission.

2.6.3 *Human workers.* Human workers on the course must be avoided and must be distinguished from the containers. Human workers will be simulated with Barbie dolls and spread throughout the course. There can be up to 3 workers present on the course, including standing near a container or black line. Workers will be at least 3 inches away from a container, and 5" away from the black line. If a worker is placed in a black circle in a room, the worker will be 3 inches from the point that the black line enters the circle. Otherwise, the worker can be anywhere else inside the circle.

Locations of workers will be changed at the beginning of each run.

Knocking over a human worker results in a penalty. A robot that grabs and moves a human instead of a container will be penalized more harshly. See section 3.0.

Human workers will be dressed in bright yellow coveralls to aid in distinguishing them. The color of the workers clothing is useful to a vision detection system, but is not the only means of detection. Barbies not only wear yellow, but are taller and thinner than soda cans. Barbies also do not conduct electricity (and by OSHA standards cannot wear conductive jewelry while on duty).

A commonly available stand will be used to make the worker stable while in a standing position. This stand will be painted white to match the floor of the course.

3.0 Points and Penalties Schedule:

3.1 Points per container. Each container that is moved from an INCOMING room to an OUTGOING room while there is still time remaining on the official clock for that run is scored 10 points. A container must be completely inside the circle.

3.2 Penalty for container that does not remain upright. A container that is placed in a circle but that does not remain upright for at least 5 seconds will only receive 5 points.

3.3 Penalty for container moved to wrong room. Any part of a container that is placed in a wrong OUTGOING room's black circle is penalized 10 points. Thus moving a container to the wrong OUTGOING room results in 0 score for that container.

3.4 Penalty for container moved to INCOMING room. A container that is placed anywhere inside any INCOMING room is penalized 20 points.

3.5 Penalty for contact with walls. Any contact with the "walls" (rounded molding) results in a deduction of 5 points. If any portion of the robot touches the molding, this is deemed as contact and results in a penalty. Since the molding simulates a wall, a robot may not pass a portion of its fuselage over the molding. The judge will give a ruling for this based on visual inspection and must err on the side of discretion, so do not design a robot that is so large that such subjective methods become frequently necessary. Any such ruling by the judge is final and cannot be contested.

3.6 Note regarding deviation from black navigation line. There is no deduction for a robot that does not travel at all times on the black line so long as it does not make contact with the walls.

3.7 Penalty for leaving course boundary. A robot that strays off the course will be disqualified. Straying off of the course is defined as any portion of the robot touching the floor on which the plywood course rests. No score will be tallied for that robot's run.

3.8 Penalty for harmful contact with human. Touching a human worker that results in the worker falling over results in a penalty of 10 points. Merely touching a human does not result in a penalty. Only contact that knocks the human from her feet results in a penalty.

3.9 Penalty for moving a human. Moving a human worker more than 2 inches results in a penalty of 20 points.

3.10 Provision for unsafe robots. A judge may at any time declare a robot to be unsafe and disqualified for that run. No score is tallied for disqualification of this type.

4.0 Other considerations for course:

4.1 University Team vs. Open categories: The Open category is proposed to allow teams from corporations or other entities to put forth a competing robot. Since often these teams may consist of a company or individual with resources that may not be available to universities, they will not compete against each other. The Open category allows companies to showcase their products and their personnel and gives the opportunity for the professional and academic worlds to meet in friendly competition.