2009 High School LEGO Robotics Competition Rule Book

Rev. 1.0

"Supply and Demand"

Welcome to the 2009 Case Engineering LEGO Robotics Competition! This challenge is intended as a learning experience in creative problem solving and team building. I'm pleased to have the opportunity to organize such an event, and am looking forward to the innovative solutions we've all come to expect and enjoy in this competition.

Workshops will be held to cover a number of the major issues that are expected to be encountered throughout the challenge. Further information and helpful links will be provided through the competition website (http://filer.case.edu/org/leogorobots). If you have any questions that cannot be answered through either of these, please feel free to contact me at jeremy.marvel@case.edu. I wish you all the very best of luck.

Regards,

Jeremy A. Marvel

Challenge Objectives

This year's competition is a supply-run challenge modeled after the quintessential logistical quagmire, the traveling salesman problem (http://en.wikipedia.org/wiki/Travelling_salesman_problem). Teams will be expected to build robots capable of autonomously navigating a "roadmap" constructed of taped lines, visiting specific high-priority target locations throughout the map, and depositing tokens at these target locations for points.

The world consists of a series of road lines laid out on a fabric map. Along these roads are scattered ten pre-defined regions specifically marked out for automated detection by your mobile robots. These locations—"drop zones"—represent depots requiring supplies that your robots must deliver. Your robots must depart the "home" location on their five-minute run, and, once they determine they have landed on a drop zone, they should place their payloads on the map. Scoring is based on the number of payloads located in the drop zones at the end of the team's run.

The challenge is that of the ten drop zones, only five will be given point values for a given run. These five zones will change from run to run, and teams will be given a mission file five minutes prior to their run that will specify the respective values of all zones. Your robots should devise an intelligent strategy for visiting those zones that will award the most points in the allotted time. To add to the challenge, your robots can only be loaded with payloads while in the home position. Whenever your robot runs out of payloads, it should return to the home position on its own to be refilled.

Robots are to consist of a mobile base and an actuated dispenser to place payloads on the map. Vehicle and payload restrictions are discussed later in this document. The use of team-provided laptops is permitted, but only for the purpose of interventions. All autonomous code should be run on the LEGO Mindstorms brick. Teams are allowed to use whatever language they feel most comfortable with, but we will provide support only for NXC (http://bricxcc.sourceforge.net/nbc/).

Scoring

Positive scoring is judged solely on payload placement on target drop zones. For any given mission configuration, there will be a total of five zones "activated" to carry point values, and five "deactivated" zones that count for no points. The five activated zones will be numbered one through five—a representation of the zone priority, with five being the most important—and will award points equivalent to this number. While multiple tokens per drop zone are permitted, only the first token placed in that zone will actually count toward scoring. For instance, if five tokens were put down on the drop target worth four points, only four points would be awarded for that target. A maximum number of fifteen points may be awarded per run.

Point deductions are incurred whenever a team's robot leaves the playing field. One point will be subtracted for each unique instance of the robot moving off of the map. For example, if the robot moves off the map, then back onto the map, and then off the map once again, never to return, two points will be taken from the final score. Judges will tally the number of map exits, and the numbers will be totaled at the end of the run. The lowest possible score is set at zero, thus no negative scores will be given to any team.

As mentioned previously, a run will last for five minutes. A team may choose to call for their run to end early, however. Each team will be given two runs, and the scores from those runs will be summed to provide the overall score of each team. In the event of a tie between two or more teams, the team that uses the fewest number of interventions and finishes the round in the shortest amount of time will be considered the victor of the tie-breaker. The three leading teams will run a playoff round consisting of one final run each to determine the top three rankings.

Vehicle Requirements

At the heart of each robot must be a LEGO Mindstorms programmable brick. Either the current NXTs or the older RCX bricks may be used in this regard. Creativity in robot construction is highly encouraged, though certain rules must be established in order to ensure your robot is capable of competing.

- The robot must fit within the bounds of the starting block. In order to do so it may not be more than eight inches (8") wide nor longer than twelve inches (12"). There are no size limits for height.

- The robot must be constructed entirely out of LEGO parts. You are more than welcome to use parts that were not provided in the kits (including sensors), but you must provide these yourself.
- Any custom sensors must be constructed to fit within standard LEGO bricks.
- The robot may not damage or alter the tape course.
- The robot must be capable of carrying and placing payloads without human assistance. There is no limit to the number of payloads a given robot may carry.

Payload Requirements

While the challenge of the competition is autonomous navigation, the actual goal is safe payload ("token") delivery. The robot must carry its payload from the home position to the target drop points without posing any danger to the participants, robots, or environment. The actual tokens used are ultimately up to the discretion of the teams, but should adhere to the following guidelines:

- Tokens must be at least one inch (1.0") long by one-half inch (0.5") wide, and should fit within the bounds of the drop zone.
- Tokens should be sufficiently weighted such that they stay where they are placed on the map.
- Payloads must be "dead weight," meaning that they cannot move on their own (i.e. you cannot designate a robot or living organism as a token).
- Once a token has been placed on the map, it may not be touched by either the participants or the judges until the run is finished. Robots, however, are permitted to "retake" payloads, but it is important to remember that only those tokens present on the map at the end of a run are considered for scoring.

A few examples of acceptable payloads include poker chips, backgammon pips, and LEGOs. Keep in mind that you will have to carry and dispense these tokens, so choose something appropriate for your robot's construction.

Interventions

Teams are awarded an unlimited number of interventions should their robots need assistance in navigating the roadmap. These interventions, however, must adhere to the following guidelines:

- Interventions are limited to a frequency of 1Hz (i.e. once per second)
- All interventions must be conveyed through wireless communications (Bluetooth or IR) from a team-provided computer. With the exception of token loading in the home position, no physical contact with the robot is allowed during the five-minute run.
- Every time an intervention command is sent and received, an audible indicator of receipt must be played by the robot. Judges will tally and record the number of intervention signals received in each run by your robot. These tallies will be used *only* for tie-breaking purposes, and will not affect a team's score.
- Interventions may not be used to actuate the payload dispenser.

We will provide a simple Bluetooth command-issuing Windows application and sample NXC code for Bluetooth intervention signal handling. Students wishing to use a command application with more functionality or are programming in languages other than NXC must provide their own code.

Course Layout

The course will be laid out on a portable playing field constructed from a five-foot square canvas drop cloth and black and white Scotch brand 1.88" duct tape (see Table 1). Roads will be marked in black tape, while the drop zones and home positions will be laid out in a ten-inch (10") square outline in white tape. Roads will intersect only at drop zone locations, but will not actually touch one another. They will, however, overlap the outer perimeters of the drop zones by approximately one inch (1"). Each edge of the

drop zones will have at most one road attached, and all drop zones will be guaranteed to be reachable by means of some road path (i.e. there will be no blind navigation required). See Figure 1 for an example map.

Course connectivity will be described in an XML file, which will contain all information necessary for the robots to construct a virtual road map. An image of the actual competition layout and the map definition file will be distributed to the teams during the preceding weekend. Players should anticipate minor variances in the actual placement of the tape on the map, though all attempts will be made to be as accurate as possible while constructing the maps.

Course Obstacles

It should be noted that a number of impassible obstacles will be placed throughout the map, but will not interfere with the robots' paths along any road. These obstacles will not appear on any representation of the map given to the teams. Robots that leave the road and collide with the obstacles will not be penalized in any way, though teams will likely have to use interventions in order to recover.

The Map and Mission Files

This year we will be providing map descriptions in Extensible Markup Language (XML. http://en.wikipedia.org/wiki/XML) format, which is intended to codify data in a format that is also human-readable. A number of XML parsers are readily available online, and you are free to use any of these or to program your own. These files will specify drop zone identities, locations, and connectivity. An excerpt from a sample map description file for the map displayed in Figure 1 is shown below.

```
<map name="Antiga Prime">
   <zone id="0" x="0" y="0">
      <road side="w" target="1" />
   </zone>
   <zone id="1" x="-10" y="40">
      <road side="n" target="3" />
      <road side="s" target="0" />
      <road side="e" target="2" />
      <road side="w" target="8" />
   </zone>
   .
   .
   .
   <zone id="10" x="-100" y="80">
      <road side="w" target="9" />
      <road side="s" target="5" />
   </zone>
</map>
```

Here is an explanation of the various tags seen :

Tag	Description
map	Begin a new map description
name	String identifying the map name
zone	Begin a new drop zone description
id	An integer between 0 and 10*, identifying the unique identity of the zone
x	X location of the center of the drop zone in inches**
y	Y location of the center of the drop zone in inches**
road	Begin a road description leading away from the current drop zone
side	The cardinal direction of the exit to the specified road***
target	The drop zone to which the specified road leads

* - A total of eleven zones will be specified in the map description file. The eleventh zone, id number 0, is the home position of the robot.

** - All measurements are taken relative to the center of the home location

*** - Note that the cardinal north is independent of the exit(s) leading out of the home position. *Note: Among your startup parameters you may want to have a flag that specifies which direction your robot is facing.*

Five minutes prior to a given team's run, that team will receive its mission file via a USB flash disk. The mission file will be a simple flat text file that will list the point values for the ten drop zones in the order that their ID numbers appear. For instance, if drop zones 2, 5, 7, 8 and 10 are awarded the point values 2, 1, 4, 3 and 5 respectively, the mission file will consist of the following ten numbers:

```
0 2 0 0 1 0 4 3 0 5
```

All mission files will be guaranteed to have exactly ten single-digit numbers. Five are guaranteed to have 0 value, and no two non-zero numbers will be identical.

Startup

Teams will be given their mission definition files prior to their scheduled start time. This window should be used to establish wireless communications and other necessary startup procedures. Just prior to the run, teams are to place their robots in the home position in any configuration they so choose, but the robot must be entirely within the perimeter of the box. The run will begin five minutes after the team has been given its mission file, or whenever the robot starts moving, whichever comes first.

Have Fun and Good Luck

This competition is meant for you, the students and mentors, as an enjoyable learning experience in which we are all brought together by common interests. Good sportsmanship and comradery are vital elements to making these events enjoyable, and we openly invite any constructive feedback that will improve the competition and the way it is experienced by everyone.

Appendix: Figures and Tables

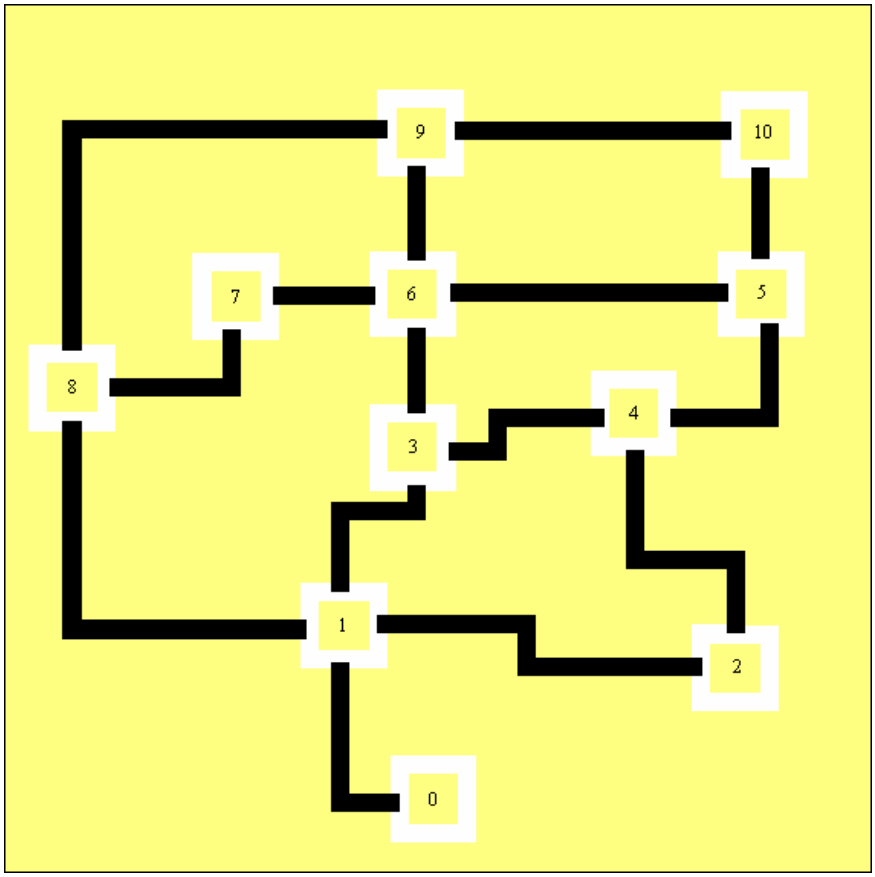

Figure 1: Sample road map.

Seller	PN (MFG)	Description	Price
Home Depot	1060-WHT	Scotch white duct tape (1.88” x 60 yd)	$6.97
Home Depot	1060-BLK	Scotch black duct tape (1.88” x 60 yd)	$6.97
Home Depot	297-254	WorkForce Easy Drop 5’x5’ canvas drop cloth	$5.97

Table 1: Official material supply list