MINI-URBAN CHALLENGE

RULEBOOK

Revision 2014.0

Sponsored By

DOOLITTLE INSTITUTE
speed - innovation - solutions

AIR FORCE RESEARCH LABORATORY

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1 GENERAL OVERVIEW

The Doolittle Institute (DI) announces the 6th Annual Mini-Urban Challenge (MUC) sponsored by DI and the Air Force Research Laboratory (AFRL).

The purpose of this competition is to design and operate a "car" that can successfully navigate through a model city, using a LEGO Mindstorms® kit, at a MUC Competition.

At both the Regional and National Competitions, teams will be scored in a variety of categories and the winning team will be selected based on the highest total score. Scoring details are provided in Section 2.5. The top two teams at each Regional Competition will be invited to compete at the National Competition.

The National Competition will be held on June 14, 2014. The Venue is still to be determined. Awards will be presented to the top three teams.

1.1 GENERAL TEAM RULES

1. Teams may only be comprised of high school students. The team may have a minimum of 3 up to a maximum of 10 students. (Note: For Nationals, there will be a travel stipend provided to cover travel and hotel for the top two teams in each region. This will be a flat fee, depending on the distance you are traveling. You will be responsible for any expenses beyond the stipend.)

2. Schools may have up to two team entries. Each entry must have their own hardware, have been developed by each different team, and must be documented by a separate application form. Teams may be supervised by the same teacher.

3. Only members that participated on the day of Regionals are eligible to move on to Nationals and must compete on the same team.

4. Each team must be supervised and accompanied to competitions by at least one teacher over 21 years of age. On the application, the supervising teacher will certify that all team members are high school students and acquire signed waivers from the school principal, each parent/guardian and for themselves.

5. A "home base" team area will be provided at the competition with power connections. Teams will be responsible for bringing any equipment they will need the day of the competition.

6. Only the student component of each team will be eligible for awards.

7. All teams will be required to download a copy of the following, on our MUC computer, before the awards ceremony of the Regional competition:
   a. A copy of the team's code
   b. What program they used to write their code
   c. A photo of the design/layout of their car
   d. A copy of the team's PowerPoint presentation

These items will not be shared with any other teams. Failure to turn in the items listed above may result in disqualification from participating in the 2014 National Competition and/or any future MUC competitions.

8. Team mentors are encouraged. Competition staff will work to pair mentors with teams. Mentors may be engineers working in the local area or engineering students attending schools in the local area. Mentors are encouraged to meet with the students and help them with their project or may be a support for the teacher. The teacher/mentor's role should be limited to guiding problem solving and providing solution examples. The teacher/mentor is not to build any part of the project or write any of the code used in the competition. These rules apply at home working on it and at the competition. The teacher/mentor will be allowed in the Calibration area but not in the City mat area with the students.

1.2 BEST TECHNICAL PRESENTATION

The Best Technical Presentation Award will be presented to the team with the highest score for their presentation. Presentation details are outlined in Section 2.5.2.

1.3 BEST IN SHOW

The Best In Show Award will be presented to the team that has the most aesthetically pleasing car. Since, by definition, "aesthetically pleasing' is subjective, you are encouraged to personalize your car however you like. It must be fully functional during competition time and it is not required to use lego components for "decorating" your car. No part of the decoration may shield sensors to enhance technical capabilities. Only lego parts/components may be used around sensors.
Each team will have the opportunity to explain to the judges why they designed their car the way they did. The judging for this award will be based on two categories: look and feel as well as form and function, each worth 50% of the total "Show" score. Each vehicle will be given a grade based on a 5-point scale for each category.

2 MINI-URBAN CHALLENGE

2.1 OVERVIEW

The purpose of this competition is to design and operate an autonomous "car" that can successfully navigate through a model city using a LEGO® Mindstorms® NXT kit.
Please note: only NXT's may be used for the 2014 competitions.
The teams are placed based on their total scores: 70% of the total score is based on navigating the model city and 30% of the total score is based on the presentation given by the team.

2.2 THE CHALLENGE

Your challenge is to design a car that can successfully navigate the Mini-Urban Challenge model city using the provided sensors. Your car must enter the city from the designated entry point (see course map: single parking space nearest the "runway") then continue to travel through the city on the roads, obeying the speed limits and stop signs. While in the city, you must stop at your assigned designated locations. Upon checking in at your assigned calibration time during the competition, you will be given the map of the city along with the locations of the six assigned parking stops you must make. At each parking stop your team will be required to (refer to City Score sheets pages 9-10): **"correctly identify"** each spot that your team has been assigned by navigating to the spot assigned. **"Park in the parking lot"** by navigating to the lot assigned. And **"park in the assigned parking spot"** by pulling in and stopping for 3 seconds to simulate that you parked, then backing out of the correct spot. These stops may be made in any order. Once all the stops have been completed you will then be required to exit the city via the same spot as you entered. **Note "infractions"** on the score sheet that will cause points to be deducted from your run.

Your team will have 45 minutes at a calibration station, followed by a maximum of 45 minutes within the model city. Time within the model city may be used for practice runs and up to three scored attempts. You must inform the judges before you begin a run that you plan to have scored and counted towards the competition. Once the time within the city has expired, all scoring will stop.
Your TOP SCORING RUN will be counted toward your team's composite score ("city" score is worth 70% plus "presentation" score worth 30%). The total time of the top scoring run will also be recorded in the event of a tie.

2.3 RULES & REGULATIONS

2.3.1 Car Design

1. Cars shall be autonomous and shall not be remotely controlled (by bluetooth or any other control device) during the competition. "Remotely controlled" includes, but is not limited to: commands to reset the car's computer, commands to reinitialize the car, commands to adjust the car's route, etc.
2. Cars shall be built using only the NXT system. Only one brick may be used per car.
3. Car movement shall be accomplished through direct contact with the competition surface. Power shall only be provided through the battery pack in the NXT controller.
4. The car motor may not be adjusted in any way.
5. The car will only be built using LEGO components. LEGOs not included in the LEGO Mindstorms® kit may be used. NOTE: For decorating "best in show" refer back to section 1.3.
6. Only the following sensors may be used:
   a. Black and white light sensor
   b. Color light sensor
   c. Touch sensor
   d. Ultrasonic sensor

   Teams may use more than one of the approved sensors if they choose.
   Additional approved sensors must be purchased by the team.

2.3.2 Driving

1. Car must obey the designated speed limits at all times. NOTE: refer to section 2.4.3
2. Car must obey all one way directions. NOTE: see arrows on course map
3. Car must not leave the road surface.
4. Car must obey all stop signs, coming to a complete stop before beginning again.
   NOTE: refer to section 2.4.2

2.3.3 Programming

Teams may use any programming language they would like on the NXT. All teams will be provided with the LEGO Mindstorms Education NXT Software v2.1© and the NXT User Guide©. There are many other programming languages and compilers that are available for free online. The Mini-Urban Challenge website (www.miniurbanchallenge.com) provides a list of some of the software options that are available.

2.4 CITY DESCRIPTION

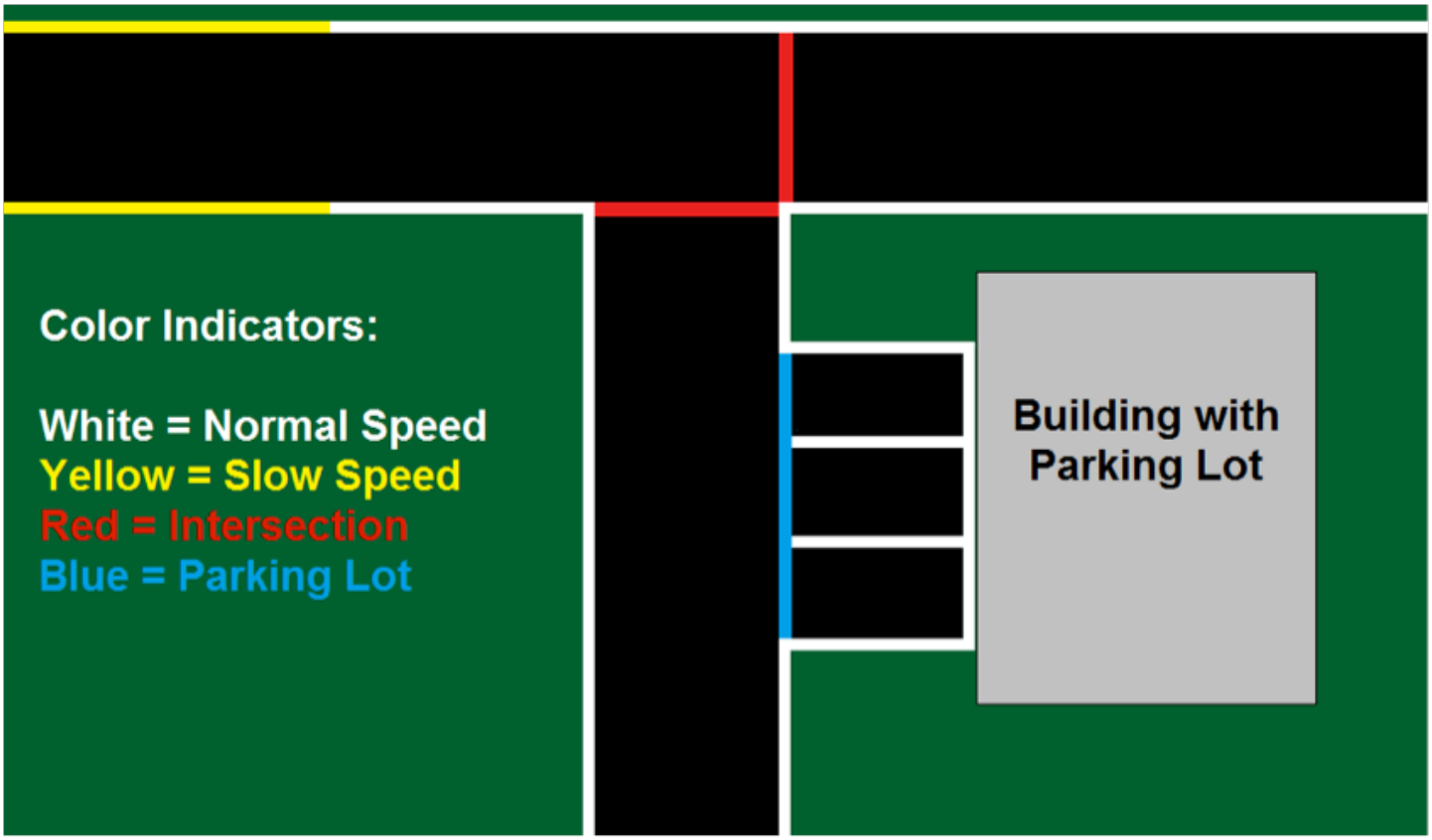
Welcome to the Mini-Urban Challenge City! Within this city you will encounter many of the things you find in an average American city. There are roads, intersections, stop signs, speed limits and buildings and stores galore. Everything you will encounter is described in detail below.

The city competition will take place on a printed mat comprised of 2‘ x 2‘ soft tiles measuring 10‘ x 42’. There are 2 identical city mats. You will be assigned to “City 1” or “City 2” the day of the competition.

2.4.1 Road Surface

The road surface will be at least 20cm wide at all times. Parking spaces measure at least 20cm x 20cm. Each road is assigned a one-way direction. The road can only be traversed in that direction.
Along each edge of the road there is a painted colored line, 1.25cm wide, giving information about the road (see Figure 2-1). The colored line will be touching the edge of the road (i.e. no black will show between the colored line and the “grass”). Between the road and the “grass” many roads have “cobble-stone” sidewalks that are shades of gray. All lines will be painted using pantone colors so that teams can exactly match these colors when programming their kit.
Pantone Colors:
Pantone Process Black = Road Surface
Pantone Red 032 = Stop Sign
Pantone Yellow = Slow Speed
Pantone Process Blue = Parking Lot Indicator
Pantone 347 = Green out of bounds
Calibration stations will be available on competition day for each team to make adjustments due to color and lighting. Calibration stations DO NOT have the “cobble stone” sidewalks. A copy of the course mat diagram can be downloaded from the MUC website.

Competition Mat Design Concept (Figure 2-1)



2.4.2 Intersections

There will be multiple intersections within the city. At all intersections your car will be required to stop. Intersections will be marked with a red line (roughly 1.25 cm wide) running perpendicular to the road at the location of the stop sign. The red stripe will only be located on the sides of the intersection requiring cars to stop, based on the one-way direction of the roads. The red line will not cross into the colored lines along the edge of the road. Cars will be required to come to a complete stop before proceeding through the intersection.

2.4.3 Speed Limits

There are multiple roads within this city. In more congested, down-town areas, the roads have a speed limit of 6 meters/minute. This speed limit is marked along the side of the road using a yellow line that is roughly 1.25cm wide. On more open roads and on the city bypass you will be allowed to go faster. The speed limit of these roads is 10 meters/minute. This speed limit is marked along the side of the road using a white line that is roughly 1.25cm wide.

2.4.4 Buildings/Parking Lots

To complete your challenge you are required to stop at a variety of buildings. These buildings have parking spots directly off the road. For a stop to be considered successful, you are required to pull your car into the parking space and **remain there for at least 3 seconds**. To earn maximum points for parking, all parts of the car must be inside the parking space. Each parking space will be designated by a blue line on the side of the road. Parking spaces within the parking lot will be lined with white lines that are 1.25cm wide. Each parking space is at least 20cm wide. Parking spaces are located along the edge of the road as depicted in Figure 2-1.

At your assigned calibration time, you will be told which parking spots you are to park in. For maximum point accumulation you may choose to park in spaces with obstacles in the space next to your assigned spots. Hint: Be sure your algorithm does not require you to cross multiple spots when parking and that your car doesn't leave the road surface.

2.5 SCORING

Competitors are placed based on their total score in the competition. Points are earned during the navigation of the Mini-Urban City (70%) and during the Team Presentation (30%). The individual components and the total scoring criteria are outlined in the following section.

2.5.1 Mini-Urban City Challenge Scoring

There is a possibility of 350 points for the driving/navigating portion of the competition. Teams can choose to remove obstacles from the course (such as parked cars) in exchange for a decreased maximum possible score of 260. See sample score sheets on pages 9 and 10.

2.5.2 Technical Presentation Scoring

Each team shall give an oral Technical Presentation as part of the Regional Competition. Teams that qualify for the National Competition will give their presentation again. The presentations will be a total of 25 minutes (approximately 20 minutes for your presentation and 5 minutes for answering questions from the judges). All team members are encouraged to be present during the presentation, but teams may elect to designate certain team members as their spokespeople.

There is a possibility of 150 points for the Technical Presentation. See a sample score sheet on page 11.

Teams should approach the presentation as if they were meeting with a company to sell the idea of their robot. They should answer the following questions and add any other info your team believes to be important:

- ✦ What was your approach to meeting the challenge provided by the Mini-Urban Challenge?
- ✦ Why was your approach unique?
- ✦ Why do you consider your approach to be the best?
- ✦ Why did you choose the robot design that you used?
- ✦ What challenges did you meet along the way and how did you overcome them?
- ✦ Who is on your team and what did they each contribute to the competition?
- ✦ What software or programming language did you use?
- ✦ What are the unique aspects of your program?

You will be scored on the content of your presentation, as well as the overall delivery, organization and clarity. Artistic design counts! Your team is strongly encouraged to include photos, videos, sketches or even to give a demonstration of your robot's capabilities. Be creative and make your presentation stand out.

A projector and computer with Microsoft PowerPoint 2010 shall be provided. Teams are not required to use the provided MUC computer. You will need to bring a backup copy of your presentation on a CD or memory stick.
All teams will be required to download a copy of the following on our MUC computer, preferably at the end of your presentation; at the latest, before the awards ceremony of the competition:

a. A copy of the team's code
b. What program they used to write their code
c. A photo of the design/layout of their car
d. A copy of the team's PowerPoint presentation

These items will not be shared with any other teams. Failure to turn in the items listed above may result in disqualification from participating in the 2014 National Competition and/or any future MUC competitions.
We cannot guarantee WiFi will be available at all competitions. Your presentation should be self contained so you will not have to omit something at the last minute you thought you would be able to access beyond your own computer.

2.5.3 Total Scoring

All ruling and scoring by the judges shall be final.
The final team score is the sum total of points accumulated in the navigation of the Mini-Urban City (70%) and the Team Technical Presentation (30%).

In the event of a tie, the team that navigated the Mini-Urban City Challenge in the least amount of time (single scored run) will be declared the winner. This time is based on the difference between the optimum time to navigate the city (calculated before the competition using the team's assigned stops) and the team's final run time.

2.6 PRIZES

The top 3 winning teams of the Regional Competition will be presented trophies and the top 2 teams will be invited to compete at the National Competition. Winners of the National Competition will receive trophies as well as travel and prize money. Prize amounts are based on the number of sponsors and values will be posted on the Mini-Urban Challenge website when they are determined.

2014 Mini-Urban Challenge
Regional Competition
City Score Sheet: With Obstacles

SCHOOL:
TEAM:
JUDGE: 1 2 3 4 5 6

Challenge	Pts Possible (Per Run)	Awarded Run 1	Awarded Run 2	Awarded Run 3
Entered city at designated point	10			
Correctly identified first stop	30			
Parked in parking lot	15			
Parked in assigned parking spot	10			
Correctly identified second stop	30			
Parked in parking lot	15			
Parked in assigned parking spot	10			
Correctly identified third stop	30			
Parked in parking lot	15			
Parked in assigned parking spot	10			
Correctly identified fourth stop	30			
Parked in parking lot	15			
Parked in assigned parking spot	10			
Correctly identified fifth stop	30			
Parked in parking lot	15			
Parked in assigned parking spot	10			
Correctly identified sixth stop	30			
Parked in parking lot	15			
Parked in assigned parking spot	10			
Exited city at designated point	10			
SUBTOTAL	**350**			

DEDUCTIONS

Infraction	Points Deducted (Per Occurrence)	Run 1	Run 2	Run 3
Left road surface	-5 per infraction, max -20			
Contact building/person	-10 per infraction, max -30			
Exceeded speed limit	-5 per infraction, max -25			
Disregarded stop sign	-5 per infraction, max -25			
Wrong direction on road	-5 per infraction, max -30			
SUBTOTAL				

FINAL TOTAL PER RUN	**Max: 350**			

TIME PER RUN	**Optimum:**			
TIME DIFFERENCE (Optimum – Actual Run Time)	**Final:**			

2014 Mini-Urban Challenge
Regional Competition
City Score Sheet: Without Obstacles

SCHOOL:
TEAM:
JUDGE: 1 2 3 4 5 6

Challenge	Pts Possible (Per Run)	Awarded Run 1	Awarded Run 2	Awarded Run 3
Entered city at designated point	10			
Correctly identified first stop	30			
Parked in parking lot	5			
Parked in assigned parking spot	5			
Correctly identified second stop	30			
Parked in parking lot	5			
Parked in assigned parking spot	5			
Correctly identified third stop	30			
Parked in parking lot	5			
Parked in assigned parking spot	5			
Correctly identified fourth stop	30			
Parked in parking lot	5			
Parked in assigned parking spot	5			
Correctly identified fifth stop	30			
Parked in parking lot	5			
Parked in assigned parking spot	5			
Correctly identified sixth stop	30			
Parked in parking lot	5			
Parked in assigned parking spot	5			
Exited city at designated point	10			
SUBTOTAL	**260**			

DEDUCTIONS

Infraction	Points Deducted (Per Occurrence)	Run 1	Run 2	Run 3
Left road surface	-5 per infraction, max -20			
Contact building/person	-10 per infraction, max -30			
Exceeded speed limit	-5 per infraction, max -25			
Disregarded stop sign	-5 per infraction, max -25			
Wrong direction on road	-5 per infraction, max -30			
SUBTOTAL				

FINAL TOTAL PER RUN	**Max: 260**			

TIME PER RUN	**Optimum:**			
TIME DIFFERENCE (Optimum - Actual Run Time)	**Final:**			

2014 Mini-Urban Challenge
Florida Competition
Presentation Score Sheet

SCHOOL:
TEAM:
JUDGE: 1 2 3 4 5 6

Presentations are scored out of a total of 150 points.
The point totals for each of the three major categories are indicated.
Items of consideration are suggested for each category.

Clarity of Presentation	**Possible: 50**	**Earned:**

Points of Consideration:

- Clear organization (intro, body, conclusion)
- Smooth transitions
- Grammar
- Vocal clarity (speed, volume)
- Visual aid clarity

Technical Relevance	**Possible: 50**	**Earned:**

Points of Consideration:

- Explained design
- Explained teamwork
- Explained testing done
- Explained programming

Ability to Capture Audience's Attention	**Possible: 25**	**Earned:**

Points of Consideration:

- Included visual aids/multimedia
- Opening grabs attention
- Maintains interest
- Closing interesting
- Appropriateness of humor, etc.

Questions	**Possible: 25**	**Earned:**

Points of Consideration:

- Student is able to adequately respond to questions posed by judges

Total Points	**Possible: 150**	**Earned:**

PLEASE TOTAL ALL POINTS AWARDED AND ENTER ABOVE BEFORE TURNING IN TO COMPETITION CHAIR

Judge's Comments

Best In Show "Look & Feel"	Low Score	1	2	3	4	5	High Score
Best In Show "Form & Function"	Low Score	1	2	3	4	5	High Score