2018 Task and Rules Document

NI AUTONOMOUS ROBOTICS COMPETITION

STUDENT DESIGN SHOWCASE

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The 2018 Task and Rules Documentation will be updated throughout the duration of the competition for further clarity on matters such as competition track materials, clarifications/revisions on competition rules. Updates will be communicated via email to your supervisor and the most updated document will reside in australia.ni.com/ni-arc.

Competition Background:

Now in its 7th year, the annual NI Autonomous Robotics Competition (NI ARC) welcomes teams from top universities and educational institutions around Australia, New Zealand, Singapore and Malaysia to participate in this premier tertiary level international robotics competition.

Each team will be tasked to design and build an autonomous robot over the course of 6 months to perform certain tasks and compete against other university teams in the live final event.

Team robots will have to carry out various tasks within a certain time limit. Points will be awarded based on specific tasks executed and the time it takes to complete all the tasks.

This year, teams will be required to complete and submit 6 milestones aligned to the competition tasks over the course of several months. The milestones are progressive and will demonstrate the robot's capability to perform the core tasks that will all be carried out at the live final event. To qualify for the live final event, teams must complete all 6 milestones.

Theme: Autonomous Vehicles – Fast Track to the Future

Autonomous vehicles will join human drivers on our roads sooner than most people think. However, as quickly as these self-driving car technology is advancing, these vehicles struggle operating in off-road conditions.

Recent research and advancements have focused on introducing technologies into such driverless cars to make them safer, more viable in the widest range of real life, (both on and off-road) driving environments and weather conditions so that future highly automated and fully autonomous technologies are not limited to tarmac. The researchers in the automotive giants, Jaguar and Land Rover, are currently developing and demonstrating the next-generation sensing technologies to introduce an all-terrain capability into the future autonomous vehicles.

Innovations in driverless cars technology ensuring safety of driverless cars in extreme off-road conditions is a current pressing requirement in the industry. The theme for the 2018 competition is centred around this.

Design Elements and Learning Outcomes

NI recommends distributing the work load to each member equally and as an example of a four-student team work distribution can be as follows:

Student 1 – Software design

Student 2 – Software design/components procurement

Student 3 – Mechanical design and build

Student 4 – Electronics design and build

Generally, there are no restrictions on the size of the robot. However, the track will have certain parameters (e.g. space between elements) which the designers need to abide by.

The competition is designed to test various common facets of robotics applications, including:

- **Localisation** – Knowing the robot's position within a certain map is essential if the robot is required to move within the map.

- **Obstacle Avoidance** – Avoiding obstacles is another key element of the design.
- **High Speed Algorithm** – A key element of this year's competition is speed. Therefore, teams should implement their designs such as, Sensor fusion, High speed decisions and Localisation with speed in mind.

The track will see the robots navigate through a track with various elements. The elements are terrain based, meaning the robot is required to understand the terrain it is in and respond accordingly. The various elements include; terrain with different co-efficient of friction, hazardous terrain, uneven surfaces and static obstacles.

Competition Stages Overview

The competition final will consist of a group stage followed by four knockout rounds.

During the group stages, all teams that top their groups will advance automatically to the next stage. The remaining slots in the knockout rounds will be filled based on the points system from all remaining teams from all the groups.

Knockout rounds will then commence wherein the team that ends up with the most points after the round will progress to the next round. The team will lesser points will automatically be eliminated from the competition.

As the rounds progress, the level of complexity increases with the number of obstacles involved, and the amount of points on offer.

Objectives of the Robot

The main objective of the robot, is to complete the track circuit abiding by the rules in the least amount of time. A key element to achieve this, is speed.

1. **Navigating and track intelligence:** The robot will begin from Start position. Intelligence will need to be implemented in order determine which course the robot will be in.

2. **Obstacle avoidance:** Static obstacles will be placed in certain position, which the robot must avoid. Failure to avoid such obstacles will result in point deductions.

3. **Interaction with track:** While traversing the track, the robot will need to adjust to different surfaces, consisting of even, uneven and raised surfaces.

The Track and Course Elements

The Track:

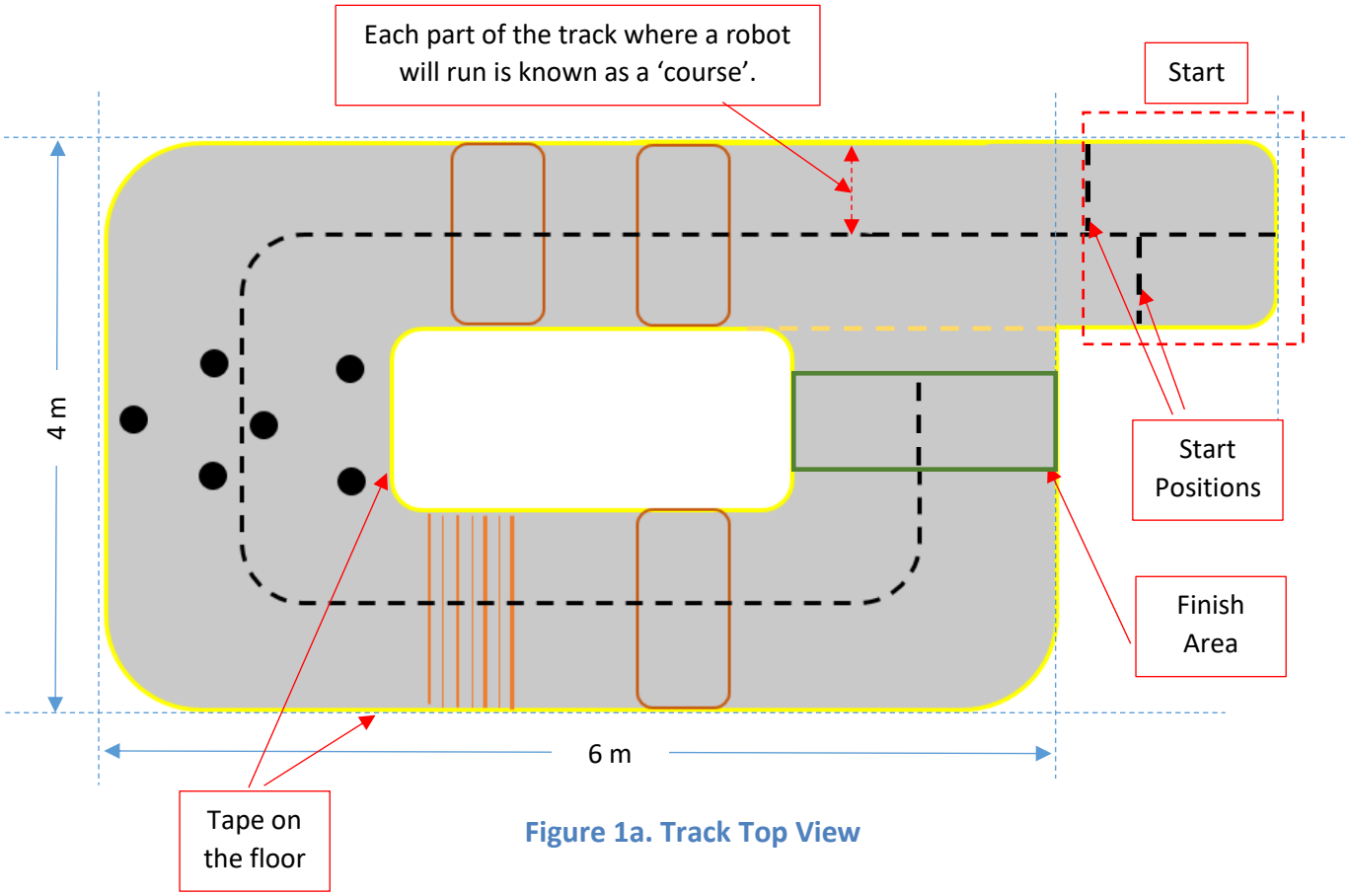

Figure 1a. Track Top View

The single track will consist of two courses side by side and will be 500 mm wide. Each course will be separated by a raised barrier of a known material. The height and thickness of the barrier will be 100 mm and 5-6mm respectively. The material will be dark-blue coloured acrylic.

However, the outer side of each course (will not have any wall or raised barrier, rather, there will be marked yellow tape (75mm wide) on the floor. Therefore, the robot design needs to implement a sensor reading the floor to detect and track the markings.

Start

The robots will start at this position. To compensate for the travel distance between the outer and inner course, the outer start position will be ahead of the inner start position, as indicated in Figure 1b.

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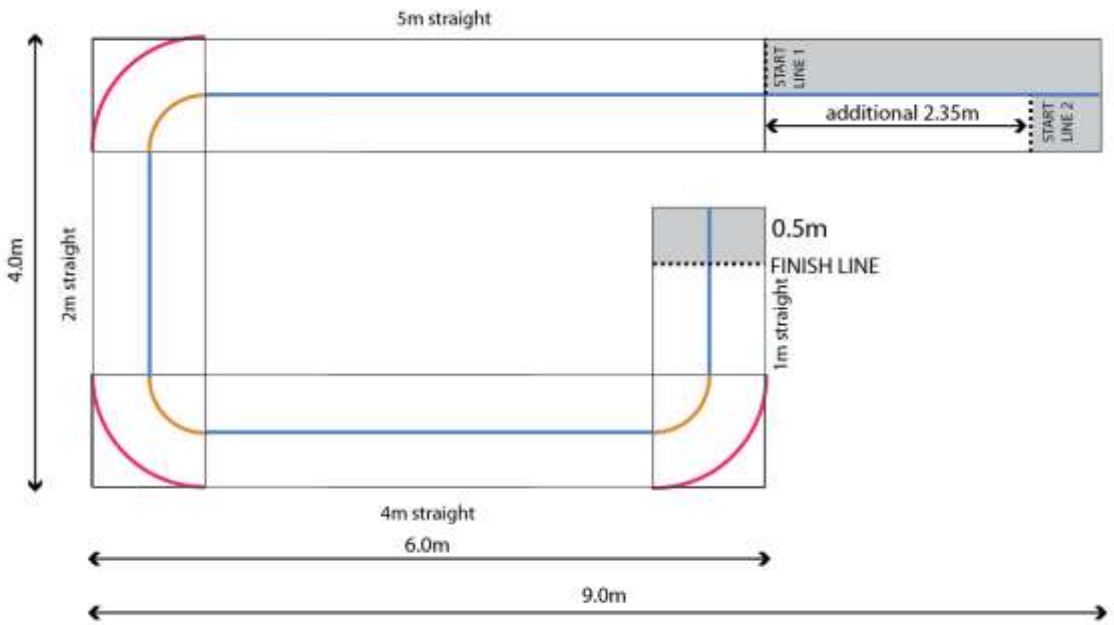


Figure 1b. Track Top View with dimensions

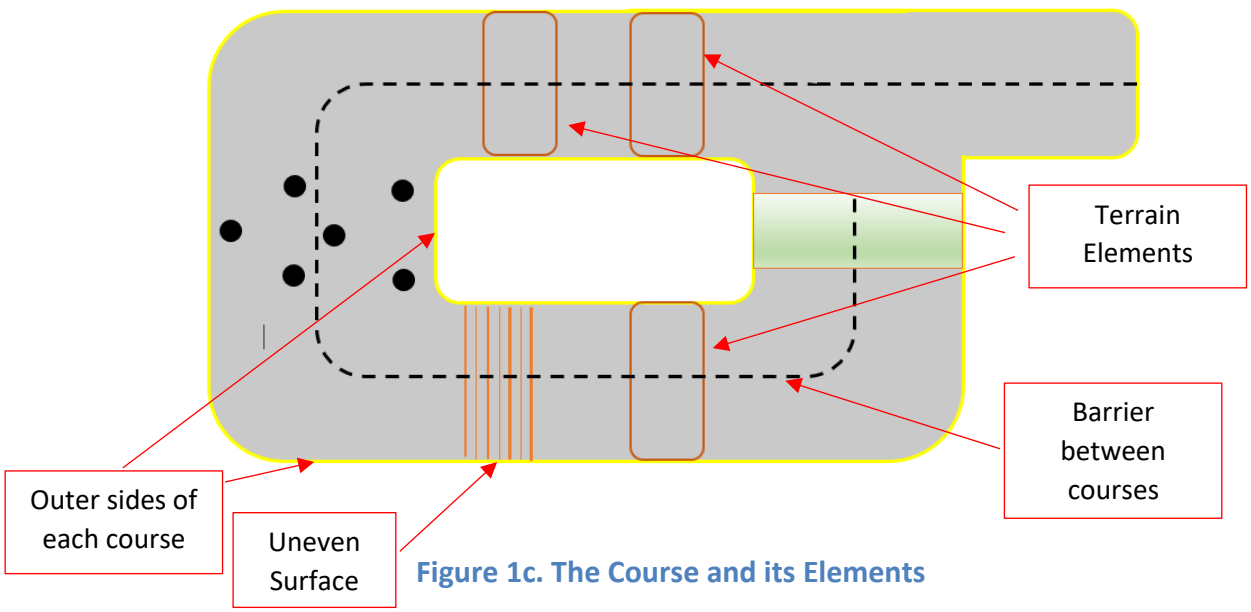


Figure 1c. The Course and its Elements

Figure 1c is an example of how the different elements can be positioned. However, the location of these elements will be unknown to the teams except for the Start, Uneven Surface and Finish Area.

Static Obstacles:

The static obstacles are placed on the track which the robots must avoid. Hitting these will result in point deductions.

A static obstacle will always be considered as 2x tyre objects stacked on top of each other.

A single tyre object will have the following properties:

- Dimensions: 68 mm (diameter) x 33 mm (height)
- Made from soft Polyurethane (PU) material
- An appearance of a tyre (Refer to the image for reference)

The coordinates of the obstacles will not be known and will be placed in different locations in the track. See Figure 1 for example of the placement.

Uneven Surface:

The uneven surface is an area where the ground consists of bumps and level surfaces and we will be using foam mats as shown below. This is a permanent fixture with dimensions shown in Figure 2a and 3b.

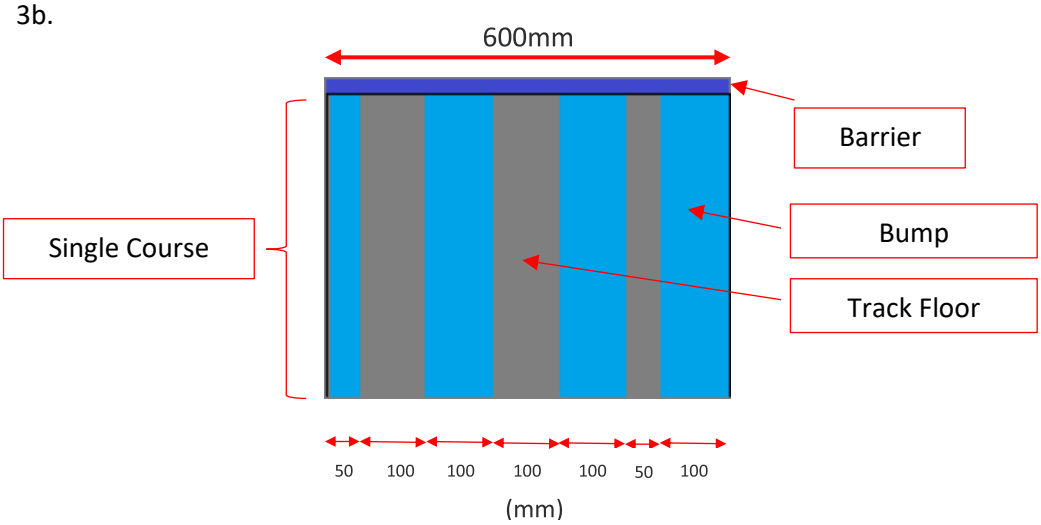


Figure 2a. Uneven Surface Top View

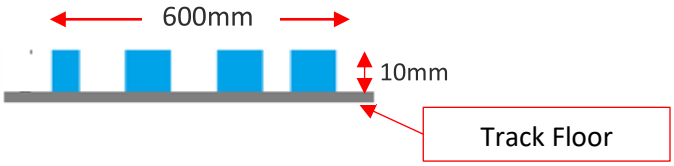


Figure 2b. Uneven Surface Side View

Terrain Elements (Hazardous or a Ramp):

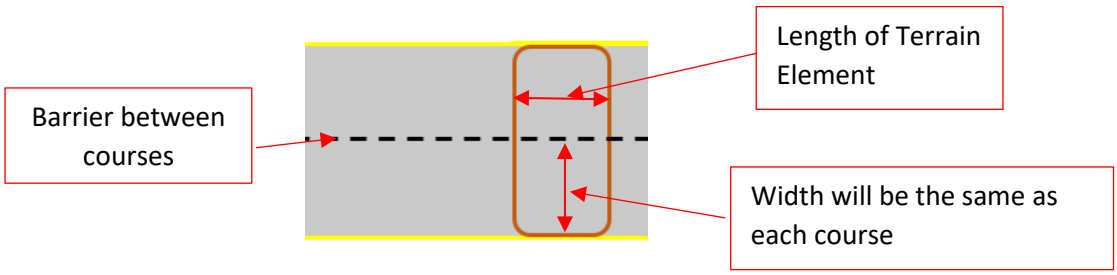


Figure 3. Terrain Elements

The Terrain elements are modular pieces of the track vinyl with the width of each course. When these elements are used, they will be placed on top of each course (1 mm height).

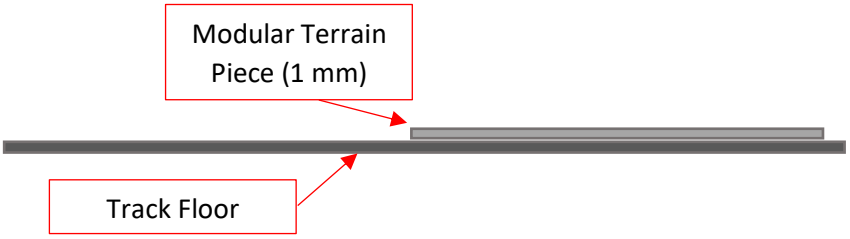


Figure 4. Course Side view

The brown outline on the figure above represents the Terrain Elements, note, that there is the barrier in between each course (Refer to Figure 3 & 5) and therefore, it will also separate each Terrain Element.

The number of these elements will depend on each round (Refer to Table 1).

Terrain Elements include:

Hazardous Terrain:

This area will have black and yellow (each 50mm wide) tape to cover the width of the course. When the robots enter this zone, it must move forward in a zig-zag direction. The robot must cover approximately 80% of the width of the course in this motion (Refer to the figure below).

Whether or not the robot has the 80% coverage will be up to the judge and will be determined visually, taking into account the robot's dimensions. *There will be no spacing between yellow and black tapes.*

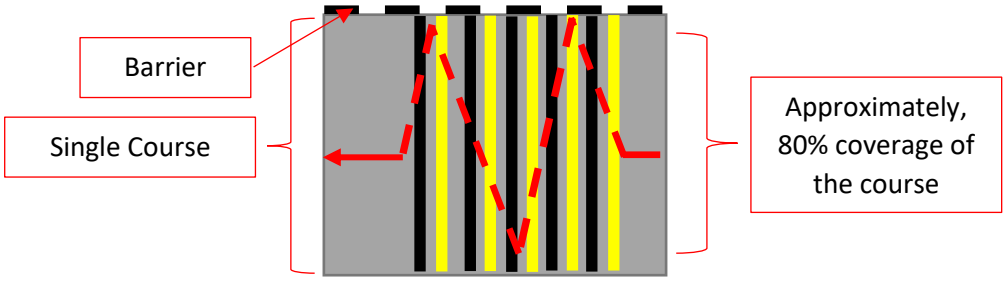


Figure 5. Single Course Top View

Ramp:

The ramp will be made of MDF material and will have height of 50 mm. The width of the ramp will be almost the same as the width of the course (i.e. 500 mm).

The terrain will include red tape (50mm wide) in front of the ramp (on the floor) to indicate 'ramp ahead'.

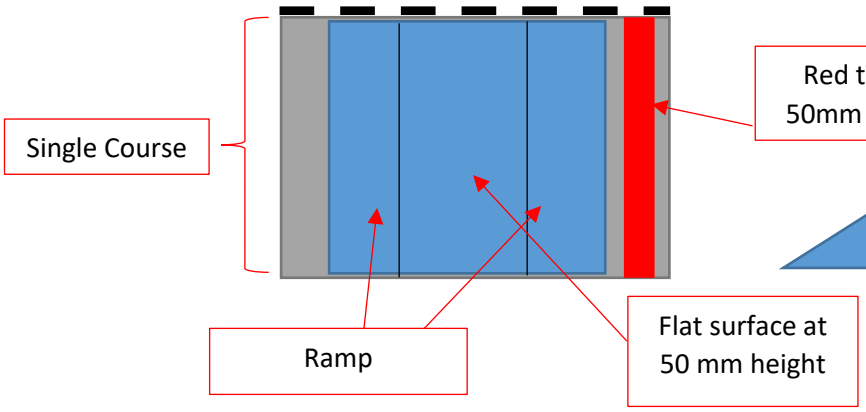


Figure 6a. Ramp Top View

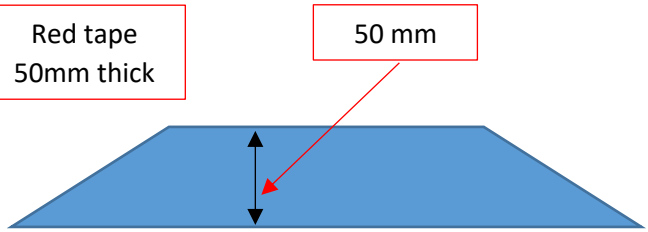


Figure 6b. Ramp Side view

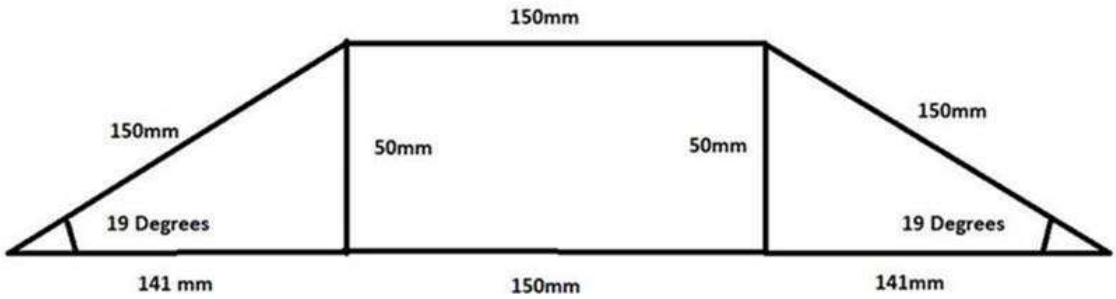


Figure 6c. Slope of the Ramp

NOTE: The coordinates of these elements will not be known and will be placed in different locations in the track. See Figure 1 for example of the placement. Teams may use colour detection to detect what terrain they are on. The length of these elements will be communicated to the teams at a later date.

Zones:

The track will be divided into multiple zones and the end of each zone will be marked by black tape, 50mm wide (zone lines) on the track floor (Refer to Figure 7). When a robot passes a zone (i.e. passes a black tape), the team will accumulate points (Refer to Table 2 for points).

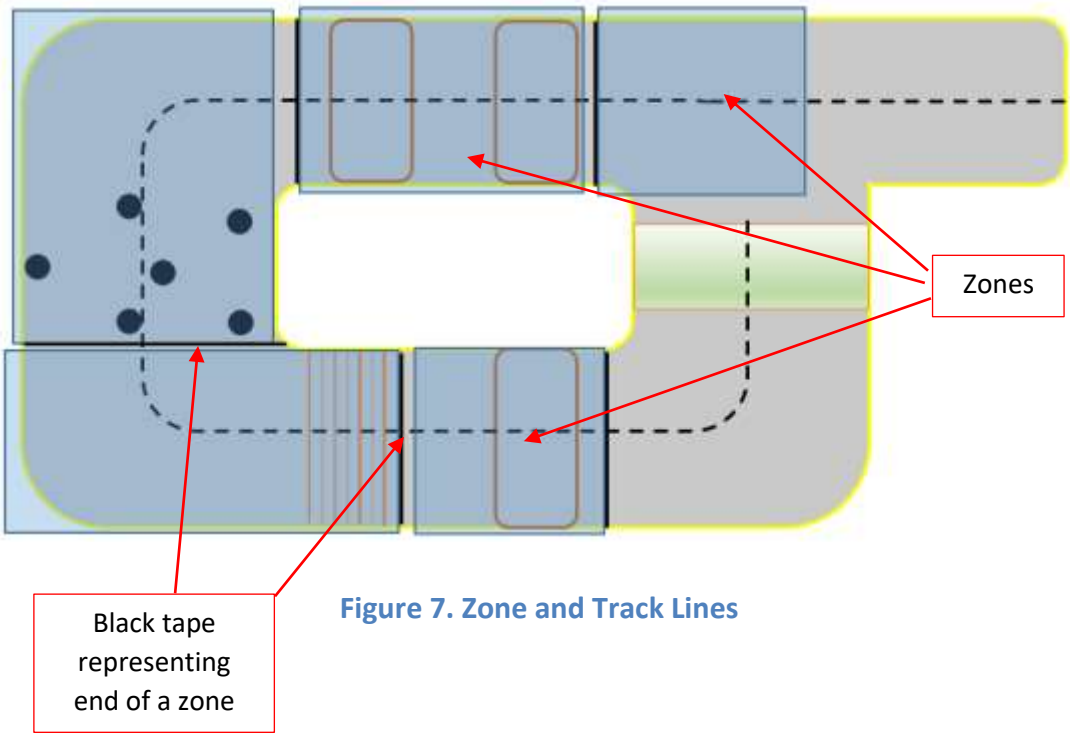


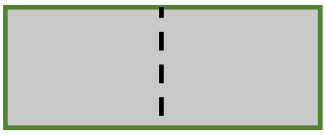
Figure 7. Zone and Track Lines

Teams can only score points once per zone. A robot must completely pass, including all parts, the black tape to score the points.

Note: the purpose of the black tape is for judges to visually determine if a robot will score points for passing a zone.

Note: the zone rectangles in the Figure 7, is only for visualisation. Will not be apparent in the competition track.

Finish Area:



The robot must come to a complete stop and the entire robot must be within the finish area to have completed the circuit. The area will have green tape (50mm wide) on all sides.

Point System and Live Competition Structure

On the day of the live final, teams will be drawn randomly and placed in groups. The coordinates and dimensions of known elements in each course will be identical.

There will only be 1x competition track where 2x teams will be running simultaneously.

There will be a total of five rounds in the live competition. With each round progression, there will be added difficulty and tasks for additional points.

First Round (Group Stage - Qualification)

Each team will participate in four heats. For each heat, teams will have the objective of navigating through the different terrains while competing with one other team. Points for each heat will be awarded based on the point system outlined below.

Out of the four heats (or number of heats each team partakes in), only the highest scoring heat will be counted for each team (average scores will not be accumulated at any stage). Teams will get two heats in the inner course and two in the outer course.

The highest scoring team from each group in the first round (group stage) will automatically advance to the round of 16.

All remaining teams (all teams excluding those that qualified for the quarter finals by placing first in their groups) will then be placed in order based on their highest score. The highest scoring teams from each group plus the highest scoring teams from the remaining teams will make up the 16 teams that will advance to the next round.

Knockout Rounds

Note: for knockout rounds, each round will consist of two runs. Meaning, each team will run once in the inner course and once in the outer course. From both the runs, the highest score will be considered for both teams.

Round of 16 (Knockout)

In this round, the top teams will compete against the bottom teams, after the 8 first-placed teams are put in order based on points, and the other 8 qualifiers are ordered by the same methodology.

First will play sixteenth, second will play fifteenth, and so on. This round is a knockout round, where you will compete against one opposing team only, with the team earning more points progressing to the next round.

Quarter-finals (Knockout)

This round is a knockout round, where you will compete against one opposing team only, with the team earning more points progressing to the next round. *Refer to Table 1 and Table 2.*

Semi-Finals (Knockout)

This round is a knockout round, where you will compete against one opposing team only, with the team earning the most points progressing to the next round. *Refer to Table 1 and Table 2.*

Final round (Championship Round and 3rd place playoff) (Knockout)

This round is the final and knockout round, where you will compete against one opposing team only, with the team earning more points to be crowned the 2018 Champion. *Refer to Table 1 and Table 2.*

The equation for determining points (for all rounds) is:

Total Points = [(90 sec - time taken) x multiplier] + points added - points deducted.

The multiplier will vary according to the round.

Name of Round	Round	Format	Time Limit (secs)	# Static Obstacles (Max)	#of Terrain Elements (Max)	Multiplier
Qualifiers	1	Group Stages	90	4	1	1
Round of 16	2	Knockout	90	4	2	1.5
QTR-Finals	3	Knockout	90	6	3	2
Semi-Finals	4	Knockout	90	6	4	2.5
Battle for 3rd place	5	Best of 3	90	8	5	3
Championship Round	6	Best of 3	90	8	5	3

Table 1. Round Format

Note: Number of obstacles, terrain elements and the multiplier may be subject to revision and as such, the final format will be published later.

Note: In the case of identical times for multiple teams, additional points will be counted according to Table 2 below.

Name of Round	Points	Point Deduction
Qualifiers	• Going past zone lines marked with black tape on the track: 75pts /zone passed • Points for successfully detecting and navigating through uneven surface/each terrain element without the robot being confused/reversing direction (will be determined visually): 50pts • Points for covering 80% of the width of track in hazardous area in a zig-zag shape: 100pts • Completing the track without collision with any barriers or static obstacles: 100pts • Completing the track and coming to a complete stop at the finish line within time limit: 75pts *The robot must come to a complete stop within the finish area. No part of the robot must touch or be outside the finish area.*	• False starts: -20 pts. Time gained from the false start will be considered as time taken to complete the task. • Deduction for bumping static obstacles: -30 pts /Bump. • Deduction for bumping to the barrier between the two courses: -50 pts/Bump. • Any part of the robot crossing the outer bounds of the course (marked by yellow tape) will result in points deduction: -50pts /Violation. • The robot must come to a complete halt within the finish line. If any part of the robot touches/is over the finish line, points will be deducted: -25 pts. • Deduction for robot moving in the wrong way (Reverse): -20 pts /Violation

		• Points will be deducted if teams call time (stop their robots run): -60pts (penalty of 3x bumps)
Round of 16	• Going past zone lines marked with black tape on the track: 75pts /zone passed • Points for successfully detecting and navigating through uneven surface/each terrain element without the robot being confused/reversing direction (will be determined visually): 50pts • Points for covering 80% of the width of track in hazardous area in a zig-zag shape: 100pts • Completing the track without collision with any barriers or static obstacles: 100pts • Completing the track and coming to a complete stop at the finish line within time limit: 75pts *The robot must come to a complete stop within the finish area. No part of the robot must touch or be outside the finish area.*	• False starts: -20 pts. Time gained from the false start will be considered as time taken to complete the task. • Deduction for bumping static obstacles: -30 pts /Bump. • Deduction for bumping to the barrier between the two courses: -50 pts/Bump. • Any part of the robot crossing the outer bounds of the course (marked by yellow tape) will result in points deduction: -50pts /Violation. • The robot must come to a complete halt within the finish line. If any part of the robot touches/is over the finish line, points will be deducted: -25 pts. • Deduction for robot moving in the wrong way (Reverse): -20 pts /Violation • Points will be deducted if teams call time (stop their robots run): -60pts (penalty of 3x bumps)
QTR-Finals	• Going past zone lines marked with black tape on the track: 75pts /zone passed • Points for successfully detecting and navigating through uneven surface/each terrain element without the robot being confused/reversing direction (will be determined visually): 50pts • Points for covering 80% of the width of track in hazardous area in a zig-zag shape: 100pts • Completing the track without collision with any barriers or static obstacles: 100pts • Completing the track and coming to a complete stop at the finish line within time limit: 75pts *The robot must come to a complete stop within the finish area. No part of the robot must touch or be outside the finish area.*	• False starts: -20 pts. Time gained from the false start will be considered as time taken to complete the task. • Deduction for bumping static obstacles: -30 pts /Bump. • Deduction for bumping to the barrier between the two courses: -50 pts/Bump. • Any part of the robot crossing the outer bounds of the course (marked by yellow tape) will result in points deduction: -50pts /Violation. • The robot must come to a complete halt within the finish line. If any part of the robot touches/is over the finish line, points will be deducted: -25 pts. • Deduction for robot moving in the wrong way (Reverse): -20 pts /Violation • Points will be deducted if teams call time (stop their robots run): -60pts (penalty of 3x bumps)
Semi-Finals	• Going past zone lines marked with black tape on the track: 75pts /zone passed • Points for successfully detecting and navigating through uneven surface/each terrain element without the robot being confused/reversing direction (will be determined visually): 50pts • Points for covering 80% of the width of track in hazardous area in a zig-zag shape: 100pts • Completing the track without collision with any barriers or static obstacles: 100pts	• False starts: -20 pts. Time gained from the false start will be considered as time taken to complete the task. • Deduction for bumping static obstacles: -30 pts /Bump. • Deduction for bumping to the barrier between the two courses: -50 pts/Bump. • Any part of the robot crossing the outer bounds of the course (marked by yellow

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Playoffs for 3rd Place and the Championship Round	• Going past zone lines marked with black tape on the track: 75pts /zone passed • Points for successfully detecting and navigating through uneven surface/each terrain element without the robot being confused/reversing direction (will be determined visually): 50pts • Points for covering 80% of the width of track in hazardous area in a zig-zag shape: 100pts • Completing the track without collision with any barriers or static obstacles: 100pts • Completing the track and coming to a complete stop at the finish line within time limit: 75pts *The robot must come to a complete stop within the finish area. No part of the robot must touch or be outside the finish area.*	• False starts: -20 pts. Time gained from the false start will be considered as time taken to complete the task. • Deduction for bumping static obstacles: -30 pts /Bump. • Deduction for bumping to the barrier between the two courses: -50 pts/Bump. • Any part of the robot crossing the outer bounds of the course (marked by yellow tape) will result in points deduction: -50pts /Violation. • The robot must come to a complete halt within the finish line. If any part of the robot touches/is over the finish line, points will be deducted: -25 pts. • Deduction for robot moving in the wrong way (Reverse): -20 pts /Violation • Points will be deducted if teams call time (stop their robots run): -60pts (penalty of 3x bumps)

Table 2. Points System

Rules

1. The Robotic Vehicle:
   - Should be a single robot (swarms and ancillary help are not allowed), fully autonomous, self-powered and must move i.e. you cannot build a conveyor system etc.
   - Must use the NI myRIO provided.
   - Aerial robots are prohibited due to possible harm or injury it may inflict to people around the vicinity.
   - Must have most of the code written and implemented using the LabVIEW software provided. Alternate programming languages can be used to program sensors and actuators if it is required, however, NI will not provide technical support for those languages.
   - Must not use any other Central Processing Unit (CPU) apart from the myRIO controller unless it is embedded inside a sensor or actuator for signal conditioning purposes. Image processing cameras with built in CPUs such as NI Smart Camera can be used to offload **Image processing**. Always consult with the NI ARC team before purchasing additional hardware.
   - Must have a switch (hardware) to trigger it to start performing the task and an emergency switch to stop it.

- Must begin from the Start position. Refer to Figure 1.
- Should not bump into any barriers or static obstacles within the track.
- Must not damage any component of the track. Disqualification may apply at the discretion of competition judges if the robot is deemed destructive to the competition track and its elements.

2. Additional external circuitry for signal conditioning (i.e. amplification, filtering etc.) may be used.
3. While round is in progress, only NI staff is permitted in the competition arena. Only when the referee has called time can a representative of each team step in to collect the robot.
4. Interference and human interaction with the robot when a team's run has commenced is prohibited unless permission from the judges have been granted. Otherwise, the team will forfeit their run for the qualifiers, battle for third and championship round and an automatic loss in the round of 16, quarterfinals and semi-finals.
5. Teams can appeal to call time if they want to stop their robot's run. Time can be called only if the judges agree that it will be harmful to the robot or the track to continue. **A penalty of 3 bumps (60pts) will be applied to the team's run when they call time.**

Sample Track Elements:

Tapes:

Tapes Usage	Details
Outside of each course	75mm Non-Reflective Yellow Tape
Start of Ramp	50mm Red Tape
End of Zones	50mm Black Tape
Finish Area	50mm Green Tape
Hazardous terrain	50mm Black and Yellow

Uneven Surface:

We will be using foam mats as shown in figure 8.

Colour: Light Blue
Thickness: ~10mm

Figure 8. Uneven surface

Contacts

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Web: australia.ni.com/ni-arc
Community: Facebook (facebook.com/niroboticscomp)