Redback Autonomous Car

Project Brief

In response to the challenge of transportation safety, and in collaboration with Redback Racing, the project challenges students to create an autonomous racing vehicle.

1. Background

Design challenges, like the one you are about to undertake, have historically acted as a catalyst for technological advances. For example, the DARPA Grand Challenge and Urban Challenge kickstarted the development of autonomous vehicles, see Figure 1.

A) B)

Figure 1. A) Wired: Inside the Races that Jump Started the Self-Driving Car **B)** The New York Times: No Drivers, but a Lot of Drive

Driverless vehicles could transform transportation safety by reducing human-induced errors and accidents – in Australia alone there are around 61,500 hospitalisations and 1,400 deaths from transport each year [AIHW 2021]. But to achieve this promise of driverless safety, more testing is still required, and motorsport may prove valuable here.

Motorsport has long been an important testing ground for new automotive technologies. The competitive demands of the racetrack push engineers to the limit, generating innovations that often trickle down to consumer vehicles – rearview mirrors, disk brakes, traction control and energy recovery systems to name a few. Electric autonomous vehicles are now emerging on the race tracks, with professional competitions such as Roborace, and student-led races such as Formula SAE, see Figure 2. Through the RRR project, you'll have the chance to contribute to the development of safe driverless vehicles through a competitive design challenge.

2. Objective

Design and construct an autonomous lane-following robot that can safely complete a predetermined track as quickly as possible, while adhering to specified cost, weight, and size constraints, with an innovative and aesthetic design.

A) **B)**

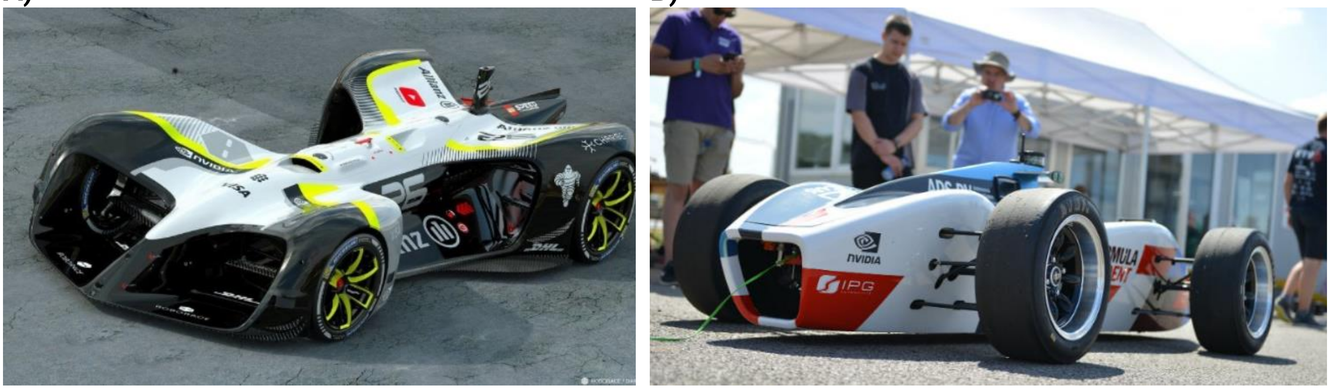


Figure 2. A) Wired: [Roborace unveils Robocar, the world's first AI-powered, self-driving electric racer]() B) Institution of Mechanical Engineers: [Formula Student AI]()

2.1. Client instructions

As an engineer, clients will often give you instructions for a project. Their instructions may be unclear, incomplete, contradictory and difficult to verify. Part of your job as an engineer is to address these shortcomings and formally define the problem. You'll practice this problem definition skill in this project, specifically during week 2 through the creation of a 'Problem Statement' and 'Requirements Matrix'. For now, here's a "transcript" to simulate a clients verbal instructions:

> *"Alright, everyone, if I could just get your attention. I've pressed record on this, so if you miss anything, you can replay it later.*
>
> *So, diving right in, when you're working on your robots, consider their size. Imagine a box in front of you that's about... let's say, 250mm in every direction. That's the size your robot should fit within. Weight is another factor, makes sure its under 500 grams. Safety is also super important, so your robot must respect the track. What I mean is, they should stay in the lane. You wouldn't want your creation veering off course during its big moment, right? Oh, and while we're discussing design choices, be mindful of costs. If your robot's total cost creeps up above $100 that's too much, so rethink a few things. Just to clarify, if you're getting some components for free, make sure you account for their market value in this cost as well. As many of have have asked, we ill be giving you a Pixicam 2, and it's costs are off the books. Whether you use it or not? Well that's completely your choice.*
>
> *Oh and another thing, autonomy. That's the magic of this project. So once your robot starts the trial, it's on its own. no remote controls. By the way, for the actual time trials, only one robot on each track, so you don't have to worry about interferance from other cars. Last thing, and I know some of you won't love this – no Lego parts this time around. I'm keen to see what other creative ideas you'll bring to the table.*
>
> *Remember, you'll have to formally define these instructions using requirements, so check out NASAs guide on how to write good requirements. And if you have any questions, just ask me in class.*
>
> *Alright, that should cover most of it. Dive in, have fun, and remember why we're here. It's as much about the process as it is about the end result.*
>
> *[End of recording.]*

3. Compliance Testing

Compliance Testing aims to ensure that all participating robots meet basic design and performance requirements before Final Competition, to limit failures and disqualification, and encourage a competitive race. Compliance Testing will be conducted in Colombo LG02 on the Monday of Week 8 from 2 pm to 4 pm. Each team will be allocated a random testing time slot, so please arrive on time, and bring your robot and any necessary tools and equipment. Compliance Testing will be worth 10% of your final grade for DESN1000. Redback leaders and the Course Coordinator will be present to assess and score each team's robot. Feedback will be provided to inform each team of their strengths and areas of improvement.

Table 1 Compliance testing stages

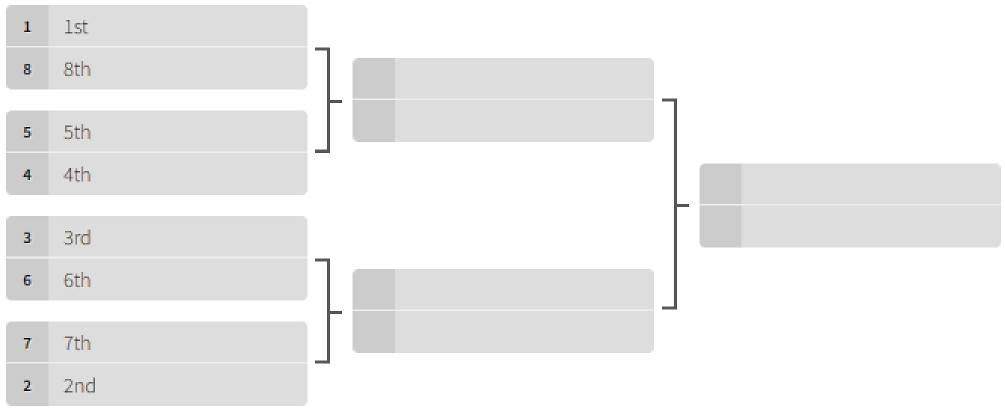
Stage gate	Pass criteria	Time	Marks
1. Design compliance	Judges weigh and measure the robot to check size and weight constraints. Teams also report on cost for judges to approve.	5 min	2.5
2. Movement test	Robot can move at least 1m from start point	5 min	2.5
3. Corner lane following	Robot autonomously stays in lane through any corner of the track in no more than 3 attempts	5 min	2.5
4. Complete track loop	Robot autonomously completes a full loop of the competition track in no more than 3 attempts	5 min	2.5

4. Final Competition

The Final Competition offers students the opportunity to put their engineering skills to the test and showcase their autonomous capabilities, as well as the innovation and aesthetics of their robot. The competition will take place in the Redback Racing Lab, located in the J18 Willis Annexe building, on Thursday of Week 10 from 2 pm to 4 pm. Redback leaders and the Course Coordinator will be present to assess and score each team's robot. The final Competition will be worth 15% of your final grade for DESN1000, broken down as follows:

1. **Aesthetics (2.5%)** Consideration is given to the build quality, ease of assembly, and design coherence of the robot.
2. **Innovation (2.5%)** Marks are awarded for novel features, creative problem-solving, and unique functionality that differentiates the robot from others.
3. **Racing Rank (10%)** Teams will first complete a time trial to determine their position in the single-elimination tournament bracket. They will each have 5-minutes to record their fastest 3 laps. Failure to meet weight, size, cost or autonomy constraints will result in a disqualification (DQ). Failure to complete 3 laps while staying within the lane will results in a did not finish (DNF). These times will be used to determine each team's position in the competition bracket. It will be single round elimination. Failure to complete 3 laps while staying in the lane will result in an elimination. If both teams are eliminated in this way, the race will restart, upon 3 repetitions the team with the faster qualifying time will progress to the next round and the other will be eliminated. At each stage, the position of eliminated teams will be based on qualifying times. That is, the times of teams eliminated in round 1 will determine positions 5-8, and in round 2 positions 3-4.

A)



B)

Position	Marks
1st	10.0
2nd	8.5
3rd	8.0
4th	7.5
5th	7.0
6th	6.5
7th	6.0
8th	5.0
DNF	0
DQ	0

Figure 3 A) Single round elimination tournament bracket B) Table of racing rank marks based on position

4.1. Track specifications

The 'Competition Track' is on a 6 mm thick plywood sheet with an area of 2400 x 1200 mm. The lines are black paint and 15 mm thick. The lanes are a minimum width of 200 mm.

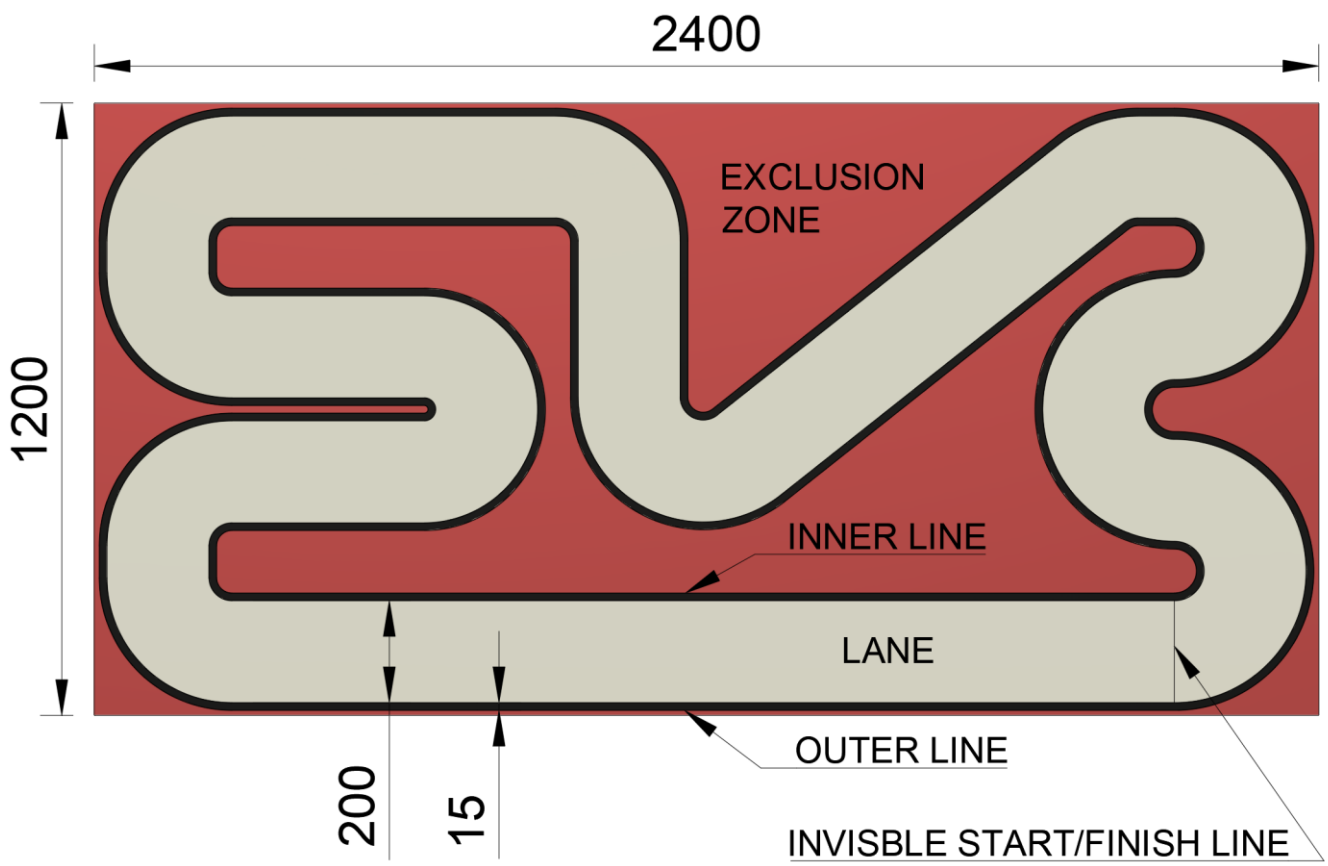


Figure 4 Competition track dimensions and zones

5. Question and answer log

ID	Question	Answer
1	Is this a lane following or line following vehicle?	This is a lane following vehicle. So, the vehicle cannot physically touch the track, besides the lane and lines. Note the start and end time will be measured from the time the vehicles front-most ground contact point crosses the start and finish line.
2	Are we allowed to use off-the-shelf components like motors and sensors?	Yes, you may use individual off-the-shelf components such as motors, sensors, wheels and gears. You may also use modules, such as a motor and gearbox, or an IR sensor module. However, you may not use a fully pre-built kit such as 1 and 2. Your design may use parts of these kits and may learn from them and other online guides. However, you cannot copy them, as this is a form of plagiarism. If staff deem your design plagiarised it will be disqualified. If you are unsure whether your design is too similar, then please check with course staff before the competition – open and transparent communication is important. Also be sure to keep a record of your design process in your design journal, as evidence of your creative and original work.
3	Are the Arduino, Pixicam and battery included in the cost?	The Arduino ($15) and Battery ($28) are included in the cost. The Pixicam 2 ($140) is not included in the cost.

6. Revision log

ID	Revision	Date
01	Combined 'Project Brief' and 'Compliance testing and Final competition' document to centralise information.	20/9/2023
02	Updated Figure 4 to clarify the use of 'Lane' and 'Line' terminology and specify the 'Exclusion zone'. Also added the start/finish line.	20/9/2023
03	Added 'Revision log' to track changes to project specification, and 'Q&A log' to share project information related to student engineers questions.	20/9/2023
04	Adjusted the racing rank marks such that any team that qualifies scores a minimum of 50%	9/11/2023