



Bosch Future Mobility Challenge 2019

Competition Regulations

Robert Bosch Romania

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1 Overview

1.1 Introduction

The *Bosch Future Mobility Challenge* (hereafter “*Bosch FMC*”) is an event organized by Robert Bosch Romania, targeted to engage students in a technical oriented competition and offer them a professional context to prove their talent.

Bosch FMC offers students the opportunity to prove their abilities and to overcome challenges in a team. It is of great interest to us to support this commitment and to promote upcoming engineers.

We are convinced that young talent, with fresh ideas and extraordinary commitment, is enormously important for the future of mobility. This competition offers us the opportunity to talk to enthusiastic, highly-motivated, and qualified students.

1.2 Objectives

The main objective of the *Bosch FMC* is to have several student teams realize the best performing model vehicle guidance system for different scenarios, which have been derived from requirements arising from a realistic environment.

Bosch will provide the model vehicle platforms for the student teams and they will be responsible for the conceptualization and implementation of automated model vehicles.

During the competition, the students will present their know-how in front of judges from industry and academia while competing with other teams.

At the end, it is not necessarily that the fastest model vehicle wins. The team with the best overall package of design and driving performance, project planning, and overall arguments goes home with the trophy.

1.3 Tasks

Every student team is responsible for designing, building and demonstrating a cost- and energy-efficient 1:10 scale concept for an automated vehicle by a fictional Original Equipment Manufacturer (OEM).

During the competition several driving tasks have to be executed, as fast and precise as possible, on a complex racetrack. In addition, the developed concept must be presented and explained.

The challenges would include sensing the position of the model vehicle, controlling the steering to keep the vehicle on the track, controlling the speed of the vehicle, and avoiding obstacles.

1.4 Competition

1.4.1 Organization

The student competition *Bosch FMC* is organized by Robert Bosch Engineering Center from Cluj-Napoca, Romania.

1.4.2 Competition Dates and Place

Bosch FMC will take place in May 2019, in Cluj-Napoca, Romania.

Enrolment and selection process for the *Bosch FMC* will take place in 1st October-2nd November 2018.

Monthly reporting is expected from the teams, consisting of a one pager with the technical content progress and time-plan update. Additionally, every two Months a one hour Skype/personal interview will be conducted to discuss the progress. The date of the reviews will be communicated and agreed at the kick-off event.

One day before the final event, there will be a qualification round. This round will define the teams that will compete in the final event.

The exact date and location of the competition will be communicated at a later date.

1.4.3 Scoring

Each concept and its realization will be evaluated, during the development and also during the contest, in comparison to the results of the other participating teams. For this, the teams compete in different static and dynamic events, while being awarded at most 1000 points.

The maximum amount of points per event is distributed as follows:

Static Events:

S1: Evaluation during development stage	200 Points
S2: Overall concept presentation in front of the contest jury	100 Points
S3: Technical approaches	100 Points

Dynamic Events:

D1: Free drive (w/o obstacles)	300 Points
D2: Obstacle evasion drive	300 Points

Maximum Score: 1000 Points

1.4.4 Official Language

Until further notice, the *Bosch FMC* official language is English. Presentations, communication with the teams (e-mails, phone calls, etc.) are also possible to be conducted in Romanian.

1.5 Regulations

1.5.1 Rules Committee

The *Bosch FMC* Rules Committee (hereafter “committee”) is the only responsible party which is allowed to modify the regulations of the *Bosch FMC*.

In case of disputable events, the statements of the committee are the only effectual statements.

Members of the committee:

- Dennis Raabe – Head of Engineering Center Cluj, Robert Bosch Romania
- Marco Schwarzmüller – Head of Department Sw. Devel., Robert Bosch Romania
- Septimiu Crişan - Technical University Cluj-Napoca
- Ionut Muntean – Project Manager, Robert Bosch Romania
 - contact: Ionut.Muntean@ro.bosch.com
- TBD
- TBD

1.5.2 Validity of Regulations

Only the regulations which have been officially published are valid for the competition. Old regulations are invalidated as soon as a new version of the regulations is published.

1.5.3 Authority

The committee may change the schedule or the regulations before the contest date. All changes will be communicated through established channels and all participants are obliged to cooperate with and following the instructions of the committee.

1.5.4 Regulations Questions

Every participant is obliged to thoroughly read, understand and accept the regulations.

Any rule clarification questions or rule ambiguities concerning the rules for *Bosch FMC* will be resolved by the *Bosch FMC* Rules Committee.

Rules questions can be directly posed to the committee or should be submitted to the following email address: “ideabox@bosch.com”.

2 Prerequisites for Attending

Every team must be composed of:

- a team leader, enrolled at university as student,
- a mentor/project manager, enrolled at university as teaching/research staff,
- team members, enrolled at university as students.

The role of the mentor/project manager is to guide the team, offer support in creating the time-plan, monitor progress in order to ensure that milestones are reached with the desired level of content and quality.

Only students and teaching/research university staff fulfilling the following conditions are allowed to participate at the *Bosch FMC*.

2.1 Status of Enrolment

Students must either be currently enrolled in a Bachelor's, Master's or a comparable degree program or the respective degree must not have been obtained more than six months before the competition registration. A corresponding registration number or certificate of enrolment has to be presented if requested. There is no restriction concerning the subject of study.

2.2 Minimum Age

Every participant must be 18 or older.

2.3 Number of Participating Teams

Bosch FMC offers the opportunity to participate to anyone who wishes to.

2.4 Registration Process

2.4.1 Registration Steps

Registration requests have to be submitted to the following email address: "ideabox@bosch.com".

Each participating team has to send one email with the following content:

- Complete registration form (mandatory);
- CVs of each team member (mandatory);
- Letter of intent (optional);
- Relevant awards received in other contests (optional);

- Recommendation letters from University professors (optional);

After receiving all registration requests a first screening will take place and the selected teams will be individually contacted and planned for a face-to-face interview.

After conducting all interviews, the selected teams will receive the model vehicle platforms during the kick-off meeting.

Selection criteria will be, but not limited to:

- Motivation and intention of each team;
- Link between the contest topic and ongoing University projects (i.e. diploma projects);
- Proven interest and experience in similar contests;
- Recommendation from University professors.

The registration will be revoked in case of submitting false information.

Further details concerning the registration and selection process will be published at a later date.

2.4.2 Date of Registration

Registration for the competition will take place on 1st October -2nd November 2018.

2.4.3 Admission Fee

There is no admission fee for the *Bosch FMC*.

Bosch FMC will ask that the kit is returned, if one was provided, in case the team does not participate on the qualification round.

2.5 Publication Rights

By registering, every team and every participant declares her/his agreement with the publication of image, video and audio recordings. This also includes the recording of team presentations. This agreement might be revoked until the day of the competition.

3 Vehicle Requirements and Limitations

The observance of the following regulations will be monitored during the competition. Violating these regulations will lead to a deduction of points or exclusion from the competition. The same vehicle must be used for all events. Adding stickers or marketing messages of any other company to the vehicles or clothing of participants is not allowed.

3.1 Drivetrain

The vehicle must be exclusively equipped with (an) electrical drive(s). The number of driven wheels is not limited (torque vectoring is allowed). Alternate drives (e.g. chain drives) are not permitted.

3.2 Energy Supply

Energy must be supplied in the form of LiPo batteries. Changing the batteries between single events is allowed.

3.3 Physical Dimensions

The vehicles must be based on four-wheeled 1:10 scale chassis. Only two axles are permitted. The wheelbase must measure at least 200 mm. The track width (measured from the centre of the wheels) must measure at least 160 mm. The vehicle, including possible extensions and bodywork, must not be wider than 250 mm, and not longer than 460 mm. The height of fixed installations must not exceed a height of 300 mm above the track surface. Flexible antennae are allowed. These physical dimensions will be checked before the competition during the acceptance test executed by a jury member.

3.4 Steering / Chassis

The front axle must be steerable. An additional steerable rear axle is allowed. Apart from this, the design of the chassis is subject to the team's creativity, as long as it adheres the maximum physical dimensions. The steerable axle(s) must feature Ackermann steering.

3.5 Sensor Setup

The sensor setup can be arbitrarily chosen by the teams. Laser sensors are allowed only up to class 2 devices.

3.6 Data Transmission

No data or signals must be transferred from the vehicle to the outside world during the dynamic events, except for those signals necessary for GPS navigation.

3.7 Bodywork

The teams must be able to quickly disassemble the vehicles' bodywork, so that the inner parts of the vehicle can be inspected at any time.

3.8 Development Know-How

The basic concepts of the vehicles must be conceptualized and implemented by the students themselves. They must not accept direct help of professional engineers or suppliers. The students are encouraged to do research and/or discuss their problems with professional engineers or suppliers. Ready-made solutions may never be included in the vehicle. This particularly concerns the usage of predesigned algorithms which may be part of a hardware platform, which serve the purpose of providing a fully functional system for perception, behaviour generation or control for automated vehicles or robots. The final decision on acceptable components is taken by the committee. The teams are encouraged to contact the committee in case of doubts or questions about a particular component. In case of violating these guidelines or intentional fraud, the committee has the right to exclude the respective team from the competition.

3.9 Safety Regulations

During the competition, safety instructions issued by the committee members are to be followed. Ignorance of notes or guidelines can be punished by excluding the respective team from the training sessions or the competition. Each individual shall take care at all times so that neither other participants are injured, nor other vehicles are damaged due to careless behaviour. As far as the sensor setup is concerned, the following requirement and restriction arise: all components within the vehicles must adhere to established guidelines for safe public usage. Particularly the usage of active sensors can be limited by this rule. The teams must make sure that no third parties are subject to possible injury due to installation or handling of the sensors. In case of questions concerning particular sensors, the admission must be discussed with the committee prior to the beginning of the training sessions. Violations of these regulations lead to the immediate exclusion from the competition.

3.10 Modification of the Vehicle

Every team that received a model vehicle from Robert Bosch is allowed to modify this vehicle (i.e. by installing additional sensors) while still complying with the above mentioned standards.

During the dynamic events, the hardware of the vehicle must not be modified except in case of supervised repair. The software must not be modified during the dynamic events. Changing and charging batteries is allowed.

4 GPS system

A video camera based “GPS like” navigation system will be installed in order to provide geo-spatial positioning. It allows each model vehicle to determine their location and rotation in relation to the track as a reference system.

Geo-spatial positioning will be provided with a granularity of 1 second.

5 Static Events

During the static events, the teams must present and defend their concepts in front of a jury. Each team is awarded an individual grade for each key aspect of the presentation. The judges are experts from the industry and academia. The maximum attainable number of points is described in chapter 1.4.3.

5.1 Project Review

Teams participating at the *Bosch FMC* must agree to present, at the dates specified in section 1.4.2, the progress status to Bosch representatives who will review and advise the team’s progress. Performance in these meetings will be scored and added to the final score with an emphasis on visible improvements (i.e. top marks are given to teams that reach an efficient organisational process, not necessarily having one from the beginning).

5.2 Overall Concept Presentation

Each team has the possibility to explain the overall concept behind their vehicle. The overall concept covers hardware and software architecture. Additionally, each team shall present how energy and cost efficiency have been considered during the design phase. Finally, the teams shall explain how obtained knowledge and know-how is preserved for future team generations (knowledge management).

5.3 Presentation of Technical Approaches

Each team must present their concepts for each key aspect of the dynamic events. These dynamic aspects are: automatic drive, lane detection and lateral control, traffic signs recognition, parking, obstacles/intersection. Each key aspect is divided into the aspects of perception and control.

5.4 Deliverables: Presentation

All presentations must be digitally available (i.e. .ppt, .pptx or .pdf) and sent to **ideabox@bosch.com** prior to the competition. The files must not exceed a file size of 10 MB.

The presentation files must be submitted no later than one week before the event.

5.5 Agenda

There is a time budget of 5 minutes for the presentation of the team's concept that will continue with a panel discussion with the jury of about 5 minutes.

The discussions are followed by the dynamic events: one free drive w/o obstacles and one obstacle evasion drive, where the jury will score the performance of the automated driving algorithms developed by each team.

These time intervals may be changed and announced at a later date

6 Dynamic Events

During the dynamic events, the actual performance of the automated model vehicles will be challenged in two different events.

6.1 Free Drive w/o Obstacles

In this event, the vehicle shall automatically cover the farthest possible distance to a destination point in a given time. The vehicle drives in the right lane, and also executes requested parking manoeuvres.

6.1.1 Scenario

The complexity of this scenario is limited. It consists of a road with two parallel lanes - one in each direction: straight sections, tight turns, designated parking spaces and intersections. The lanes are marked by different types of lane markings. All markings are white and approx. 20 mm side, if not specified differently.

Driving on the right side of the road, the vehicle shall find a suitable parking spot and manoeuvre into it as quickly as possible, without touching the surrounding obstacles. There are parking spots in parallel orientation to the track. Both areas for parking are located on a straight part of the track without missing lane markings.

6.1.1.1 Lane width

Each lane has a width of 350 mm, measured from the inside of the respective markings. The left and right markings do not show lateral discontinuities. However, the centreline may under circumstances (e.g. because of change of marking type) display discontinuities.

6.1.1.2 Lane markings

Both lanes may be separated by a dashed or continuous centre line. The dashed centreline is interrupted every 50 mm for another 50 mm. This shape continues until reaching an intersection or the scratch line, so that the centre line might end with a gap at these points. Alternatively to the dashed centreline, a continuous solid line can be present. Marking types can occur in arbitrary order. Marking types will persist for a distance of at least 900 mm. There will be immediate changes between marking types. For the Free Drive event, all marking types are to be treated as regular dashed markings. The left and right track boundaries are given by solid white lines.

Neighbouring sections of the track are installed at least 50 mm apart, measured from the outer edges of the markings. The circuit is mostly planar. All of the lane markings can be missing at arbitrary locations for a maximum of 1000 mm. Except for intersections, no more than two markings are missing at the same time. In this event, no obstacles are located on the track. Possible stop lines and regulations concerning the right of way are to be ignored.

6.1.1.3 Parallel Parking Spots

There is a 300 mm wide area next to the right lane. Cardboard boxes represent other vehicles. The boxes can be fixed to the ground. There is a space of 20 mm - 200 mm between the right lane marking and the side of the obstacle which faces the track. The obstacles are spaced apart from each other for at least 700 mm. The obstacles measure at least 200 mm in height and length. The parking area and the track are located in the same ground plane.

The parking spots can be arranged in arbitrary order. They measure 850 mm or 1300 mm in length and 300 mm in width.

The left and right hand limits of the parking spots are defined by the right lane marking and an additional solid white line (also 20 mm width). Front and rear limits are defined either by white cardboard boxes or by a no parking area.

6.1.1.4 Traffic Signs

In order to mark sharp turns, supporting traffic signs at the roadside may be present. They mark a curved section of the track with radii below 1.2 m, if this is located after a straight section of at least 2 m length. The supporting traffic signs will be placed 1 m before the transition to the turn.

Additional traffic signs can be present at the roadside. They are located on the right hand side of the lane.

6.1.1.5 Artefacts

The design of the area outside of the road is not defined. Artefacts in the form of objects or remainders of lane markings might be located outside of the road area. The minimal distance between artefacts and valid lane markings is 100 mm.

6.1.2 Execution of the Event

6.1.2.1 Start

At the beginning of the event, the vehicle must be ready to start and it must be placed in the start box, which is located next to the track. The start box can be separated from the track by a solid white line. This line may be crossed to enter the track. The attempt is started when allowance is given by a judge or a referee. The starting order of the teams will be announced by the committee, visualized using the start scheduling system during the competition.

6.1.2.2 Attempts

Each team is entitled to one attempt. An attempt can be cancelled by the team representative within 30 seconds. The team is then allowed a second attempt, after all other teams have completed their first attempt. Cancelling an attempt is penalized.

6.1.3 Scoring

6.1.3.1 Timing

Each team has a maximum of 5 minutes to complete this event. Timing for the event starts with crossing the scratch line.

6.1.3.2 Penalties

-5% of the maximum event points

- Crossing the road and/or parking space limits while driving (for each case)
- Collision with obstacle (for each case)
- Distance < 50 mm to front and rear limits when vehicle is parked

-10% of the maximum event points
- Cancelled attempt

-20% of the maximum event points
- Invalid parking attempt

6.1.3.3 Scoring

The longest covered distance, under consideration of penalties, will be awarded the maximum number of points. The subsequent teams will be scored in relation to the best team.

6.2 Obstacle Evasion Drive

The event "Obstacle Evasion Drive" extends the Free Drive w/o Obstacles with additional elements which need to be considered during the driving task.

The vehicle will not be required to execute a parking task.

The vehicle will be placed on the race track at a random point and then will have to drive and safely exit the race track through a defined exit point.

6.2.1 Static Obstacles

During this event, a number of static obstacles will be placed in the right lane, in the left lane and outside of the track. The body of each obstacle consists of white cardboard boxes. Obstacles can be fixed on the ground and are spaced at least 1 m apart. The obstacles cannot always be attributed to a single lane, however under no circumstance can both lanes be blocked. Obstacles may force the vehicle to change lanes. Passing manoeuvres must be executed without touching an obstacle. They must be completed after a maximum distance of 2 m after having passed the obstacle.

6.2.2 Dynamic Obstacles

Apart from static obstacles, at least one dynamic obstacle may be present on the track. Dynamic obstacles are competitor model vehicles. Dynamic obstacles can stop temporarily and in turn block the right lane. It may be passed. Passing manoeuvres can be executed without encountering an obstacle on the left lane. The passing manoeuvre is subject to the same regulations as when passing a static obstacle.

6.2.3 Intersections

Sections of the track can be part of intersections with other parts of the track. The respective lanes cross perpendicularly. Design and layout are shown in the appendix. In addition to the perpendicular cross section of the respective left and right lane boundaries, the intersection can display a round shape with a radius of about 100 mm. Intersections may be displayed with stop lines to opposing entries. These lines are 40 mm wide and cross one lane completely. Additionally, a stop line may be complemented by a traffic sign. The right of way is only announced by the respective traffic sign. If a stop sign is located in the own lane, the vehicle must stop for at least 3 seconds. The front of the vehicle must be located in front of the stop sign, however the distance must not be greater than 20 cm. The right of way of a dynamic obstacle must be respected at an intersection, if the dynamic obstacle is located within the defined area. If the vehicle does not possess the right of way, it must wait until the dynamic obstacle has completely crossed the intersection. Only one dynamic obstacle at a time can be present at an intersection.

6.2.3.1 Speed Control

The vehicle has to adhere to the given speed limit. Devices for controlling the speed of the vehicle may be present.

6.2.4 Execution of the Event

6.2.4.1 Start (Additions)

The starting order of the teams will be visualized using the start scheduling system during the competition. The same start box as for the Free Drive w/o Obstacles may be used. An attempt can be cancelled by the team representative within 30 seconds.

6.2.4.2 Attempts

Each team is entitled to one attempt. An attempt can be cancelled by the team representative within 30 seconds. The team is then allowed a second attempt, after all other teams have completed their first attempt. Cancelling an attempt is penalized.

6.2.5 Scoring (Additions)

6.2.5.1 Timing

Each team has 5 minutes to complete this event.

6.2.5.2 Penalties

-5% of the maximum event points

- Crossing the road space limits while driving (for each case)
 - Collision with obstacle (for each case)
 - Violating safety distance to obstacle (< 50 mm) (for each case)
- 10% of the maximum event points
- Cancelled attempt
 - Collision with obstacle (for each case)
 - Violating right of way (for each case)
- 20% of the maximum event points

6.2.5.3 Scoring

The longest covered distance under consideration of penalties will be awarded the maximum number of points. The subsequent teams will be scored in relation to the best team.

7 Competition Schedule

In this section, the general schedule execution of the competition is described.

7.1 Training

In order to guarantee safe and fair training conditions, the training sessions are divided into time slots. The number of teams allowed on the track at the same time and the length of the slots will be announced before the competition. The commission might change the slots and the number of teams on the track without further notice. In case of repetitive violation of training slots, the commission may issue penalties which will be subtracted from the final score of the respective teams. In case of repetitive violations of slots or if team members endanger other teams or their equipment, the commission may expel single team members or whole teams from the competition.

7.2 Qualifying

In order to compete in the dynamic events, the vehicle must fulfil the following requirements in addition to the technical regulations in Chapter 3:

1. The vehicle must be able to follow the road for at least 30 seconds.
2. One out of three parking attempts must be successful.

The fulfilment of these requirements will be checked by the jury members during the qualification round in the day before the event. This qualifying round will follow the same rules as the final event. The best teams, based on the scoring obtained in the eliminatory round, will be invited to compete at the final event.

7.3 Competition

7.3.1 Preparations

30 minutes before the beginning of the competition, the teams must hand in their vehicles at the park fermi. No modifications of the vehicles must be made after this point. Batteries must be separated from the system, the vehicle must be switched off. All external tools must be removed from the vehicle, all wireless communication on board the vehicles must be switched off or removed. When handing in the vehicle, the teams must make a definite statement to the head referee in which events they would like to participate. This is to ensure a smooth execution of the competition.

7.3.2 Start Scheduling System

If implemented, a traffic-light-like start scheduling system will signal the teams when to pick up their vehicle at the park fermi and when to begin to prepare for starting. The traffic light will show the following stages:

1. Red: No preparation necessary
2. Yellow: The vehicle must be prepared for start. The team picks up their vehicle at the park fermi. Time budget for preparation is 5 minutes. The teams may change to fully charged batteries in this context. However, no additional tools must be used at this stage. The idle but ready vehicle must be placed inside the start box or at least brought to the scratch line at this point. Timing will start, regardless whether the vehicle is ready or not.
3. Green: When showing "green" the teams have 30 s to start their vehicle.

After each event, the vehicle must be returned to the park fermi.

7.3.3 Order of Events

The events "Free Driving w/o Obstacles" and "Obstacle Evasion Drive" will take place in the given order. An attempt can be cancelled according to the regulations. The respective team is moved to the end of the schedule and will be called again to attempt a second run. Eventually, the event "Obstacle Evasion Drive" may be executed.

8 Appendix

8.1 Example model vehicle main components

8.1.1 Model vehicle chassis



Image source: www.conrad.de

8.1.2 Model vehicle body



Image source: www.conrad.de

8.1.3 Road version wheels



Image source: www.conrad.de

8.1.4 Electric motor



Image source: www.conrad.de

8.1.5 Steering servo drive



Image source: www.conrad.de

8.1.6 Rechargeable battery pack (LiPO)



Image source: www.conrad.de

8.1.7 Other electronic parts:

- Controller board
- Electric motor driver
- Incremental rotary encoder
- Optical sensors
- Accelerometer & Gyroscope

8.2 Possible Parking Lot Layouts

8.2.1 Parallel Parking

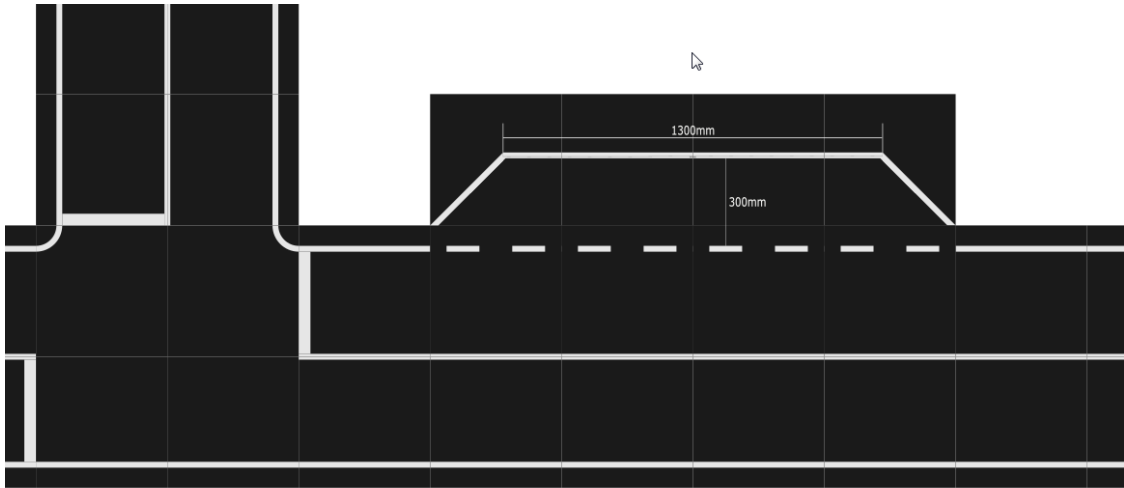


Figure 1: Parallel Parking

8.3 Example Race Track

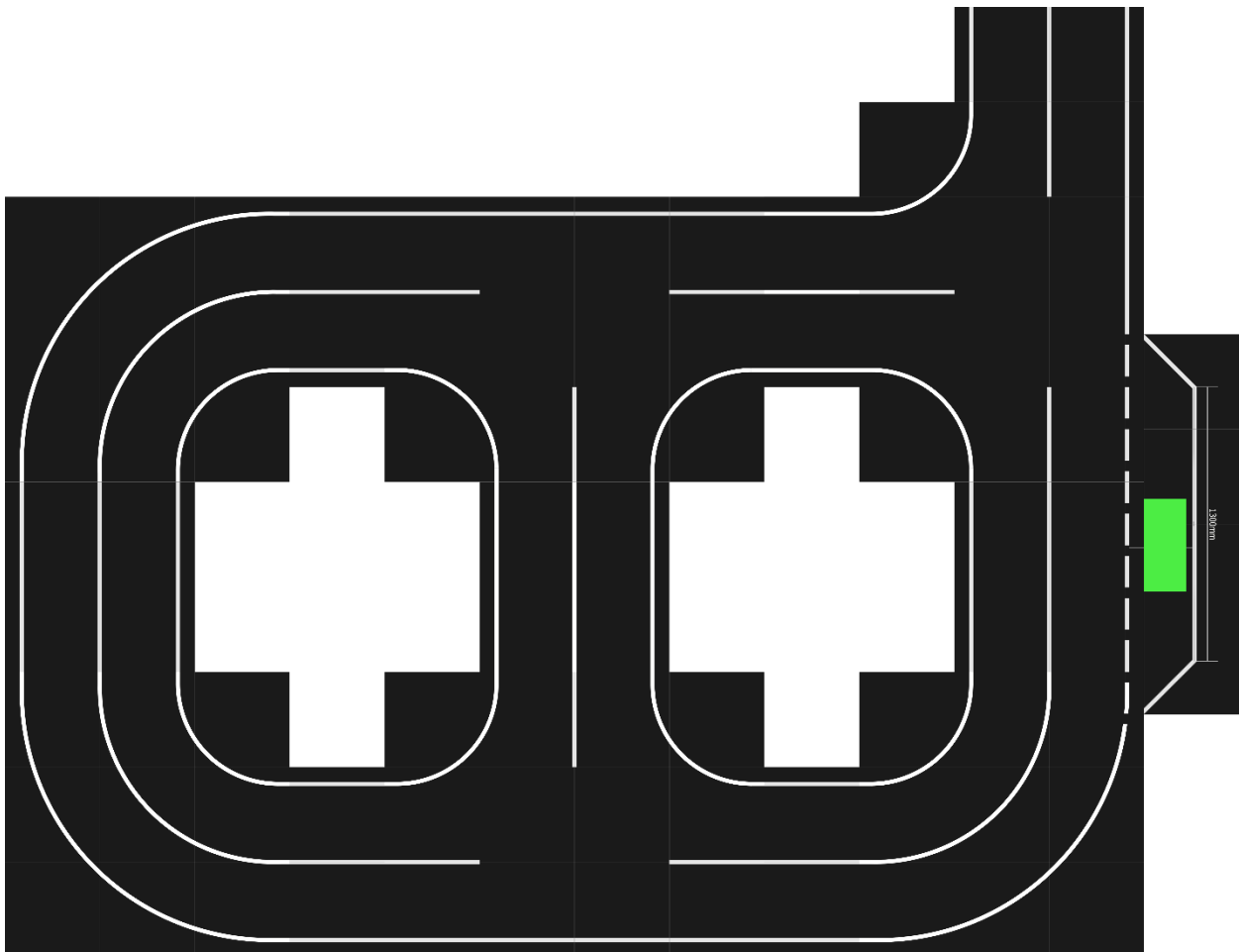


Figure 2: Example Race Track