

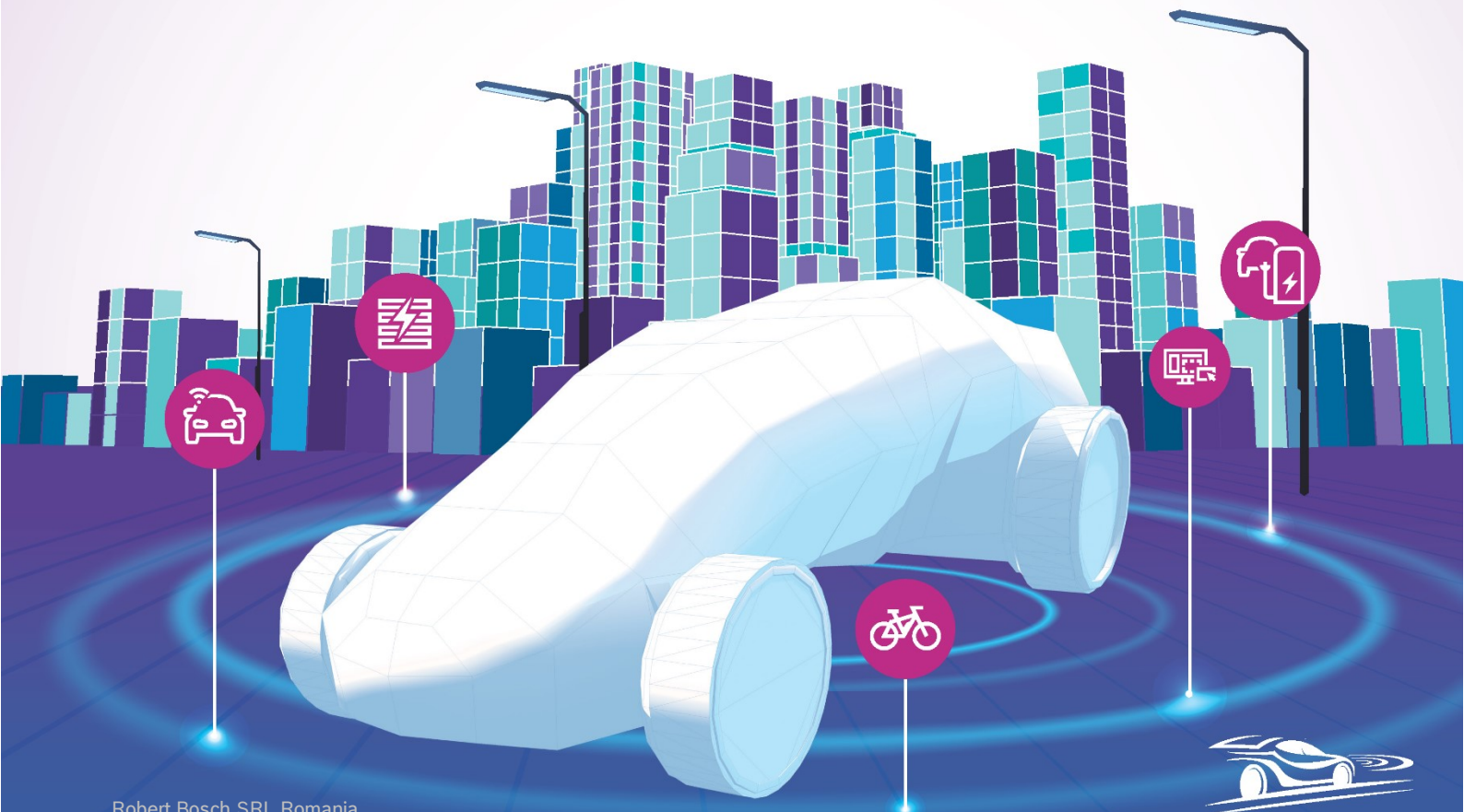


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# Bosch Future Mobility Challenge 2021

## *Competition Regulations*



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**Bosch Future  
Mobility Challenge**

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# 1 Overview

## 1.1 Introduction

This document presents the regulations of the *Bosch Future Mobility Challenge* (hereafter “*BFMC*”) event.

BFMC participants should use the competition’s web page ([www.boschfuturemobility.com](http://www.boschfuturemobility.com)), especially the **Forum**, for obtaining information regarding technical and organizational aspects of the event. The **web page**, along with the **Forum** will be the main communication channels with the organizers. In case of additional questions, **e-mails** can be sent to the organizers at the following e-mail address: [futuremobilitychallenge@bosch.com](mailto:futuremobilitychallenge@bosch.com) .

# 2 The Competition

## 2.1 Prerequisites

### 2.1.1 Team structure

Every team must be composed of:

- A **team leader**, enrolled at a university as Bachelor or Master student;
- **Team member/s**. Minimum one, maximum 4, all enrolled at a university as Bachelor or Master students;
- A **mentor**, a teaching/research staff-member of a university, including Ph.D. student.

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

After submitting the registration, the team structure can be modified with only one of the following changes:

- adding a new team member;
- changing one team member with a new one;
- excluding a team member.

These modification requests will be accessible for the team leader on the event’s web page after the selection step. Additional information regarding the modification and uploading new documents (if necessary) will be required. Any modification could be accepted or declined by the organizing team, based on the same criteria as the initial selection process.

### 2.1.2 The Registration Process

Registration requests have to be submitted through the Registration Form available on the event's web page: [www.boschfuturemobility.com](http://www.boschfuturemobility.com). Each participating team has to fill in the required information and the team leader has to upload the documents required in the registration form.

### 2.1.3 Period of Registration

Registration for the competition will open on 1<sup>st</sup> October 2020 and will end on 8<sup>th</sup> of November 2020.

### 2.1.4 The selection process

At the end of the registration period, a first screening will take place and the selected teams will be individually contacted and planned for a face-to-face or Skype interview.

After conducting all interviews, the selected teams will receive a 1:10 model vehicle platform during the kick-off meeting or via courier.

Selection criteria will be, but not limited to:

- Motivation and goal of each team;
- Link between the competition topic and personal/university projects (e.g. diploma projects);
- Proven interest and experience in similar contests;
- Recommendation from University professors.

The teams that reached the finals during the previous editions are admitted to the contest without interview, if they register for the current edition.

## 2.2 Monitoring

Teams participating at the *BFMC* agree to send every month a periodic status via the competition website, containing: a **technical report**, a **project status** and **multimedia files** showing their progress to Bosch representatives. The quality of these reports 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). The grading for those reports is described in the Section 5.3.

**Technical report** – It is associated with the industry practice of periodic reports on a project, describing the difficulties, the resources and the technology used in developing a product. It should emphasize the key aspects that a client usually wants to know. The report shall not be longer than 3 pages. A report model will be given to the participants in the official documentation.

**Multimedia** – Some multimedia files, with a limit in dimension of 15MB, should be included. These should emphasize with visual aid the actual status of the project. The files can be in video format, images, gifs.

**Project plan** – Each team should have a plan with the delivery date of each task and subtask, the resources for them and their corresponding difficulty. In the industry, this planning is used to know at each moment if the project is going as planned or if it needs additional resources on certain tasks. The project plan shall allow the inclusion of non-planned activities and it can be updated at any point during the development of the project. A project plan model will be given to the participants in the official documentation.

## 2.3 *Schedule*

### 2.3.1 **Qualifying Rounds**

For testing purposes, a series of training videos on the competition track will be given to the students, with different lighting conditions, paths and obstacles encountered. Two weeks prior the qualifying rounds, a video of the exam test will be made available to the teams. Each team will have the freedom to choose one of the three possible alternatives to send a video and demonstrate the capabilities of their algorithms, which should perform the following actions:

- Lane keeping;
- Intersection crossing;
- Sign detection.

The three actions have to be fulfilled in one autonomous run. Failure to successfully complete one of the before mentioned actions results in the team's disqualification.

The three alternatives to pass the exam are:

- I. A video of the car performing the actions on a real-life like map created by the team,
- II. A video of the car performing the actions in a simulator,
- III. A video of the car in front of a Desktop, taking the exam video as a simulated input and acting accordingly;

**In case the team does not pass this test, the team will be disqualified and *BFMC* organizers will ask that the model vehicle is returned, if one was provided.**

### 2.3.2 **Semi-Finals:**

The semi-finals will take place on 12<sup>th</sup> -15<sup>th</sup> of May 2021. The Jury may differ from the one on the day of the challenge.

The semi-finals will follow the same rules as the final event. The fulfilment of the requirements will be checked by the jury members, each team having a dedicated time slot on the day before this stage to test their algorithms on the competition track and on the test track. The organizers will ask to return the provided model car, in case the team does not qualify for the final event. The ten best teams, based on the scores obtained in the semi-finals, will be invited to compete at the final challenge and they can keep the model vehicle after the participation at the event.

### 2.3.3 **Finals:**

The final event will take place on 16<sup>th</sup> of May 2021.

### **2.3.3.1 Preparations**

30 minutes before the start of the competition, the teams must be present at their stands. The order will be announced by the organizers.

### **2.3.3.2 Presentation in front of the Jury**

At the beginning of the static event, 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. These consist of the presentation itself, their way of exposing the ideas, the overall concept behind their vehicle, considerations regarding automated driving, lane detection and lateral control, traffic signs recognition, parking, obstacles and intersections. The judges are experts from the industry and from academia. The maximum time for the presentation itself is 5 minutes followed by an open discussion of maximum 5 minutes. The maximum achievable number of points is described in Section 5. All presentations must be digitally available (in .ppt or .pptx format) and sent to the organizers **no later than the day** before the challenge.

### **2.3.3.3 Start**

The vehicle must be placed on the signalled starting point. The attempt is started when the start traffic light shows the colour green. Each team will first do the technical challenge followed by the speed one. The order of the teams will be announced by the organizers.

### **2.3.3.4 Attempts**

The attempt may be cancelled by the team representative within 30 seconds. Cancelling an attempt results automatically in a penalty (Section 5) for the next run. A maximum of two attempts is allowed for each challenge (technical and speed). If the cancellation of the run is done after 30 seconds, the points gathered so far will be taken into consideration.

## **3 The vehicle**

### **3.1 *Development Know-How***

The basic concepts of the vehicles must be conceptualized and implemented by the students themselves. The students are encouraged to do research and/or discuss their problems with professional engineers or suppliers, however direct development work should not be accepted from the latter ones. In case of violating these guidelines the organizers have the right to exclude the respective team from the competition.

### **3.2 *Safety Regulations***

During the competition, safety instructions issued by the committee members are to be followed. Ignorance of notes or guidelines can be sanctioned 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 requirements and restrictions 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 organizers prior to the beginning of the training sessions. Violations of these regulations lead to the immediate exclusion from the competition.

### **3.3 *Modification of the Vehicle***

Every team that received a model vehicle from Robert Bosch is allowed to modify it (e.g. by installing additional sensors or boards) only after a member has made the modification request on the site and on the forum and it has been accepted by the organizers.

### **3.4 *The vehicle and the outside world***

#### **3.4.1 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 the environmental systems of the challenge (described in the subsection 4.5).

#### **3.4.2 University graduation work**

Each member of each team is encouraged to develop its own Bachelor's or Master's thesis on one or more systems of the car. If additional help is needed in the developing of the thesis in term of components or know-how, the organizing team shall be contacted via the given channels described in the Section 1.

#### **3.4.3 Software availability**

The participating teams will make the software available, upon request, for the organizing team. The organizing team grants the fact that all information exchanged with the participant teams remains confidential between each team and Bosch. The code will not be made available/visible to any other participants. There will be no additional scoring or penalties based on the software quality.

## **4 The challenge**

During the dynamic events, the actual performance of the automated model vehicles will be evaluated in **two different challenges**: a technical one and one where speed is taken into account.

## 4.1 **Technical challenge**

In the technical challenge, the vehicle shall automatically reach and pass within the described scenario the obstacles present on the map. Each team is free to choose its own obstacles beside the mandatory ones in order to gain more points or finish the race by returning to the finish line (check subsection 5.1 for scoring details). Each team will have a maximum of 8 minutes on the track in order to accumulate their points. The team shall inform the organizers of the optional challenges selected, prior the race.

## 4.2 **Speed challenge**

In the speed challenge, the scope is for the team to start their car at the starting point and complete the described scenario as fast as possible while still respecting the road conditions (traffic signs, semaphores, pedestrian, static car), while not exceeding 5 minutes. The grading for this challenge will be the corresponding points obtained from the resulted time after including the penalties (check subsection 5.2).

## 4.3 **Track description**

The road has straight sections, turns, designated parking spaces, ramp, intersections, a roundabout, one lane road, two lane roads and a highway.

Real life traffic rules have to be obeyed. The vehicle has to take into account traffic light colours, traffic signs and it has to avoid incidents with other cars or with pedestrians.

Description of the track and the placement of the known obstacles on the road will be given with the official documentation on Github.

### 4.3.1 **Lane markings and dimensions**

Lanes may be separated by a dashed or continuous central line. All markings are white and approximately 20 mm wide, if not specified differently. Each lane has a width of 350 mm, measured from the inside of the respective markings. On the highway, the centre lanes are separated by a series of Jersey barriers.

### 4.3.2 **Parallel Parking Spots**

The parking spots measure 700 mm in length and 300 mm in width and are placed next to the right lane. They are signalled by the corresponding traffic sign.

### 4.3.3 **Perpendicular Parking Spots**

The parking spots measure 400 mm in length and 500 mm in width and are placed next to the right lane. They are signalled by the corresponding traffic sign.

#### **4.3.4 Roundabout**

It is a one lane roundabout with the inner diameter of 880mm and the outer diameter of 1280mm.

#### **4.3.5 Decorative elements**

Outside the road lanes there will be some decorative elements: trees, pedestrian like shapes and buildings.

### **4.4 *Track obstacles and reactions***

#### **4.4.1 Pedestrian and crosswalk**

If a pedestrian is present in between the road limits, the car must completely stop until it leaves the road. If a crosswalk is encountered on the road, the car must visibly slow in its proximity. In case the team opts for having the pedestrian also outside the crosswalk, this has to be communicated prior the run to the organizers. The pedestrian will be placed randomly on the track somewhere on their route.

#### **4.4.2 Car overtake/tailing**

If a car is encountered on the road, an overtake manoeuvre shall be initiated if the road signalling allows it, while tailing should be initiated otherwise.

#### **4.4.3 Parking**

Two parking spots of each type of parking will be present (perpendicular and parallel), one being occupied and one not. The car should perform a parking manoeuvre in the empty parking spot.

#### **4.4.4 Traffic Lights**

Traffic lights will be placed at the start point and in one intersection. The vehicles should wait for the green light for passing the intersection.

#### **4.4.5 Bumpy road conditions**

An area with sand/small stones will be present on the track. If the car is crossing a bumpy road, a corresponding message will be sent to the environmental server with its position.

#### **4.4.6 Traffic Signs**

The traffic signs are located on the right side of the lane. These can be: **STOP, parking place, crosswalk, priority road, highway entrance, highway exit, roundabout, one-way road and no-entry road**. If a stop sign is located in the car's own lane, the vehicle must stop for at least 3 seconds. If a crosswalk sign is located in the car's own lane, the vehicle must visibly slow while in its proximity.

#### **4.4.7 Road closed stand**

A stand with the road under construction signalling will be placed randomly on one of the lanes of one way road. If the sign is on the right side, the car should turn left at the intersection, if placed on the left side, the car should turn right.

### **4.5 Environmental systems**

#### **4.5.1 GPS**

A video camera based “GPS like” localization 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 frequency of 1 signal/second. The GPS system will also have small uncovered areas, where signals will not be available, to simulate real-life conditions.

#### **4.5.2 Intelligent traffic lights**

A traffic light system on which each traffic light is streaming its own ID and state will be installed. The frequency of the sent packages is of 1 signal/ second.

#### **4.5.3 Inter-vehicle communication**

Each vehicle present on the track will stream its own position and orientation on the map to the other vehicles with a frequency of 1 signal/second.

#### **4.5.4 Environmental server**

Each car will send information to the in-house environmental server collecting and giving road condition information upon request to the participating cars.

## **5 Scoring**

The members of the jury will be announced on the web page of the challenge.

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

#### **Technical Progress:**

S1: Evaluation during development stage (reports) 150 Points

S2: Overall concept presentation in front of the competition jury 150 Points

#### **Track Challenge:**

D1: Technical challenge Cumulative(250-600 Points)  
(See Subsection 5.1)

D2: Speed challenge 300 Points

#### **Impressions**

Overall running evaluation (smoothness of the car) from jury 100 Points

## 5.1 *Technical challenge - cumulative pointing system*

In order to gain the points, evident consideration of the obstacles must be visible (Detection and initiation of the necessary procedure). Failure in doing so on the mandatory ones, results in 0 total run points (The run can be restarted). Failure in doing so on the optional ones, results in +0 points (won't cumulate to the already existing points). If the necessary procedure was initiated but the scenario was not fully respected, penalties will be applied.

Scoring			
Obstacle description	Mandatory	Optional	Points
Bring the car to a <b>complete stop</b> until the <b>pedestrian</b> leaves the signalled <b>crosswalk</b>	X		70
<b>Overtake static car</b> on road if the line signalling allows	X		70
Do a parallel or perpendicular <b>parking manoeuvre</b> on an <b>empty parking</b> spot	X		50
Act accordingly in the <b>traffic lights intersection</b>	X		30
Pass the <b>ramp</b>	X		30
Bring the car to a <b>complete stop</b> until the <b>pedestrian</b> leaves the <b>road</b> (Random position – not on crosswalk)		X	70
<b>Overtaking</b> manoeuvre on highway on <b>moving car</b>		X	70
Passing through <b>Roundabout</b>		X	30
<b>One way &amp; two lane roads</b> – Recalculating the path based on the “road closed stand” positioning left/right side lane (Random)		X	70
<b>One way &amp; one lane road</b> - stay behind the <b>leading vehicle</b> and passing + signalling the <b>bumpy road section</b>		X	60
<b>Reach the Finish line</b>		X	50
<b>Total possible points</b>			600 (out of which 250 mandatory)

Penalties		
Penalty description	Maximum number of penalties	Penalty value
<b>Cancelled attempt</b>	1	60
<b>Collision</b> – car, pedestrian, human interaction (manual reposition of the car on the track)	2	60
Failure <b>lane keeping/crossing road markings</b>	5	15
Failure in <b>traffic sign/traffic light action taking</b>	3	30
<b>Streaming the position</b> of encountered obstacles	3	15

### Pointing example

- Scenario 1: the car is initiating the overtake static car on road if the line signalling allows but it crashes into the car on the lane comeback:
  - +90 points for the initiated scenario
  - -50 points for collision
- Scenario 2: the car is not initiating the overtake static car on road if the line signalling allows and crashes straight into the car:
  - 0 points total run
  - **NB: The run can be restarted, but -60 penalty for cancelled attempt will be applied (if restarted within 30 seconds)**

## 5.2 Speed challenge

The goal is to finish the scenario in the shortest time. In the case a car does not perform all actions flawlessly, the penalties will be applied for the overall time, based on the percentages indicated below (e.g. 1:40 min. measured time with 35% penalties results in 2:15 min. final time). The points received at the end of the speed challenge will be marked according to the position reached based on the teams' time after applying the penalties, and presented in the table below:

Team order	Points
1	300
2	273
3	246
4	219
5	192
6	165
7	138
8	111
9	84
10	57

-5% of the event points

- Crossing the road markings (for each case; max 5 times considered)

-10% of the maximum event points

- Failure in traffic sign/traffic light action

-20% of the event points

- Collision with obstacles or human interaction (manual reposition of the car on the track)
- Cancelled attempt

### 5.3 *Status pointing system*

The report, the multimedia and the project plan will each be given a different grade on a scale from 1 to 10. After the last project status the grades will be all summed and then scaled to the points described above.

**Report** – shall include (but not limited): an introduction on the ongoing activities, the planned activities and their status, the general status of the project, next planned activities and conclusions.

**Multimedia** – shall include visual evidence of the implementation on the robot.

**Project plan** – shall include (but not limited): a timetable with the checkpoints, tasks, subtasks and their delivery date; A task list with the difficulty, resources and description of each task and subtask.

## 6 Prizes

### 6.1 *Winners*

The winner of the first three places will be rewarded with an amount of **4500 Euro**, **3000 Euro**, and **1500 Euro** for 1<sup>st</sup> place, 2<sup>nd</sup> place, and 3<sup>rd</sup> place, respectively.

### 6.2 *New comers*

One new teams that does not have any member from a previously participating team that are closest to the first three places, and not part of them, will be rewarded with the amount of **1000 Euro**.

### 6.3 *Finalists*

All the teams that reach the final stage at the competition keep the car kit.

## 7 Final notes

The same model vehicle, provided by Bosch, must be used for all events. Adding stickers, using any other messages, slogans or names/logos of other companies to the vehicles, wearing or using equipment representing other companies (e.g. clothing, flags, banners, etc.) during the competition is not allowed. If this rule is not respected, the team will not be allowed to compete.