



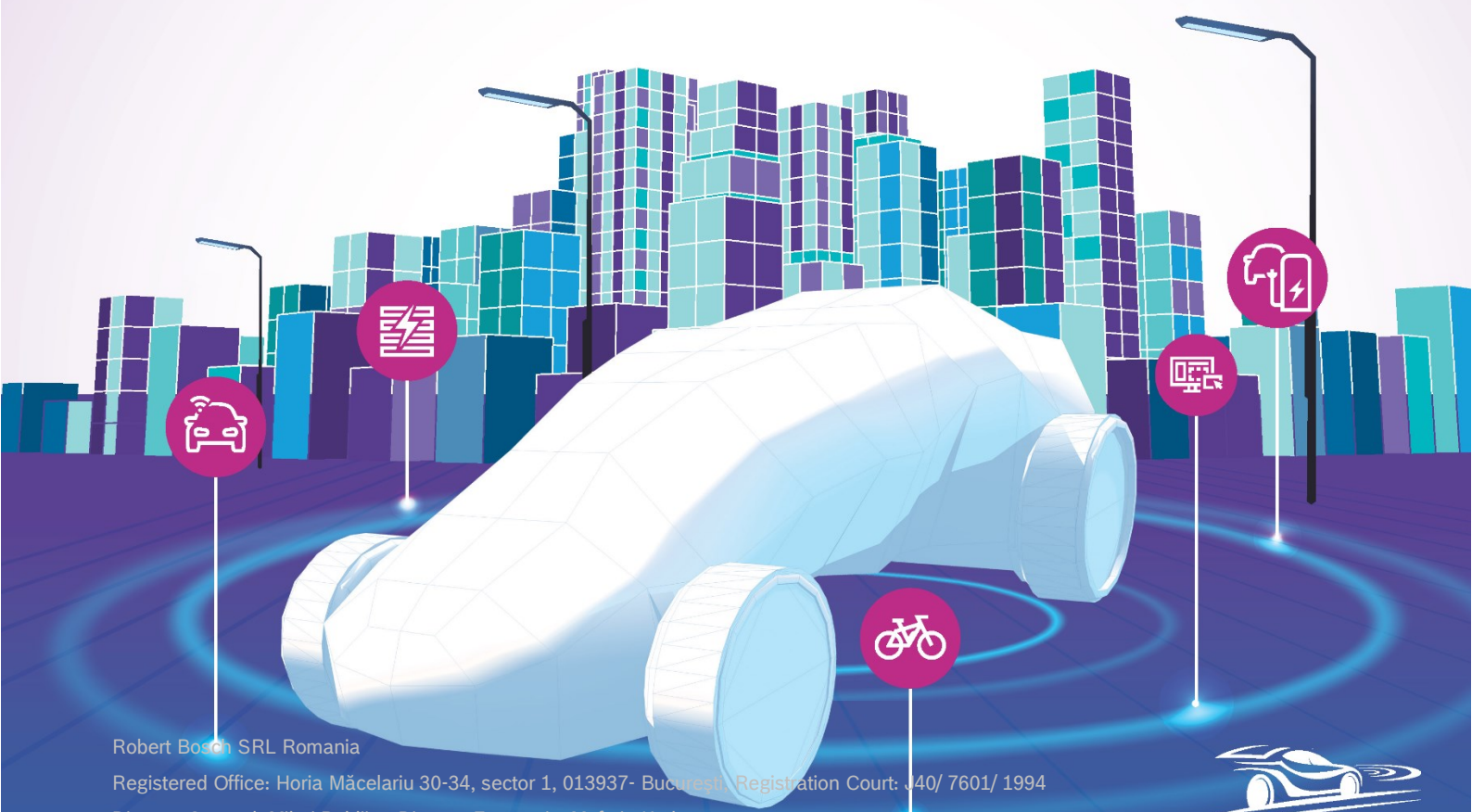
BOSCH

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Bosch Future Mobility Challenge 2022

Competition Regulations

Partner



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Bosch Future
Mobility Challenge



Table of Contents

1	Overview	3
1.1	Introduction.....	3
2	Registration & selection	3
2.1	Period of Registration	3
2.2	Team structure	3
2.3	Selection process	4
2.4	Wild cards.....	4
2.5	Acceptance.....	4
3	The competition	5
3.1	What's provided.....	5
3.2	Kick-off	5
3.3	First steps.....	5
3.4	Activity tracking – Project status	6
3.5	Mid-season quality gate.....	6
3.6	Testing	7
3.7	Qualifications.....	7
3.8	Finals.....	7
4	The run.....	8
4.1	Prior to the run.....	8
4.2	Preparations	8
4.3	Presentation in front of the Jury	8
4.4	Technical challenge.....	8
4.5	Speed challenge.....	9
4.6	Open discussion	9
5	The track	10
5.1	Environmental systems.....	10
5.1.1	Localization system	10
5.1.2	Intelligent traffic lights	10
5.1.3	Vehicle-to-vehicle communication	10
5.1.4	Environmental server.....	10
5.2	Road markings	11
5.2.1	Lane markings and dimensions	11
5.2.2	Parking spots.....	11
5.2.3	Roundabout.....	11
5.3	Track obstacles and reactions	11
5.3.1	Pedestrian and crosswalk.....	11
5.3.2	Car on road	11
5.3.3	Parking	11
5.3.4	Traffic lights	11
5.3.5	Traffic signs	12



5.3.6	Road closed stand.....	12
5.3.7	Light disturbance	12
6	Scoring	13
6.1	Evaluation during the development stage	13
6.2	Presentation in front of the jury	13
6.3	Technical challenge - cumulative pointing system	13
6.4	Speed challenge.....	15
7	Prizes	16
7.1	Winners	16
7.2	Newcomers	16
7.3	Audience award.....	16
7.4	Finalists	16
8	Additional regulations	17
8.1	Modification of the team structure	17
8.2	Modification of the vehicle	17
8.3	Development know-how	17
8.4	Safety regulations.....	17
8.5	Data transmission.....	18
8.6	Software availability	18
8.7	Additional work	18
8.8	Limitations during the challenge	18
8.9	Platforms naming.....	19
8.10	Conduct.....	19



1 Overview

1.1 Introduction

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

BFMC participants will refer to the competition’s web page (www.boschfuturemobility.com), especially the **Forum**, for obtaining information regarding the technical, organizational or other aspects of the event. The **Forum** will be the main communication channel with the organizers. In case of additional questions or private matters, **e-mails** can be sent to the organizing team at the following e-mail address: futuremobilitychallenge@bosch.com. Another official website is our git page: <https://github.com/ECC-BFMC>.

2 Registration & selection

Team registration requests will have to be submitted through the registration form available on the web page of the event: www.boschfuturemobility.com. Each **team leader** must create an account on the website and register his team by filling in all the required data via the registration form. The account creation of the team leader and the team registration form will be available only during the **period of registration**.

2.1 Period of Registration

Registration for the competition will be possible from 1st October 2021 until the 31st of October 2021, Romania time (GMT +2).

2.2 Team structure

Every team must be composed of:

- One **team leader**: high school, Bachelor or Master student;
- 1-4 **team member/s**: high school, Bachelor or Master student;
- One **mentor**: teaching or 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 to ensure that the team reaches the milestones with the desired level of content and quality.



2.3 *Selection process*

At the end of the registration period, a first screening will take place and the organizers will individually contact the potentially selected teams to plan a face-to-face or an online interview.

Selection criteria will be based, but not limited to:

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

2.4 *Wild cards*

The teams that **reached the finals** during the **previous edition** are admitted on the current edition without an interview if the team registers. For a team to receive the wild card, it must respect the following criteria:

- The team has to have the same name as in the previous edition;
- The team has to have at least one member/team leader from the previous edition;
- The team mentor has to be the same person as in the previous edition;

For exceptional cases, an e-mail with the explanation of the change will be sent to the organizing team via the communication channel. The organizers will reply if the team receives the wild card.

2.5 *Acceptance*

After conducting all the interviews, the teams will be contacted about the result of acceptance or rejection. For the selected teams, a list of **next steps** will be provided, including the date & time of the **kick-off** meeting, which marks the start of the competition.

3 The competition

3.1 *What's provided*

The selected teams will receive a 1:10 model kit during the **kick-off**, via courier or will personally pick it up from the Cluj-Napoca Bosch Offices, depending on the possibility of attendance. The physical kit includes an assembled 1:10 vehicle with all the minimum components necessary to develop an autonomous solution (DC motor for speed, encoder for speed control, servo for steering, control unit board, brain unit board, camera, and an IMU).

Beside the physical kit, the teams will also get access to other benefits included in the competition package, such as:

- Low-level code that eases the process of getting started. Includes firmware for steering and speed control, interfaces with the different sensors and APIs for the interaction with the **environmental systems**;
- A ready to work Gazebo simulator, replica of the entire competition environment;
- Access to the forum, documentation, and competition platforms;
- Access to courses on different topics (via Teams) such as: Project management, modularization and parallelism, image processing, control, and state flow.

Accommodation will also be made available for the teams during the test days, qualifications, and finals. The transportation will be covered by the teams themselves.

3.2 *Kick-off*

The kick-off meeting marks the start of the competition. During the meeting the organizing team members will introduce themselves to the selected teams, the time plan of the competition will be presented together with the provided platforms and where to access them plus other competition aspects. At the end of the meeting, a Q&A session will take place, where attendances will have the chance to clarify unclear topics.

3.3 *First steps*

Participating teams agree to prepare a small description and signature picture of the team itself for the promotion on the website and sign a GDPR form provided by us, allowing the picture and description to be used for promotion materials.

3.4 *Activity tracking – Project status*

Participating teams agree to send a monthly periodic status via the competition website, containing a **technical report**, a **project plan** and a **video file** showing their progress to the Bosch representatives. The quality of these files will be scored and added to the final score with an emphasis on visible improvements (i.e. top marks for the teams that reach an efficient organisational process). The scoring for this phase is described in the subsection 6.1. The exact timeframe period for submitting each project status will be communicated on the competition platform.

Technical report – It is associated with the industry practice of periodic reports on a project, describing the development in the last sprint, such as tasks statuses, resources, efforts, technologies, etc. The report shall not exceed three (3) pages, and it will be uploaded in pdf format. A report model will be given to the participants in the official documentation.

Project plan – In the industry, different approaches are used to keep track of the development. **We require a time plan and a project architecture for each upload.** The time plan is used to validate at each moment if the project is going as estimated 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. The teams can include also other schematics that can help to better understand the project and the logic, such as a state machine models, flow charts and others. A project plan model will be given to the participants in the official documentation, together with a project architecture. The file will have to be submitted in pdf format.

Video file – The video should emphasize with visual aid the contributions from the past month activity already present in the report and project plan. The video file will have to be in mp4 format with a limit in dimension of 15MB.

Example: On the report, implementation of traffic signs recognition is testified as being at 100%. On the time plan, the traffic sign recognition has a deadline for the next week. On the video, evident display of the recognition is present.

3.5 *Mid-season quality gate*

This is the eliminatory part of the competition, where the teams must demonstrate their capability of delivering a working solution until the day of the challenge.

Each team will have to send a video of maximum 3 minutes of the car performing a set of actions in real life. The teams will have the freedom to choose one of the three possible alternatives:

- I. A video of the car performing the actions on a real-life like map;

- II. A video of the car in front of a Desktop, taking a video as a simulated input and acting accordingly;
- III. A video of the car in front of a Desktop where the simulator is running, taking as visual input the one from the camera inside the simulator.

The cars must perform the following actions in one single autonomous run.

- Lane keeping;
- Intersection crossing;
- Prove complete maneuverer after the following signs: Stop sign, crosswalk sign, priority sign, parking sign.

A meeting will be scheduled with all the teams and the Organizers, where the Organizing team will play the videos from all teams and the teams will comment on them. Up to 30 teams will be selected and will go over this stage, depending on the general level. If a team is not considered to be eligible for the gate, it will result in the disqualification and returning of the kit. The exact period for submitting the video will be communicated on the competition platform.

3.6 Testing

From 11th to 13th of May, all the teams will be invited to our location in Cluj-Napoca, to work in our building and test their algorithms on the competition track.

3.7 Qualifications

The qualifications will take place on 14th of May 2022 and it will follow the same logic as the competition finals.

Up to eight (8) teams will be invited to join and compete in the final event, based on the scores obtained in the Qualifications. The number of finalists can decrease if the best ranked 8 teams don't complete the mandatory obstacles during the qualifications. All the teams that don't reach the finals will have to return the provided model vehicle at the end of the day.

3.8 Finals

The final event will take place on 15th of May 2022.

4 The run

4.1 *Prior to the run*

The teams will send to the organizers via the communicated channel, within the communicated timeline, prior to each run (Qualifications and Finals) the following:

- A presentation of their solution in “.ppt” format;
- One pager technical report of their solution in “.pdf” format;
- Other necessary information.

4.2 *Preparations*

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

4.3 *Presentation in front of the Jury*

At the beginning of the static event, the teams will present and defend their concepts in front of a jury with the help of their presentation. 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 subsection 6.2.

4.4 *Technical challenge*

The vehicle will be placed at the starting point and its software will be started by the team members. At the start point, a semaphore with the red colour on will be placed. After the team runs the code, the jury will press the start button, which will change the colour of the semaphore to Green. The vehicle shall automatically start the run 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 to gain more points, within the limit of 7 minutes. The team shall inform the organizers of the optional challenges selected prior the race. The grading for this challenge is described in subsection 6.3. If the random starting point is chosen, then the starting semaphore will also be placed in the car. One attempt may be cancelled by the team representative within 60 seconds from the start of the technical challenge without any penalty, restarting from the initial grid position. The limit of 7 minutes will not be restarted.



4.5 ***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 (provided during the testing days) as fast as possible, ignoring the traffic conditions (semaphores, traffic signs, etc.) Each team will have a maximum of 3 minutes on the track to finish the scenario. A timer will start in the exact moment that the car starts running, if the car has not completed the scenario in 3 minutes, 0 points will be graded. More details on the grading for this challenge is described in subsection 6.4.

4.6 ***Open discussion***

At the end of the team performance, an open discussion with the jury will be initiated. Jury members will ask questions and clarifications regarding the presentation, concept, approach and runs. The maximum time for the discussion is 5 minutes.

5 The track

The track is designed to replicate a miniature smart city, and to do so a series of V2X (Vehicle-to-everything) systems is provided by the organizers at the location, together with the respective APIs for communicating with them.

In term of road markings, it has straight sections, curves, intersections, perpendicular and parallel parking spots, one lane road, two lane roads, highways, a roundabout, one-way roads, and more.

The vehicle must consider real driving scenarios, such as driving on the right side, avoiding collisions at all costs and obeying traffic rules. The obstacles encountered on the track are traffic lights, traffic signs, static cars, moving cars, pedestrians, decorative elements, road barriers, and a ramp.

A more detailed description of the track, the placement of the known obstacles on the road and specific information of the environmental systems will be given with the official documentation after the challenge is started.

5.1 *Environmental systems*

5.1.1 **Localization system**

A “GPS like” localization system will be installed to provide geo-spatial positioning on the track, and it allows each model vehicle to determine its location. The positioning will be provided with a frequency of 5 Hz and an accuracy of 20 cm radius. The localizations system will also have small uncovered areas, where signal will not be available, so to simulate real-life conditions.

5.1.2 **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 1 Hz.

5.1.3 **Vehicle-to-vehicle communication**

The moving vehicles (driven by the organizers) present on the track will stream their own position on the map to the participant vehicles. The frequency of the sent packages is 5 Hz, the accuracy is of 20 cm.

5.1.4 **Environmental server**

Each participant car will send information to the in-house environmental server. The information will be composed of the type of obstacle encountered and its location.

5.2 *Road markings*

5.2.1 Lane markings and dimensions

A dashed or continuous central line may separate the lanes. 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, if not specified differently. On the highway, the directions of travel are separated by a series of Jersey barriers.

5.2.2 Parking spots

The parallel parking spots measure 700 mm in length and 300 mm in width. The perpendicular parking spots measure 400 mm in length and 500 mm in width. All the parking's are placed next to the right lane and the corresponding traffic sign signal them.

5.2.3 Roundabout

It is a one-lane roundabout with the inner diameter of 880mm and the outer diameter of 1280mm. The corresponding traffic sign signal the roundabout.

5.3 *Track obstacles and reactions*

5.3.1 Pedestrian and crosswalk

If a pedestrian is present on the right side of the road, simulating the will to cross the road, the car must completely stop until it crosses.

If a pedestrian is in the middle of the road, even though there is no crosswalk, the car must completely stop until it leaves.

5.3.2 Car on road

If a car is encountered on the road, an overtake manoeuvre shall be initiated if the road signalling allows it, while tailing should be done otherwise. The car can differ in colour from the given one.

5.3.3 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.

5.3.4 Traffic lights

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

5.3.5 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 in the car's own lane, the vehicle must stop for at least 3 seconds.

If a crosswalk sign is in the car's own lane, the vehicle must visibly slow while in its proximity.

If the car is on the Highway, the vehicle must visibly increase its speed.

5.3.6 Road closed stand

A stand with the road under construction signalling will be placed randomly on one of the lanes of a one-way and two-lane road. The car should swap the lanes based on the position of the stand and keep it. After the car swapped the lane, when reaching the intersection, it must turn to the direction of the lane (If the car is on the left lane, turn left, otherwise turn right).

5.3.7 Light disturbance

The track will have areas with high light disturbance, meaning shaded areas and direct sunlight on the track. Dimming the interference at the location will be attempted, but the solution must be implemented by the students themselves.

6 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:

EVALUATION DURING THE DEVELOPMENT STAGE

Activity tracking – Project statuses **Max. 15 Points**

THE RUN

Technical challenge **Max. 62 Points**

Speed challenge **Max. 15 Points**

The JURY

Overall concept presentation in front of the competition jury **Max. 10 Points**

Overall running evaluation from jury **Max. 10 Points**

6.1 Evaluation during the development stage

For the monthly evaluation, meaning the report, the multimedia, and the project plan, each will be given a different grade on a scale from one (1) to five (5). After the last project status, an average will be calculated, and the points will be given accordingly to each team.

6.2 Presentation in front of the jury

Each team is awarded an individual grade for the key aspects 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 handling, etc.

6.3 Technical challenge - cumulative pointing system

To gain the points, clear consideration of the obstacles must be visible (Example: Initiation of the necessary procedure in negotiating the roundabout). Failure in doing so on the mandatory ones excludes the possibility of the team to cumulate more point from the optional ones (Example: No reaction at all at the pedestrian on crosswalk but stops at the pedestrian on un-signalled road → no points granted for the pedestrian on un-signalled road).

Failure in doing so on the optional ones, results in +0 points (will not cumulate to the already existing points).

If the necessary procedure was initiated but the scenario was not fully respected, the total scoring will be considered, subtracting the penalties.

Scoring			
Obstacle description	Mandatory	Optional	Points
Bring the car to a complete stop until the pedestrian leaves the signalled crosswalk	X		6
Overtake static car on road if the line signalling allows	X		6
Do a parallel or perpendicular parking manoeuvre on an empty parking spot	X		4
Act accordingly in the traffic lights intersection	X		4
Pass the ramp	X		2
Passing through Roundabout	X		4
Bring the car to a complete stop until the pedestrian leaves the road (Random position – not on crosswalk)		X	4
Overtaking manoeuvre on highway of moving car		X	6
One way & two-lane road – Recalculating the path based on the “road closed stand” positioning left/right lane (Random)		X	6
One way & one-lane road – tailing the leading vehicle		X	4
Random start positioning on the map by the Jury		X	12
Reach the Finish line		X	4
Total possible points			62 (out of which 26 mandatory)

Penalties		
Penalty description	Maximum number of penalties	Penalty value
Collision – car, pedestrian, human interaction (manual reposition of the car on the track)	4	4
Failure lane keeping/crossing road markings	6	1
Failure in traffic sign/traffic light action taking	4	2
Streaming the position of encountered obstacles	6	1

Pointing example:

- 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:
 - +6 points for the initiated scenario
 - -4 points for collision

6.4 *Speed challenge*

The goal is to finish the scenario in the shortest time (The scenario will consist in a sum of checkpoints that the car must reach). In 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).

Penalties		
Penalty description	Maximum number of penalties	Penalty value
Human interaction (manual reposition of the car on the track)	4	15%
Failure lane keeping/crossing road markings	6	5%

The team with the shortest time (including penalties) will receive 15 points, while the one with the lowest time (yet not exceeding 3 minutes without penalties for the run) will receive 3 points. The teams in the middle will be scaled with the following formula.

$$P_i = \frac{(T_{max} - T_i) * 12}{(T_{max} - T_{min})} + 3$$

Pointing example:

- 1st place has the lap time of 78 seconds after penalties and has 15 points.
- Last place has lap time of 180 seconds after penalties and has 3 points.
- Another team has the lap time of 141 seconds after penalties, which makes the team get points 7.58.

$$7.58 = \frac{(180 - 141) * 12}{(180 - 78)} + 3$$



7 Prizes

7.1 *Winners*

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

7.2 *Newcomers*

One new team 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**.

7.3 *Audience award*

A voting campaign will start one month before the competition itself. The teams will have the possibility to share the team page (from the website) and try to have the most likes. The winning teams will get a surprise prize.

7.4 *Finalists*

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

8 Additional regulations

Some limitations will be applied both to the team actions and to the vehicle characteristics, to ensure a smooth development of the competition, fairness, and the safety of all the participants.

8.1 *Modification of the team structure*

Once the team is accepted in the competition, the team structure can be modified under the following circumstances:

- Any members can be excluded from the team, as long as the minimum components are met (1 member and 1 team leader);
- One member can be added to the team, as long as the maximum components are met (4 members and 1 team leader);

The modifications 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 of 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.

8.2 *Modification of the vehicle*

Any team that receives a model vehicle can modify it (e.g. by installing additional sensors or boards). The modifications will be accepted at the final event only if a member requests the modification on the forum and it is been accepted by the organizers.

8.3 *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.

8.4 *Safety regulations*

During the competition, safety instructions issued by the committee members are to be followed (a training will be done at the Bosch location). Ignorance of notes or guidelines can be sanctioned by excluding the respective team from the competition. Each individual shall take care at all times that neither participants are injured nor are other vehicles

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 competition itself. Violations of these regulations lead to the immediate exclusion from the competition.

8.5 *Data transmission*

No data or signals must be transferred between the vehicle and the outside world during the runs themselves, exception being the signals necessary for the environmental systems of the challenge (described in the section 5.1). If additional communications are discovered, the team will be eliminated from the competition.

8.6 *Software availability*

The participating teams will make the software available, upon request, to the organizing team. The organizing team grants the fact that all information exchanged with the participant teams remains confidential. The code will not be made available/visible to any other participants or used in any business-related purpose. There will be no additional scoring or penalties based on the software quality.

8.7 *Additional work*

Robert Bosch and our partners, IEEE-ITSS, encourage the participants to develop or participate in any academic, personal, corporate or contest activities. For any activity that involves the competition name, theme, hardware or software, the participants shall inform the organizing team about the activity and share additional information if required (competition name, thesis name and coordinator, project name, etc.). If additional help is needed in terms of development, components or expertise, the organizing team can be contacted via the given channels described in the section 1.

8.8 *Limitations during the challenge*

The same model vehicle, provided by Bosch, must be used for all the challenge 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.

8.9 *Platforms naming*

If pages are created (such as GitHub accounts or projects, social media pages, websites, etc.) that refer to the BFMC and involve the Bosch name (or partners) brand, the entire competition name will have to be used (BFMC / Bosch Future Mobility Challenge) together with link/s or references to the competition itself.

8.10 *Conduct*

During the entire competition, a healthy behaviour for all the participants is required. Any behaviour that may damage in any way the competitors, the involved associates or the brand of the involved companies will be penalised, without a warning, with the elimination of the team from the competition.