Bosch Future Mobility Challenge 2023
Competition Regulations

Partner
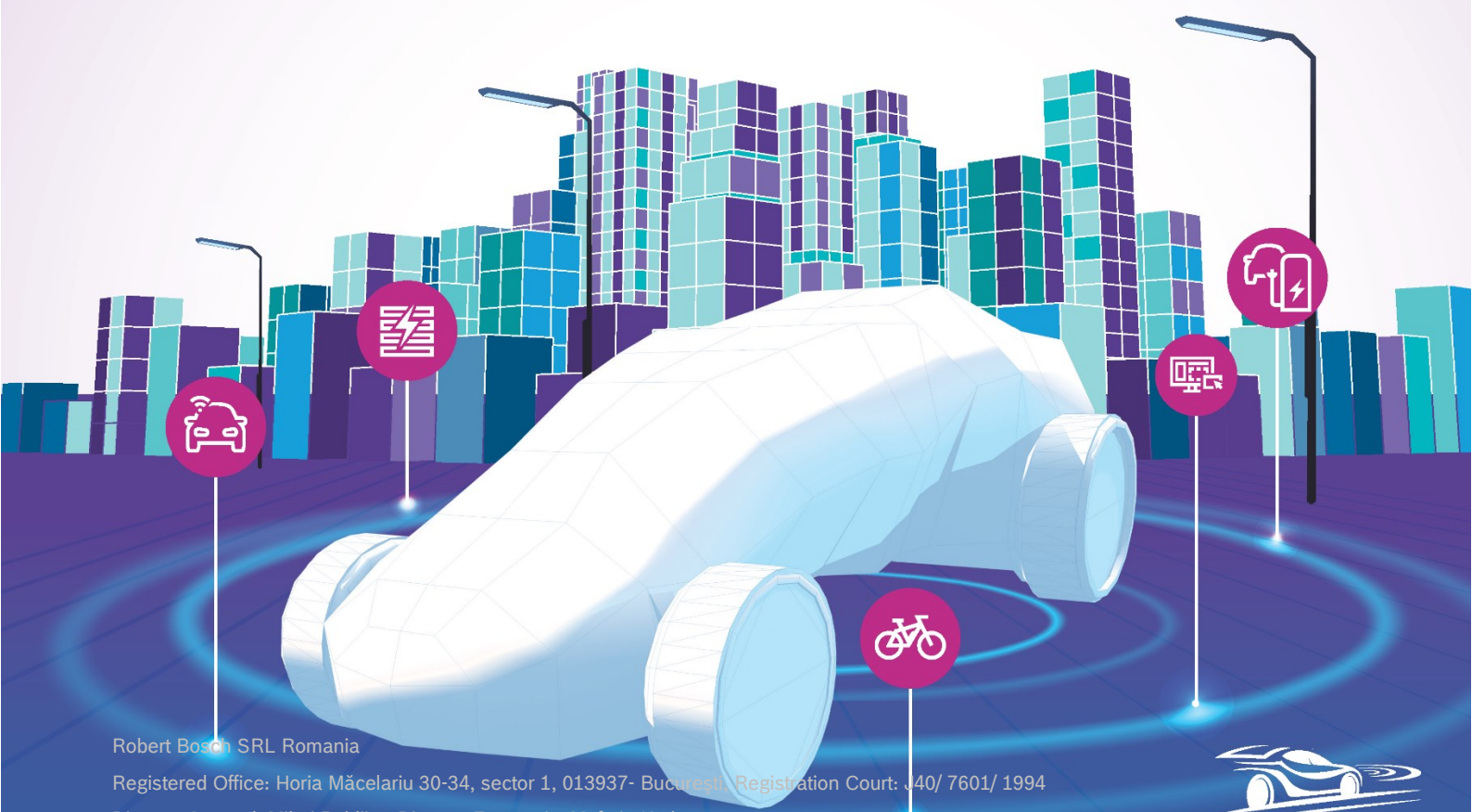
1 Overview

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 **Competition Forum (available only after the acceptance of the team),** for obtaining information regarding the challenge. The **Forum** will be the main communication channel with the organizers during the challenge. In case of questions about the application & selection process or other 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 GitHub page: https://github.com/ECC-BFMC.

2 Registration & selection

Team registration form will be **submitted by the leader of the team** through the registration form available on the page of the competition. Each **team leader** must create an account on the website and register the team by filling in all the required data via the registration form.

Only the leader of the team must create an account in this period. The account creation of the team leader and the registration form will be available solely during the **period of registration**.

The accounts for the members of the team will be created by the leader once the team is selected as part of the current year competition. All the accounts will be deleted once the preparation for the next event will start.

2.1 *Period of Registration*

Registration for the competition will be possible from 1st October 2022 until the 31st of October 2022, Romania time.

2.2 *Team structure*

Every team must be composed of:
- One **team leader**: high school, Bachelor or Master student,
- 2-4 **team member/s**: high school, Bachelor or Master student,
- One **mentor**: teaching or researcher, 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, depending on the case.

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,
- 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 must have the same name as in the previous edition,
- The team mentor must be the same person as in the previous edition,
- The team must have at least one member from the previous edition,

For exceptional cases (such as different mentor, different name, etc.), 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 is eligible for the wild card or not.

2.5 *Acceptance*

After conducting all the interviews, the teams will be contacted about the result (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.

2.6 *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 exact time plan of the competition will be presented together with the provided platforms and how 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 The development interval

3.1 *What's provided*

3.1.1 Car kit and start-up code

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

The kit comes with the following software:

- Low-level code for the control unit board, that eases the process of getting started: includes firmware for steering and speed control, PID usage for speed and readings from the encoder,
- Code for the brain unit board that has examples of pipe-ing, multi-processing and multi-threading. It interacts with a PC for remote controlling the car.

3.1.2 Other software

- APIs for the interaction with the environmental systems found at our locations and simulated servers that can be used at home to check the functionality,
- A ready to work Gazebo simulator, replica of the entire competition environment,
- ROS start-up example,
- Start-up code in C.

3.1.3 Courses and general documentation

A series of courses will be held by Bosch specialists in the domain, that will be open to attend to all the participants. The courses will be held on teams:

- Provided code explanation,
- Project management,
- Computer vision,
- Sensor data,
- Parallel computing,
- Vehicle control methods,
- Rapid prototyping and reliability,
- State-flow and prioritizations.

A general documentation is available, related on how to get started on different topics, such as Linux, python, OpenCV, ROS, and Hardware optimization.

3.2 *First steps*

Participating teams agree to prepare a small description and signature picture of the team itself for media promotion.

3.3 *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. The scoring for this phase is described in the **subsection 7.1**.

The exact timeframe period for submitting each project status will be communicated with the competition timeline.

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 SW 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 and it shall allow the inclusion of non-planned activities (it can be updated at any point during the development). The teams can include other schematics that can help to better understand the project and the logic, such as 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 parking traffic sign recognition and the parking manoeuvre is testified as being at 100%. On the time plan, the traffic sign recognition and the parking manoeuvre has a deadline for the next week. On the video, evident display of the recognition and parking is present.*

3.4 *Qualifications*

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 (in one single autonomous run.):
• Lane keeping,
• Intersection crossing,
• Prove complete maneuverer after the following traffic signs: Stop, crosswalk, priority, parking.

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 provided video as visual 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.

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 24 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.

3.5 *Competing teams*

The organizers will ask from teams that pass the qualifications round a promotion video of the team with a specific content and template. The videos will be published on the competition website.

4 The competition days

4.1 *Preparation*

One month prior the event, Bosch organizers will ask for a series of information regarding organizational aspects. During this period the teams must prepare their flights, visas (if needed) and other documents. The accommodation and meals during the test days, semi-finals, and finals will be ensured by the organizers, while the transportation will be covered by the teams themselves. The teams must prepare their stay from 9th to 15th of May.

4.2 *Get to know each-other*

On 10th of May 2023 a meeting that will mark the start of the event will take place, where the schedule and other aspects will be presented to the teams. Other networking activities will be included.

4.3 *Testing*

On 10th, 11th, and 12th of May 2023, 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.

4.4 *Semi-finals*

The semi-finals will take place on 13th of May 2023, and it will follow the same run logic (Section 5) 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 deliver an appropriate working prototype. All the teams that don't reach the finals will have to return the provided model vehicle at the end of the day.

4.5 *Finals*

The final event will take place on 14th of May 2023 (the run logic is explained in Section 5).

5 The run

5.1 *Prior to the run*

The teams will send to the organizers via the communicated channel, within the communicated timeline, prior to each run (Semi-Finals 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.

The teams must come prepared in front of the Jury with two running scripts: one for the technical challenge and another for the speed challenge.

5.2 *Preparations*

Each team must be present at its stand at the time communicated priorly by the organizers. The order will be announced by the organizers, and it will be fully random.

5.3 *Presentation in front of the Jury*

As the first activity of the team on the stage, it will present and defend its car concept in front of a jury with the help of their presentation (no more than 5 minutes). The presentation should contain information regarding the car concept (hardware and software) and the strong points of their project. The concept will be evaluated by the judges, whom are experts from the industry and from academia. The maximum achievable number of points is described in subsection 7.2.

5.4 *Technical challenge*

The vehicle will be placed at the starting point and its software will be started by the team members (the script must be prepared in advance, the only action on the stand being to "press enter", after which point the team must not interact with the computer anymore and it can use the screen for displaying purposes (to the Jury or to the members themselves). At the starting point, a semaphore with the red colour on will be present, the jury will press the start button, which will change the colour of the semaphore to Green. The vehicle shall automatically detect the starting of the run and pass within their own 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 10 minutes. The grading for this challenge is described in subsection 7.3. The team shall inform the organizers of the optional challenges selected prior the race. If the random starting point is chosen, then the starting semaphore will also be placed in the cars own field of view.

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 10 minutes will not be restarted.

5.5 *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.). A timer will start in the exact moment that the car starts running and no other traffic participants will be encountered (cars or pedestrians). More details on the grading for this challenge is described in subsection 6.4.

6 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.

6.1 *Environmental systems*

6.1.1 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 10 Hz, an error in position of maximum 20 cm radius and a delay of maximum 1 second. The localization system can have uncovered areas, where signal will not be available, so to simulate real-life conditions.

6.1.2 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.

6.1.3 Vehicle-to-vehicle communication

The moving vehicles (driven by the organizers) present on the track will stream its own position on the map to the participant vehicles. The technical details of the communication are the same as the ones of the localization system.

6.1.4 Live traffic system

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

6.2 *Road markings*

6.2.1 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.

6.2.2 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.

6.2.3 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.

6.2.4 Other markings

Other markings can be observed on the map itself, which will be given to the participants in the documentation.

6.3 *Track obstacles and reactions*

6.3.1 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.

6.3.2 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.

6.3.3 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.

6.3.4 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.

6.3.5 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.

If a priority sign is in the car's own lane, the vehicle must not stop at all in the intersection.

6.3.6 Road closed stand

A stand with the road under construction. 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).

6.3.7 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.

7 Scoring

The members of the jury will be announced on the web page of the challenge.
The maximum number of points per event is distributed as follows:

DEVELOPMENT PERIOD (Activity tracking)
Activity tracking − Project statuses   Max. **15 Points**

THE RUN
Technical challenge   Max. **65 Points**
Speed challenge   **15 Points**

The JURY
Car concept   Max. **15 Points**
Running evaluation   Max. **20 Points**

7.1 *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.

7.2 *Technical challenge - cumulative pointing system*

Teach team is free to choose the obstacles it wants to pass from the table below and will be graded accordingly and to get the points, clear consideration of the obstacle description must be proven.

Failure in reaching and showing reaction to any of the mandatory obstacles halves the points gathered on the completed optional obstacles

Example:
The team successfully starts at the random starting point but doesn't consider the roundabout at all → +0 points for roundabout, +6 points for random starting point.

If the necessary procedure was initiated but a fault of the car was observer, the total scoring of the scenario will be considered, subtracting the penalties.

Scoring			
Obstacle description	Mandatory	Optional	Points
Start with the green traffic light	X		3
Bring the car to a **complete stop** at the **pedestrian** signalling **the will to cross the road on the crosswalk** and wait until it crosses	X		4
Overtake static car on road if the line signalling allows (Random position).	X		5
Do a parallel or perpendicular **parking manoeuvre** on an **empty parking** spot (Random position).	X		6
Act accordingly in the **traffic lights intersection**	X		4
Pass the **ramp**	X		4
Pass through **correctly through the Roundabout**	X		4
Bring the car to a **complete stop** at the **pedestrian** staying in the middle of the lane (Random position)		X	6
Overtaking manoeuvre on highway of **moving car**		X	5
Road closed stand on the **One way & two-lane road:** recalculating the path based on the lane where the road closed stand is located (Random position)		X	6
One way & one-lane road − tailing the **leading vehicle**		X	5
Random start positioning on the map by the Jury (anywhere on the map withing the road marking and outside a state, such as a parking, roundabout, or an intersection)		X	10
Reach the Finish line		X	3
Total possible points			65 (out of which 30 mandatory)

Penalties		
Penalty description	Maximum number of penalties	Penalty value
Collision − car, pedestrian, human interaction (manual reposition of the car on the track)	No limit	3
Failure in **traffic sign action taking**	No limit	2
Streaming the position of encountered obstacles	6	1

Pointing example:
- The car is initiating the <u>overtake static car on road if the line signalling allows</u> but it crashes into the car on the lane comeback:
  - +6 points for the initiated scenario
  - -4 points for collision

7.3 *Speed challenge*

The goal is to finish the scenario under 3 minutes. The scenario will consist in a sum of checkpoints that the car must reach without respecting the traffic signs or traffic signs, while obstacles will not be present on the map. Errors will be summed for faults on the track based on the table below. If the error gets bigger than 4 points, the team will get 0 points on the speed run. If the team does not attempt the speed run, it will also get 0 points.

Penalty description	Penalty value
Human interaction (manual reposition of the car on the track)	1
Failure **lane keeping/crossing road markings**	0.2

7.4 *The jury*

7.4.1 Car concept

With the help of the presentation, the teams will present the key points of their development on the car. Here the Jury will evaluate both the complexity and the simplicity of the concept the hardware features, software components, ideas, and, of course, the HW-performance ratio etc.

7.4.2 Run evaluation

By observing the car actions and reactions, the jury will evaluate its overall performance, such as smoothness of the movements, the performance of the lane keeping and its features, general confidence in car, etc

8 Prizes

8.1 *Winners*

The winner of the first three places will be rewarded with an amount of **7000 Euro**, **5000 Euro**, and **3000 Euro** for 1st place, 2nd place, and 3rd place, respectively.

8.2 *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**.

8.3 *Marketing award*

Each team can create its own Facebook or Instagram page and promote itself during the entire competition. Posts about the following topics will have to be present on the page:
- Presentation of the team (members + mentor)
- Blooper's challenge (funny side of the experience)
- During development
- Announcements (going to semi-finals, finals, etc.)
- On-site experience
The evaluation criteria for this award will be shared later in the competition.

8.4 *Audience award*

A separate page for each team will be created on the competition website, containing some details about it. A voting campaign on the competition website will be open from 1st of May until 14th of May (before the first team enters the track); The teams can share their own page and try to get most likes.

8.5 *Finalists*

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

9 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.

9.1 *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.

9.2 *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 has been accepted by the organizers.

9.3 *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.

9.4 *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. Everyone shall always take care 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 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.

9.5 *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 subsection 6.1). If additional communications are discovered, the team will be eliminated from the competition.

9.6 *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.

9.7 *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.

9.8 *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.

9.9 *Platform's 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.

9.10 *Conduct*

During the entire competition, a sportsmanship 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 current competition and, if considered, for the next ones.