The Formula Student is the most prestigious engineering competition in the world. It is a competition where engineering students from all over the world design and build a Formula 1 car, and then take part in various events. There are currently two categories in the competition: Combustion and Electric. In both categories we have the option to compete in the Driverless Cup modality.

The competition is divided into static tests (Cost Report, Business Plan, Design Event) and dynamic ones (Acceleration, Skidpad, Autocross, Endurance, Trackdrive, Efficiency). The team with the highest score wins.

The Formula Student was born in 1981 increasing its popularity year after year. This increase is perfectly visible in our country, where more than 20 teams from Spain are currently participating. Specifically, in Catalonia there are 7 teams, the vast majority of which come from the Universitat Politècnica de Catalunya.
A group of 13 ETSEIB students created one of the first Formula Student teams in Spain, ETSEIB Motorsport. Later, other universities saw the benefits of this project and the number of teams grew. However, our team has always been the pioneer of this project moving to the electric category in 2011, when the team opted for the future: electric vehicles.

In 2018, we created Driverless UPC, the first team in Spain to make a Formula Student car in the driverless category. In addition, the electric car presented a great innovation: the technology of Torque Vectoring thanks to the incorporation of 4 motors.

In 2020 there was a very important change in the history of the team, the ETSEIB Motorsport and Driverless UPC teams joined forces to create the BCN eMotorsport team.

In this way, our goal is to build a single electric vehicle that is able to operate in a piloted and autonomous way, thus being able to compete in both modes in the summer of 2022 with only one car, the CAT14e. On the other hand, the CAT15e will be designed, taking advantage of the experience gained with its predecessor and improving it.
ETSEIB Motorsport was born in 2007 when 13 brave people decided to enter the world of Formula Student by designing and building the first car of the team that they named CAT01, which was combustion. The project managed to stay afloat and gradually consolidated. The combustion stage came to an end in 2011 with CAT04.

That same year, the team decided to bet on the future by creating the first electric car, the CAT05e. Subsequently, and after years of persistence, the CAT10e achieved its best results in competitions. Also in 2018, they incorporated a wheeled motor in the CAT11E.

At the same time, in 2018, ETSETB students founded the Driverless UPC team and manufactured the first electric and autonomous car in all of Spain.

After the Driverless UPC team and ETSEIB Motorsport were separated for two years, in 2020 the two teams joined forces to form BCN eMotorsport. This will mean that in the summer of 2022 they will compete with a single car, the CAT14E, which will compete in the electric and driverless mode.
Although there were no competitions in 2020, the Formula Student world ranking was updated. The team has climbed positions thanks to the legacy of previous seasons and the fact that we have qualified in all the competitions in which we did the quiz. In addition, we still retain the title of best electrical equipment in Spain.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Team Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>29</td>
<td>BCN eMOTORSPORT</td>
</tr>
<tr>
<td>36</td>
<td>FORMULA STUDENT BIZKAIA</td>
</tr>
<tr>
<td>52</td>
<td>ECORACING</td>
</tr>
<tr>
<td>90</td>
<td>UPM RACING</td>
</tr>
<tr>
<td>100</td>
<td>ANDALUCIA RACING TEAM</td>
</tr>
<tr>
<td>102</td>
<td>E-TECH RACING</td>
</tr>
<tr>
<td>104</td>
<td>TECNUN RACING</td>
</tr>
</tbody>
</table>

BCN eMotorsport
In the summer 2021 competitions, our electric vehicle, the CAT13e, competed in FS Netherlands, FS Austria, FS Spain and FS Germany. Being able to access these competitions meant a lot to all of us as they are the most prestigious competitions in Europe and, in the case of Germany, we managed to qualify unless we had 35 places for more than 150 teams.

The CAT13e, the electric car, was designed to exploit the concept of the four motors. For the first time in history, the team participated in four different competitions. In these good results were achieved, highlighting FS Spain, where he achieved 2nd place in Acceleration, 1st place in SkidPad, and a 2nd place in Autocross. At European level, we competed against the best teams, BCN eMotorsport set the 7th fastest time in SkidPad and the best 7th time in AutoCross.

With regard to the CAT13d, the autonomous car, this season focused on improving speed and performance on the track, going from 3m / s achieved in the previous season to an average speed of 10 m / s and 14 m / s of maximum speed in the most complicated track of a competition of FS driverless, FS Spain 2019. Regarding the competitions, it is necessary to stand out the 2nd position in the Overall of FS Czech and the recognition of the 4th best design of a Driverless car of Europe, achieved in the Design test of FS Germany.
The CAT14e is the team’s first fusion car and has been designed with the aim of presenting high reliability at both the piloted and autonomous levels to achieve better results in competitions. It is intended to implement all the improvements achieved in the previous season, such as the four engines or the autonomous system that allows you to reach high speeds in unmanned mode. It has an improved and more worked traction system, incorporating a more efficient Torque Vectoring algorithm, and can be used in both modes of the vehicle. In addition, it incorporates regenerative braking that leads to a reduction in weight in the batteries and in the whole of the car.
The new aerodynamic package remains in the upward line of recent seasons, adapted to the new chassis and low-profile tires but maintaining the same design philosophy. The CA-T14e, like its predecessor, will carry cooling to the rear of the car.

This year we have decided to create an aerodynamic package that will serve as a basis for future cars and have a stock of parts that will save resources in the future. A new design of the front wing has been made optimizing the work surface at the ends and its flow channeling, as well as adapted to bring the LIDAR to the center. The main flap on the rear wing has also been redesigned to improve its efficiency in conjunction with the endplates that have been optimized to reduce the drag induced by the vortices in the rear of the car.

Finally, the aerodynamics department has made a significant advance in knowledge regarding the CFD of the vehicle, exploring new analysis conditions that allow to obtain data on the aerodynamic balance. Efforts will also be focused on the validation of the aerodynamic package on the track and using simulation tools with wind tunnel data.
The new geometry of the monocoque adapts to the incorporations of autonomous system, as well as to the new distribution of the front suspension for a greater performance in track. In turn, the front of the chassis has been sized to include the fiber impact attenuator made by the team members.

On the other hand, the combination of monolithic inserts and 3D printing ensures the balance between lightness and rigidity of the set.

Finally, a new, even lighter fiber seat is molded to the monocoque allowing the installation of the vehicle’s new processing unit.

The main design challenge the department has faced has been adapting the car in the new regulations. As for the autonomous braking system, the ASB, a pneumatic system with a capacity to decelerate to 1.2 g has been chosen. The address autonomous, on the other hand, uses an electric motor to act on the zipper through a ball screw.

The main novelty of the suspension is the introduction of a stabilizer bar front, which will allow a greater ability to control the behavior of the vehicle. That will be especially useful in the face of the inevitable weight gain resulting from incorporation of autonomous systems. Finally, the wheel assembly will have a manufactured sleeve by 3D printing of metals, significantly reducing the unsuspended mass of the car.
This year, thanks to the introduction of a wheeled motor, the cooling of the vehicle has been extended, which, despite being sized for this application, has been tested with satisfactory results. Also, thanks to the introduction of these four engines, it has been possible to increase the amount of energy recovered during braking, which gives the driver more freedom in his use of power, also enhanced by the introduction of a new battery charge status estimator, which provides more accurate information on the dynamic state of the vehicle.

The function of the electronic section is to design, manufacture and validate both the low-voltage wiring of the car and all ECUs that receive information about its status and its environment, and act on the car based on it. It is also the section responsible for developing a telemetry system that allows information on the status of the car remotely and in real time.

Each year, the aim is to redesign those ECUs that are believed to need to be improved or to adapt to the new changes in the car each season, and to redo the wiring in search of optimization and robustness in the face of electromagnetic incompatibilities.

The goal for the new season is to merge the electronics of the two autonomous and pilot parts with new and improved ECUs, and ensure the reliability of their operation. On the other hand, this is the first time that the team will implement its own Processing Unit, designed by our section, looking for a higher power to be able to control the autonomous part of the vehicle.
VEHICLE CONTROLS

The control department has redesigned the concept of power and traction control to enhance the effect of Torque Vectoring, allowing it to define the ideal working regime of the vehicle and limiting traction only in critical situations where we predict loss of grip or exceeding the power limit given by the regulations, allowing the most critical drivers of the vehicle to work in harmony.

In terms of inverter control, thanks to the implementation of our own test bench, we are able to increase the power of the battery while maintaining the stability of the control, allowing maximum speeds higher than previous seasons.

Another point of improvement by control is related to the estimation of the state of the vehicle, defining algorithms to maintain a correct reading of the speed both longitudinally and laterally at multiple points of the vehicle. With regard to autonomous system control, with the new implementation of the algorithm dedicated to the detection of the limits of the track, it is possible to estimate longer and more reliable limits that provide a better basis for the entire autonomous control pipeline.

Last but not least, the team continues with the great improvements in the autonomous system controller, implementing a new concept of Model Predictive Control for curvature, able to more efficiently follow the trajectory given by the Planner and the global Race Optimization, the latter being an improved version over the previous season. All this will be able to be tested more efficiently by developing its own simulation aimed at and suitable for CAT14e.
In the perception section, we aim to obtain all the necessary data from the track, that is, to locate each cone (color and position). To carry out this task, our car has optical sensors, such as cameras and a LiDAR.

So, we deal with the data obtained, which in our case are images and a cloud of dots, to extract all possible information. This is an iterative process, and must be done in the shortest possible time, as we want the frequency of information capture to be as high as possible so that our car has time to act accordingly (accelerate / brake and turn).
In recent months, there have been several reports on ETSEIB Motorsport and Driverless UPC. These include those made by Mundo Deportivo, TV3 and Full d’Enginyeria.

Diari Sport published an article coinciding with the roll-out of May 2021. It states that the two cars of the CAT13e and CAT13d team would be presented in the competitions of the summer 2021 (FS Austria, FS Netherlands, FS Czech Republic, FS Spain and FS Germany). It also highlights the importance of remaining the best Spanish electric team for another year.

TV3 made a brief report on the autonomous car during a day of testing at the Circuit de Catalunya. It shows the operation of the autonomous car, as well as the radar images detected by the cones. It stands out for being the only team in Spain to compete in the driverless category.
Fulls d’Enginyeria wrote an article and an interview on the official website about how COVID-19 affects Formula Student. The interview answers questions about how the team is adapting to the situation, how the team is being restructured and how it is coping with the new season.

In addition, we have previously appeared in many other articles among which we can highlight the following:
The following report shows the most relevant data from BCN eMotorsport’s social networks in February 2021.
WHAT DO WE OFFER?

- Direct contact with future engineers
- Awareness on the networks and on the team's website
- Association of the company to an image of innovation
- Appearance of the logo on the car
- Presence at events, exhibitions and forums
- Appearance in the media
Depending on the category to which the company belongs, the company logo appears on the vehicle, equipment, events and on our social networks, as can be seen in the table below.

**SPONSORSHIP**

<table>
<thead>
<tr>
<th>Sponsor Category</th>
<th>Vehicle</th>
<th>Clothes</th>
<th>Events</th>
<th>Web</th>
<th>Media</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PRINCIPAL</strong></td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td><strong>PREMIUM</strong></td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td><strong>PLATINUM</strong></td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td><strong>GOLD</strong></td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td><strong>SILVER</strong></td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td><strong>BRONZE</strong></td>
<td>✔️</td>
<td></td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td><strong>PARTNER</strong></td>
<td>✔️</td>
<td></td>
<td></td>
<td></td>
<td>✔️</td>
</tr>
</tbody>
</table>
POSITION OF THE COMPANY LOGO IN THE VEHICLE

The category of the company determines the approximate position of its logo on the monocoque of the vehicle, depending on the final design of the car.
On the shirts, polo shirts, sweatshirts and other possible pieces of clothing of the team, there is a classification for the indicative position of the sponsor’s logo, with possible changes depending on the final design of the equipment.
**DISSEMINATION OF THE BRAND ON THE WEB AND IN THE ROLL-UP OF CAT14E**

**Principal**
- BCN eMotorsport

**Premium**
- S GETA
- SEAT SA
- Aplus
- DIADA

**Platinum**
- BUSCH
- CSIC
- AVL
- LAS CIRCUITS

**Gold**
- ETAS
- IPG
- VECTRON
- velodyne Lidar

**Silver**
- CMl
- CAN
- arm KEIL
- BESPOKE

**Bronze**
- ASSOCI
- RILE
- CARAS
- CEMETAL

**Partner**
- HESSA
- Telenor
- URGAN
- MARINA
WHY US?

In all these places, the team wears the sponsors in the kits, roll-ups and in the car. In addition, during the year we attend different events such as the Expoelectric or the car show. In terms of internal contact, we offer a network of contacts between sponsoring companies and team members, both current and from previous years, offering CVs and sending all members proposed job offers. In addition, the team attends events organized by the companies both to explain the project and to get to know the company in depth.

In short, BCN eMotorsport is the best electrical equipment in the state, which offers greater international visibility and allows for the establishment of a wider network of company-student contacts, in order to facilitate possible additions to the sponsoring companies. This, combined with being the team with the most history and constant innovation, makes the team a safe bet.