ARISTURTLE

ARISTOTLE UNIVERSITY RACING TEAM
ELECTRIC & DRIVERLESS

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The Team

Aristotle University Racing Team Electric & Driverless, also known as **Aristurtle**, is a student research team from Aristotle University of Thessaloniki that designs, develops and manufactures **electric and driverless race cars**. The team belongs to the School of Electrical and Computer Engineering and is composed of **undergraduate students** from various fields, from Electrical Engineering, Mechanical Engineering to Physics and Economics. Working under the pressure of demanding deadlines, the members of the team are shouldered with duties that require full use of their **theoretical and practical skills** in order to be confronted successfully.

The faculty advisor, responsible for the representation of the team in the academic community, is **Mr. Minas Alexiadis**, Assistant professor of the School of Electrical and Computer Engineering at Aristotle University. Manufacturing of electric race cars is executed according to the rules and standards of **Formula Student**. This process is guided by three Electrical Systems Advisors, PhD graduates from the Electrical Machines Laboratory. The team is divided into eight subteams that work in different parts of the vehicle and cooperate according to their needs. The Chief Executive Officer is responsible for the coordination of all the subteams, in order to achieve a fully consolidated and perfectly functional result.

Goal

Aristurtle's goal is to design and manufacture excellent electric race cars and take part in international Formula Student competitions against academic institutions from all around the world.

Electra

Electra is the team's first race car and the beginning of a new era in Greek motorsport.

Iris

In mythology, Iris was the Gods' messenger. In our reality, Iris is the Aristurtle's third electric race cars.

Thetis DV

A new era in both Thetis' and the team's course began when it was transformed to an autonomous vehicle, the first in Greece.

Eve

It was the one who determined the standards for the future philosophy of the team's race cars.

Thetis

The awards and international podiums during the 2018-2019 season have established Thetis' place in history.

Nemesis

Designed with a pretty different approach in comparison to its predecessors, Nemesis built the foundation for a new mindset in Aristurtle's vehicles.

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ELECTRICAL

Autonomous
High Voltage
Low Voltage

MECHANICAL

Aerodynamics
Frame & Composites
Suspension

OPERATIONS

Finances
Promotion
Static Events

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HIGH VOLTAGE

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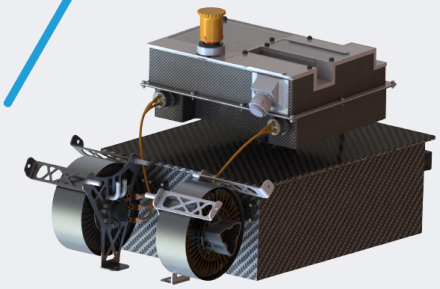
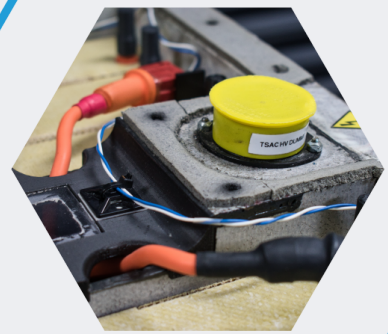
The High Voltage sub-team deals with the **high voltage systems** and more specifically with the electric powertrain systems of the vehicle. Our overall tractive system assembly contains the **accumulator container** which is responsible for storing all the energy that moves the vehicle, the **high power distribution unit** which is a casing where the current splits into the two inverters, and the **two motors** responsible for moving the vehicle actuating on the rear wheels.





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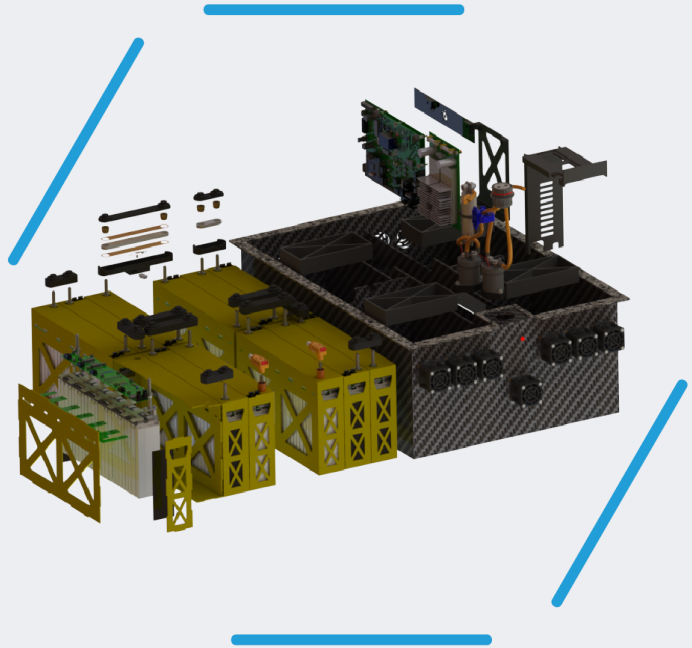
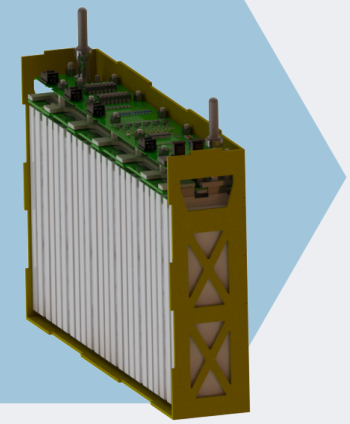
T.S.A.C.

The Tractive System Accumulator Container (TSAC) is one of the most vital components of an electric racing car, as it consists of all the cells, thus the energy source for the whole vehicle. The design of the TSAC is not a simple matter, as you have to take into consideration factors affecting safety and stability. Based on the restrictions imposed by the Formula Student rules, each team has to design and construct an Accumulator Container, properly designed and dimensioned for its racing car. A complex problem like this is approached from different angles and the High Voltage sub-team deals mainly with the electrical layout of the TSAC and its energy content. More specifically, some of the responsibilities of the sub-team are related to the study, thermal analysis and modeling of the electrical behavior of batteries, as well as their right configuration in order to determine the maximum voltage and the total energy of the TSAC, along with its internal layout, which will lead to easier cooling system, electrical connections and maintenance.



T.S.A.C.

According to the Formula Student rules, the batteries constituting the TSAC must be divided into segments for safety reasons. The challenge of designing and constructing the segments is undertaken by the members of the High Voltage sub-team. Some of the problems that must be addressed are the connections, the cooling and the Battery Management System – BMS. Due to the dangerous nature of the batteries and high voltage systems, it is necessary to follow safety standards and those involved in these systems must be properly trained and aware of the relevant safety rules.



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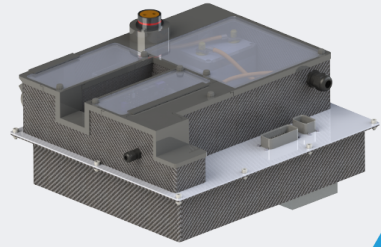
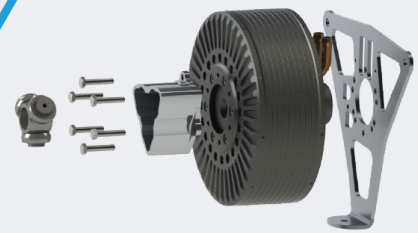
High Power Distribution Unit

In an electric racing car the connecting link for the power transfer between the TSAC and the motors is the inverters – motor controllers. The main role of the inverter is to convert the direct current of the batteries (DC) to alternating three-phase current (AC) of variable amplitude and frequency, to control the three-phase motor. Their placement inside the vehicle is crucial and the High Voltage sub-team is called to carry out the study and research for the construction that frames them. This unit also contains some of the vehicle's PCBs, as well as the area in which the power is distributed to the motors. The most common motor type in Formula Student is the Permanent Magnet Synchronous Motor – PMSM, mainly for their extremely high efficiency and power density. Our team uses two Permanent Magnet Synchronous Motors on the rear wheels and one inverter to control each motor.

The electrical connection of the powertrain system is implemented using specific High Voltage cables. The High Voltage sub-team is responsible for the thermal analysis and the power losses estimation on the high current path, aiming in a suitable dimensioned High Voltage Wiring Harness.



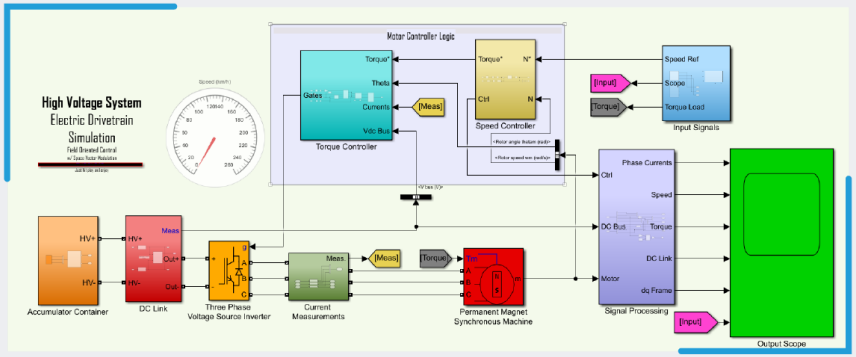


Regenerative Braking

A special feature of electric machines is their dual ability to operate either as motors or as generators. Their operation as a generator is described as regenerative braking in electromobility, due to the reduction of the vehicle's speed through the electric machine. In this way, part of the vehicle's kinetic energy is returned to the batteries as electric energy, thus increasing its autonomy. The High Voltage sub-team achieves this by implementing suitable models for inverter control based on the movement of the car and the safe charging of the batteries.

The High Voltage sub-team deals also with simulation models, like the modeling of the electric powertrain system. The purpose of this project is the data acquisition regarding the system's response during transitions and the prediction of the high voltage systems' behavior for given parameters.

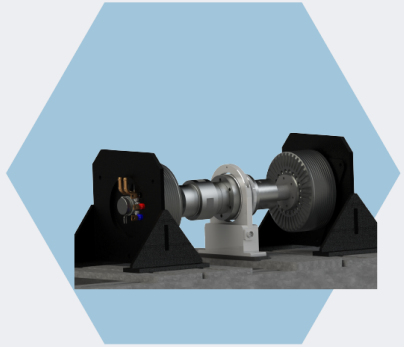
However, an accurate model of the entire High Voltage system, in order to meet reality, must be based on representative parameters for the batteries, inverters and motors which are used by the team. For this reason, special emphasis is given to the acquisition of parameters through specialized experiments on batteries and dynamometer of electric motors.

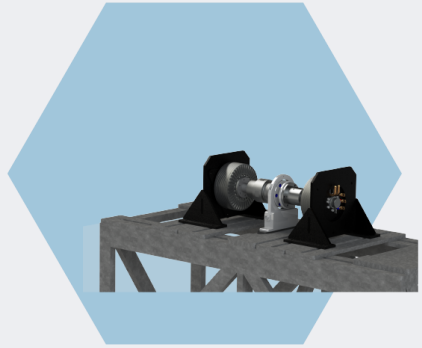


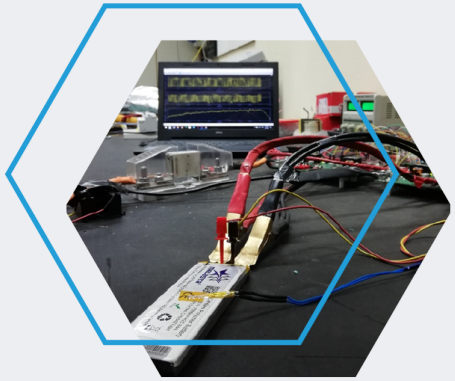
Dynamometer of Electric Motors & Batteries Experiments

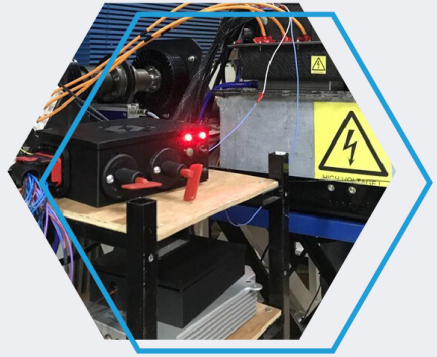
One of the main goals pertaining to the powertrain system is gaining a better understanding of our motors operation alongside the inverters, resulting in the increase of the vehicle's efficiency. Through the dynamometer configuration, the study of the correlation of the torque of the motors in relation to the RMS alternating current given by the inverters is implemented, as well as the extraction of the most appropriate settings of the inverter parameters. One more important part of information extracted by this experiment is the understanding of the total and individual high voltage system's losses.

Another goal of the High Voltage sub-team is the research on battery cells, aiming in the recovery of their electric characteristics and the design of a more efficient energy storage system. This is achieved through the conduction of charging and discharging experiments on cells and the extraction of an equivalent model of their electrical behavior.









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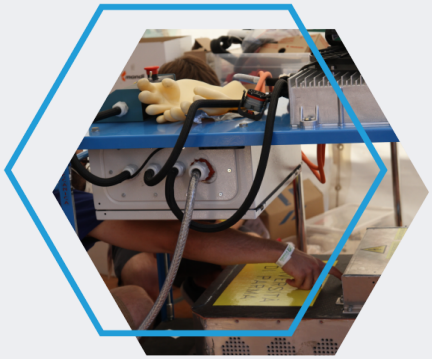
The role of the High Voltage System in an electric car is crucial to its performance and is directly involved with the rest of the sub-teams. For instance, it collaborates with the Suspension sub-team for the determination of the optimal control of the electric motors, with the Aerodynamics sub-team for the optimization of the high power components' cooling system, as well as with the Frame and Composite sub-team for the optimization of the vehicle's packaging. The members have to face challenges of finding ideas and smart solutions for designing, integrating or building systems that will follow the strict regulations of Formula Student, always in combination with weight minimization and total optimization of the car.



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Το μέλλον της ενέργειας

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Aristotle University of Thessaloniki

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