Becoming the first to complete Le Mans in a hybrid

Racing a hybrid prototype vehicle, faster and more efficiently than a modern Formula 1 car. That's the challenge for student race team Inmotion. The team aims to compete in the 24 Hours of Le Mans in a few years' time.

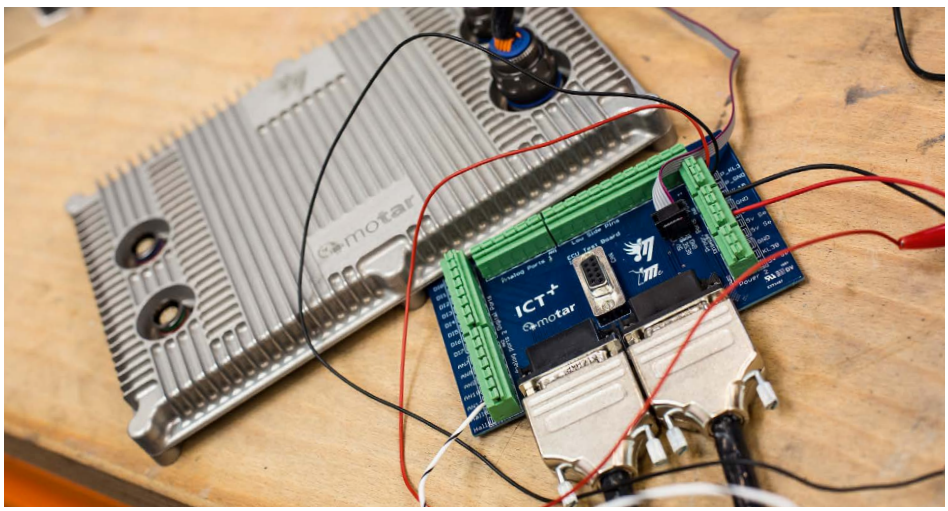
Nieke Roos

The 24 Hours of Le Mans is the most demanding race in the world, pushing both drivers and cars to the limit. It's all about endurance: which car can cover the most laps in twenty-four hours? To stand a chance, it's vital to spend the least possible time standing still. That means competing cars must be as reliable and energy-efficient as possible. There's a reason why Le Mans is often called the Grand Prix of Endurance and Efficiency.

Cars at Le Mans compete in different classes, including Garage 56. This is a special class for innovative cars, with just one spot on the grid every year. In a few years' time, the Inmotion student race team at Eindhoven University of Technology and Fontys Hogescholen plans to compete in the Garage 56 class with an entirely self-made hybrid race car: the IM01. With the IM01, Inmotion aims to be the first team to complete the full twenty-four-hour race in this category. And they'll do it with a car that is both quicker and more efficient than any Formula 1 car currently on the grid.

Limited number

The Inmotion team will build the IM01 using the experience acquired in developing a test vehicle: the KP&T IM/E. Developed in-house, this full-electric formula car will be used as a test platform for the IM01's systems and technologies. Both vehicles are controlled by a limited number of electronic control units containing advanced hardware and software. These ECUs are the brains of the car.



Research conducted by Inmotion has led to a proposed integrated automotive architecture using only five ECUs for the IM01: a single central vehicle state controller combined with four satellite controllers to which the sensors and actuators will be connected (figure 1). The main advantage of this setup is the ability to perform low-level control locally (in the satellite ECUs) and the entire high-level vehicle state control centrally (in the main ECU). This reduces the required processing power at the different nodes (compared to a fully integrated single-ECU architecture) as well as the network load (compared to a federated architecture).

For the KP&T IM/E, Inmotion has simplified this architecture. As this vehicle has a smaller number of sensors and actuators, the team has reduced the number of satellite ECUs to two, one in the front and one in the rear. The architecture's main principles and advantages still hold.

ECU development for the KP&T IM/E is an enormous challenge. One of the main reasons is exactly this limited number of electronic control units (three including the central unit); the average passenger car

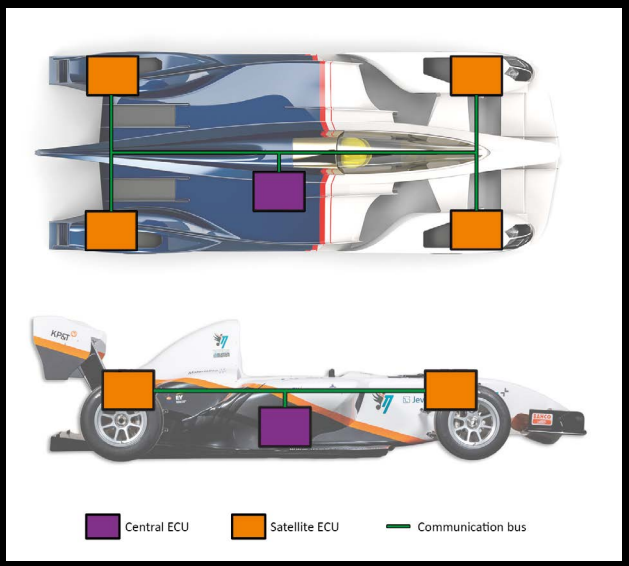


Figure 1: The IM01 will feature one central ECU and four satellite controllers, one at each corner of the vehicle.

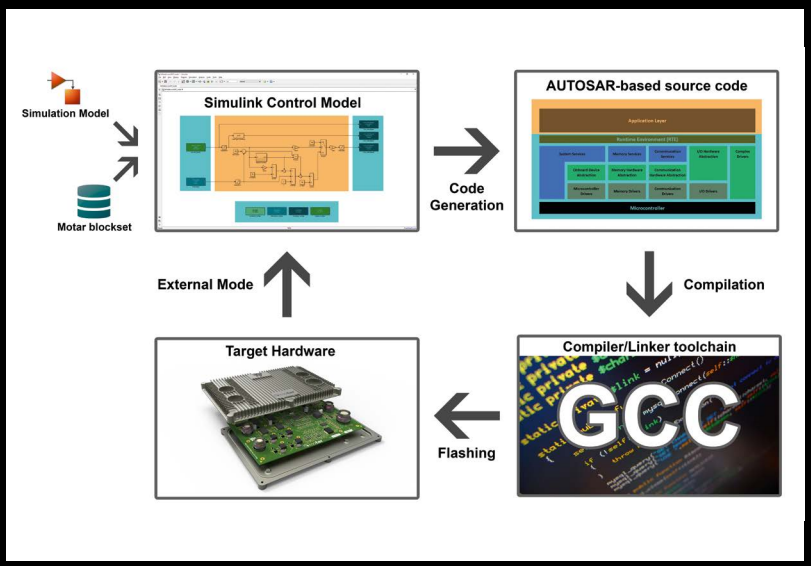


Figure 2: Using the Motar toolbox, the ECU software can be developed and deployed fully automatically.

has over a hundred ECUs to control every aspect of the vehicle. Inmotion has chosen to limit the number because the fewer the ECUs, the smaller the likelihood of technical problems during system integration. Extra challenging is the fact the ECUs have to keep operating under very harsh conditions – twenty-four hours at full capacity. With battery packs that can supply 800 volts and 300 amperes, fire and electrocution must be prevented at all costs.

Code generation

The ECU software is usually coded manually based on mathematical control models. These graphically represented calculations control the adjustment of electronic components such as traction control (for optimal grip) and active aerodynamics. Inmotion partner ICT is able to develop and deploy the ECU software using its Motar toolbox. Using this platform, the graphical control models can be translated into software fully automatically, without the need for any manual coding or integration. This speeds up the vehicle's development process while reducing the likelihood of programming errors. All this increases the ECUs' reliability.

The Motar software development process (figure 2) starts from a Matlab/Simulink model representing the application behaviour. This model contains configuration blocks from the Motar block library, which can be used to configure the Autosar-based basic software from within the Matlab/Simulink environment. Motar input and output blocks can be connected to inputs and outputs in the model.

Once connected, the model can be used to generate code for the target. The code generation process is triggered by a single button click from within the Matlab/Simulink environment. This action creates an executable that can be flashed to the dedicated target fully automatically.

During the execution of the Simulink model on the hardware target, the External Mode connection can be used to monitor and change parameters on the target in real time without the need to re-flash it. This can be useful for hardware-in-the-loop testing and verification. The External Mode can also provide feedback to enhance the model. This enables Inmotion's developers to apply a round-trip engineering methodology.

Lap record

This year Inmotion will test the KP&T IM/E at Circuit Park Zandvoort – and while they're at it, the team will have a go at beating the track's lap record for electric vehicles. Inmotion is currently preparing the car and putting the active aerodynamics (a real-time adjustable rear wing), the electric drivetrain and the three ECUs to the test. All this hard work is a labour of love by the team's members; Inmotion owes its existence to the support of several major sponsors, donors and technology partners.

If the test at Zandvoort is successful, the Inmotion team plans to go for the electric lap record at the Nürburgring Nordschleife later this year. After all this, Inmotion should have sufficient knowledge and experience to start making the IM01 and ultimately realize its dream of competing in the 24 Hours of Le Mans.