
QUIK

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Let's go Driverless

Challenges of the First Season

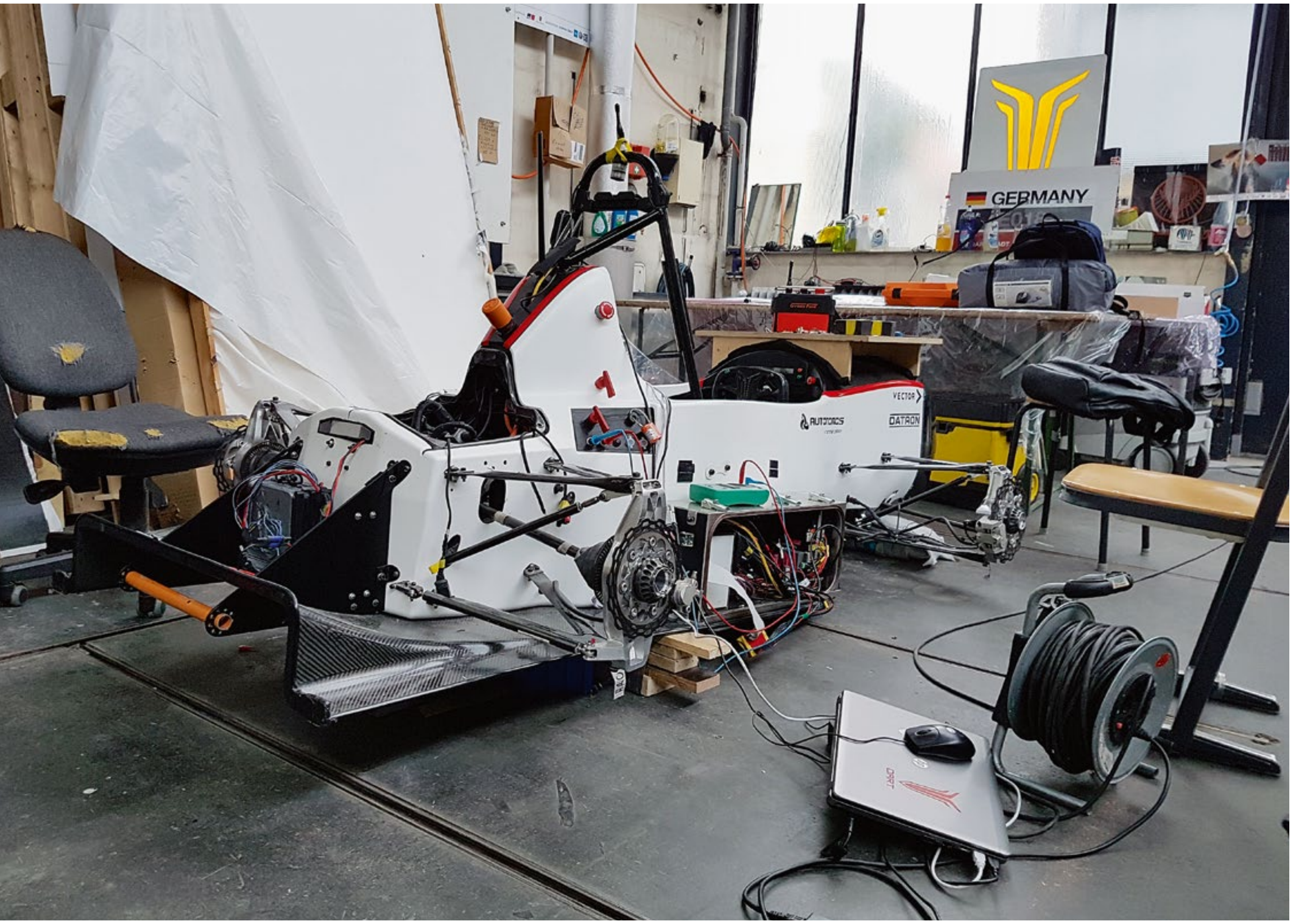
One of the teams keen to be part of the new driverless competition category of Formula Student Driverless right from the start was Dart Racing, the Formula Student team from TU Darmstadt. Reflecting this, two racing cars emerged from their workshop for Formula Student Germany in the 2016/2017 season. ATZextra visited the team in Magdalenenstrasse, Darmstadt (Germany), just five weeks before the Hockenheimring finale..

NEW SYSTEM ON AN OLD BASE

This year a driverless competition, the Formula Student Driverless (FSD), was held for the first time in the history of the international design competition. From the organisers' perspective, introducing FSD was a logical progression of the competition to prepare students for changing demands imposed in their future careers. The first year saw a total of fifteen teams rise to the new challenges. They included Dart Racing, the Formula Student team from TU Darmstadt. Their workshop spawned two new racing cars competing in the 2016/2017 season: an electric racing card named μ-2017 and an autonomous electric vehicle called μD-2017.

The rules specify that the FSD vehicle must conform to one of the existing two competition categories; namely Formula Student Combustion or Formula Student Electric. The potential to convert finished vehicles from the previous season was also intended to lower the initial hurdle to entry. The FS organisers' idea was that this would then allow the teams to focus on developing the autonomous system.

However, conversion brought disadvantages with it, as Philipp Birkholz is all too well aware. The mechanical engineering student was one of the pair responsible for the team from Darmstadt in the 2016/2017 season. Birkholz oversaw the actuating system for braking and steering, which is necessary to allow the driver's tasks of braking and steering to be performed by the autonomous system. This was all underpinned by the electric car from the previous season, the lambda-2016, the construction space of which was optimised to accommodate the driver and a small steering gear unit. The FSD rules for the 2016/2017 season specified that the space for the drive had to remain free. "This made it far from easy to integrate our 450 W motor for the steering system," explained Birkholz. At the same time, the gear unit had to be translated such as to still allow manual steering. The motor for the steering actuators has gear reduction using planetary gears. "We also developed and produced our own helical gear unit that joins the mechanical steering rod from the steering wheel with the actuators and steering rack," revealed Birkholz. Besides



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The electric car from the previous season which underpinned Team Dart Racing's autonomous vehicle, µD-2017

FSD RULES: FOCUS ON SAFETY

The rules for FSD prescribe a basic safety concept for driverless vehicles. Two of the rules' authors, Steffen Hemer and Sebastian Seewaldt, explained the key points in detail in the last ATZextra edition featuring Formula Student Germany [2]. The following is a short summary: If something goes wrong, it must be possible to stop the vehicle from the outside. This is why a commercially available, SIL-certified, radio-controlled emergency cut-off system is required, which the teams must buy and install without fail. This is included as an additional break contact in the so-called safety circuit. For electric cars, this switch interrupts the power supply from the battery, while in combustion-engine vehicles, it cuts off the ignition and fuel injection, thus deactivating the drive. To bring the vehicle to a complete standstill, the teams must also install an emergency braking system that is also activated by opening the cut-off circuit. In this case, the rules do not prescribe how this works in detail, i.e. whether for example through emergency braking with locked steering or by controlled braking coupled with swerving. However, a safety analysis report based on fault probability and fault effect analysis must be submitted, which then undergoes plausibility checking. In addition, the braking system must meet further requirements, such as response time, stability and time lag, that are then inspected in the technical examination. It must also be possible to drive the vehicle manually. The driver must be securely accommodated inside. It must be possible to safely isolate all automated actuators controlled by the system, such as brake and steering actuators. An optical signal on the vehicle's rollbar is also compulsory to indicate internal states. Teams have the greatest leeway when it comes to developing the autonomous system, which encompasses environmental recognition and sensor technology, computer hardware, architectures and algorithms. All sensors and systems, however, must comply with all legal approval requirements such as laser protection classes for laser scanners or performance restrictions on radar sensors.

In the 2016/2017 season, Philipp Birkholz was responsible for the µD-2017's actuating system for braking and steering, which allows the driver's role to be performed by the autonomous system

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the radio-controlled emergency system required by the organisers, the team also implemented a hydraulic accumulator to store energy that triggers the emergency braking system in the event of an emergency accompanied by a power failure, releasing energy and halting the car by blocking the wheels.

Automated vehicle guidance requires the system to monitor the vehicle's surroundings and route information reliably. The three physical sensor principles of radar, laser and camera were also used by FSD competition entrants. In their first year, the team from TU Darmstadt used two stereo cameras to recognise the roadway. Depending on the setting, the car drives with either one or two cameras.

SETTING PRIORITIES – IN FSD AND THEIR STUDIES

The Darmstadt team also received professorial support for image processing [1]. Professor Arjan Kuijper, Research Coach at the Fraunhofer Institute for Computer Graphics Research IGD, contributed his expertise to the Formula Student project. He was particularly impressed by the extent to which the team members proactively prioritised the project. "Many students are under great pressure to complete their studies as soon as possible," Professor Kuijper stated. "Even so, Formula Student team members consciously take time out to work on the racing car – in some cases full time," he explained, adding, "That's good, because students possibly learn even more from Formula Student than they do in lectures."

FINDING THE RIGHT PARTNERS

One aim the Formula Student Germany organisers had when introducing FSD was to recruit students for the competition from disciplines previously outside its scope, such as computer science, robotics and autonomous systems. This was challenging for the first-year teams. It was relatively difficult for Dart Racing to find the right people to develop the driverless vehicle. "It was the typical mechanical engineer who responded," revealed team member Annemike Unterschütz. For example, there were two mechanical engineering students on the team who discovered shortly before the end of their course that automated driving was actually what really interested them. The introduction of FSD came just at the right time for both. Computer scientists and mathematicians, however, did not enlist automatically.

To publicise the driverless project to students of other disciplines, the team ultimately published job ads on the Internet and contacted media representatives. This helped. Things started happening with regard to the recruitment of computer scientists after articles appeared on the VDI blog and in the FAZ – and not just for the short term. "We now have a couple of students who are already trained up for the 2017/2018 season. That's why we're hoping to start with a better lineup," explained Unterschütz. She herself is a computer science student and only learned about the new driverless competition by chance. She originally wanted to get involved with Akaflieg, a university group at TU Darmstadt that constructs gliders. Which is why, in spring 2016, she turned up at Magdalenenstrasse 6, where Akaflieg shares workshop space with Dart Racing.

Annemike Unterschütz (second from right) was responsible for sensors and IT in the driverless car during the 2016/2017 season

She joined the Formula Student team in April 2016. Her main impetus at the time was the potential to programme on real FPGAs. "A normal student can't afford to programme on such hardware. Sponsoring makes it available in Formula Student," Unterschütz disclosed. During the 2016/2017 season, she was then tasked with handling sensor & information technology in the driverless vehicle.

ONTO THE NEXT SEASON

Unterschütz's review of how the first season went is realistic. "Whether trajectory planning or image processing, every development took longer than originally estimated." The team had to defer deadlines, for actuator technology in particular. The original plan was actually to integrate the actuator technology in February 2017, but the students' work intended to underpin the initiative proved unusable. The delay caused by having to develop a new system then resulted in the production phase for the actuator system coinciding with that for the FSE vehicle. The deadline was continually pushed back. Ultimately, the actuators were only installed in early June. The team can learn a lot from these mistakes for the second season – the Dart Racing team, aware of how crucial the learning effect is, are also drawing up a roadmap to define medium-term targets for the coming year. For example, the Darmstadt team want to improve communication between the computer scientists and the young mechanical engineers. The mechanical engineers did not get along very well with the "magic numbers" of the computer scientists. This is why all measurement units are to be converted to ISO standards in the software for the 2017/2018 season.

Given the inability of the team to collect much test data from the moving vehicle in the current season, testing and data generation are also key goals for next season. "We intend to improve how image processing filters are set. We've also developed a Kalman filter to estimate speed and positioning. We don't yet have the control parameters for this," explained Unterschütz. The team also intends to get to grips with sensor fusion topics. "This year we're only driving optically using cameras and DGPS. Next year we'd also like to install lidar sensors." Sponsors have also expressed the desire for the team to also possibly use radar. As for which of these goals can be implemented within just a year, all will be revealed in 2018, when the second round of Formula Student Driverless gets underway.

Angelina Hofacker

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