Final Preperation Weeks

The last weeks before the peak of the season passed quickly. The implementation and commissioning of advanced driving modes, which use the information of the first lap, turned out to be great fun. For the first time flüela was brought to its limits and we could observe slipping tires. The team brought up further ideas to make the autonomous driving even more powerful. Most of it, however, was set aside. We deemed it best to focus on different things for the big event at the Hockenheimring. While a driver handles a change of environment relatively easily, we were less certain about that for the autonomous system. What happens if the GPS signal is lost? Do the LiDAR and the image analysis algorithms reliably remove the ground cones from all possible environments? The emphasis was set on reliability. With test days at BMW in Maisach, in Boxberg near Bosch and ETAS and together with MunichMotorsport and Starkstrom Augsburg in Wemding, we have also tested our system in various new environments. Nothing can go wrong anymore, right?

Formula Student Germany

Sunday, 6 August: Departure to Hockenheim. The entire workshop is accommodated in the car. flüela is towed with the trailer. After a smooth ride and set up of the camp, we sleep through a cold night to refill our energy storages.

The scrutineering, the rules compliance check of the car, is a tough one. The inspectors are checking whether all the visible cables carrying high voltages are marked orange and ensure that all screws pointing inside the monocoque are fitted with a protective cap. There is no bonus for flüela already having been classified safe and in accordance with the rules of 2015. After remedying the complaints, we manage to pass all known checks, as well as the successful examination of the autonomous systems. The autonomous brake test is the only remaining examination. For that the vehicle has to accelerate driverless to 40 kph and come to a standstill within ten meters, which is completed the first try on Wednesday morning. This means that there is nothing to stop us from driving some first laps on the test track.

First Impression

The test course stretches well over 400 meters on top of the north curve of the Hockenheimring. For exercise purposes, the road cones deviate from their position in the course of the upcoming race. We carry out the trained procedure: Slowly drive down the track, build the map and then, after a short break, drive fully within this track. The first laps run according to our expectations: flüela turns safely through the course. But then flüela shovels the cones with her front wing over the course. From a distance we activate the emergency brake system. The car decelerates with blocking wheels. What happened?

After hours of troubleshooting we find the bug. Never before have we been able to ride such a long distance over several laps, which was also the only environment in which the error could be noticed.

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**Bad Luck with the Weather**

Until the event start we spent a total of one test day in the rain. That this one was filled with problems means red light. Flexibility is required.

According to the forecast, the entire Thursday is overshadowed by medium-strong rainfall. The clear strategy is to drive as soon as possible and collect data to analyse.

We thus start at 01:10pm as the first team in the first autonomous discipline, the acceleration race. The interest of the present Formula Student Community is high. However, the dynamic team, which prepares flüela for the run, cannot be distracted. In a trained routine, they push the vehicle to the starting position, start the algorithms, position the safety responsible with the mobile emergency button behind the vehicle and start the run.

flüela jumps off the starting line, but quickly reaches her maximum speed, which we limited for safety reasons. Shortly after it turns aside and runs into a series of cones. The Emergency Stop button is pressed immediately. DNF – did not finish.

The analysis shows that a sensor system cannot reliably cope with the ground reflections on the wet sections of the track. However, this sensor system is a key factor enabling driving with slightly spinning tires or more generally at the vehicles limits. Now we have to find new solutions. We decide to reduce the motor torques at the start to be able to rely on the wheel odometry.

This measure turns out to be appropriate. After failing attempts by the other three driving teams, we manage to complete the first successful run. A very gripping battle for the best time follows, with the teams continuously improving the best time. In the end, the team from Karlsruhe beats us by 0.07 seconds with the fastest time of 4.29 seconds to complete the 75 meters.

Even though the rainfall intensity decreases over the course of the skid pad, the floor remains wet throughout the entire period. Once again, we are pursuing the same strategy and are proceeding to the start line directly at the first opportunity at 4:30pm. Again we notice the problems of the sensor system with the wet ground. After a successful, fast first circle, we smash the timekeeping equipment with a spectacular drift. Fortunately, both flüela and the time measurement system do not suffer any considerable damages. Whilst the other teams are starting to complete successful rounds, we are still standing there with empty hands with three of the four attempts without completion. After the last adjustments the entire team is tensed up when flüela accelerates into the last try. But this one is absolutely perfect – fastest recorded time of the day! With this relief the official day program is finished.

Thanks to the two good results, we are able to gain a point lead in the overall ranking. We are only a bit surprised
that we are placed first on the running order for the next day, which is a strategic disadvantage.

**Trackdrive**

On Friday, the discipline, which is considered the most challenging, is on the agenda. The trackdrive. A 400-meter long circuit marked only by cones. flüela has to complete ten laps autonomously.

Shortly before our half-hour window for the trackwalk, we notice that the returning rainfall is not the only problem. When the computer box is remounted onto our high-tech wheelbarrow, which we use to map the track, a failure is detected. The cable of the connector got lose and triggered an unfortunate damage chain. In the end, we are there without a map of the track and cannot stick to our time slot of the trackdrive due to the needed repair work. For the next three hours the entire team works highly focused and under big stress in order to fix the problems and adjust the software. In the meantime the other teams all fail in the first round of the trackdrive. The challenge, especially with pouring rain, is big.

Given the circumstances, our goal is to complete at least one or two laps in a safe way to collect data for the construction of a map. This map should then be used for the second run.

These expectations are even surpassed. flüela successfully completes the first lap, while simultaneously creating the map and then changes to the faster driving mode online. The improvised LiDAR rain cover made of tape reliably keeps the bulk of the rain drops away from the sensor. Even the cones that have been hit are either avoided or driven over by flüela or so that the car always remains on the track.

Amid the applause of the crowd, the racecar successfully comes to its full stop after completing the ten laps.

**Bonus**

Due to the lowered speed of the vehicle and the two-minute penalty, which we have received for not being able to take the scheduled starting time slot, we estimate the time taken as surpassable. Accordingly, we prepare ourselves directly for the second run. Dry the vehicle, analyse the collected data, determine new parameters to be set.

As we move back to the track just before 7:00 pm, the previously set time is still the reference. The concern of it getting surpassed is still present, as the cars of Greenteam Stuttgart and münchHMotorsport are just queuing up behind us.

However flüela manages to deliver once again. She perfectly completes the ten laps without hitting a single cone. The lap times are halved, a new reference time is set. We have done our best and ultimately remain the only team to master the challenge.

**Static Disciplines**

After successful presentation of the driving car, the team has to prove that it also developed the vehicle according to good engineering practice. This
requires an understanding of the manufacturing and cost development, the theory of what makes a vehicle fast, but also the possible algorithms and concepts for enabling autonomous driving. The package is rounded off with an imaginary business plan, which the team has to convincingly present to a further expert jury.

All the critical questions and prepared presentations keep us busy over the remaining two days. Despite a short feedback from the respective juries, it is difficult to assess the performance.

Award Ceremony

On Sunday evening we are accordingly eager to hear the announcement of the winners. To our big delight, we win the engineering design, the cost award and end the event with a second place in the automotive design and a third place in the business plan in all disciplines on the podium. Thanks to the equally strong performance in both the static and dynamic disciplines, we are awarded with the big trophy for the overall victory of the Driverless category.

The reward for the year of intensive preparation for this week.

Autonomous Future

We would like to thank all those who have supported us on this way. We took the project as a wonderful, big challenge and we are proud of our results. We reached all set goals at the beginning of the season. One of these goals was to have the project continue at the end of the year. In this respect, we are pleased to announce that we will compete with a new team in the next year. Once again, we will give our best to push autonomous racing further. We would be delighted to be able to count on your support once again!
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