DRIVERLESS MAGAZINE

DELFT DRIVERLESS
FORMULA STUDENT TEAM

4TH EDITION
APRIL 2019

MIT DRIVERLESS

Delft

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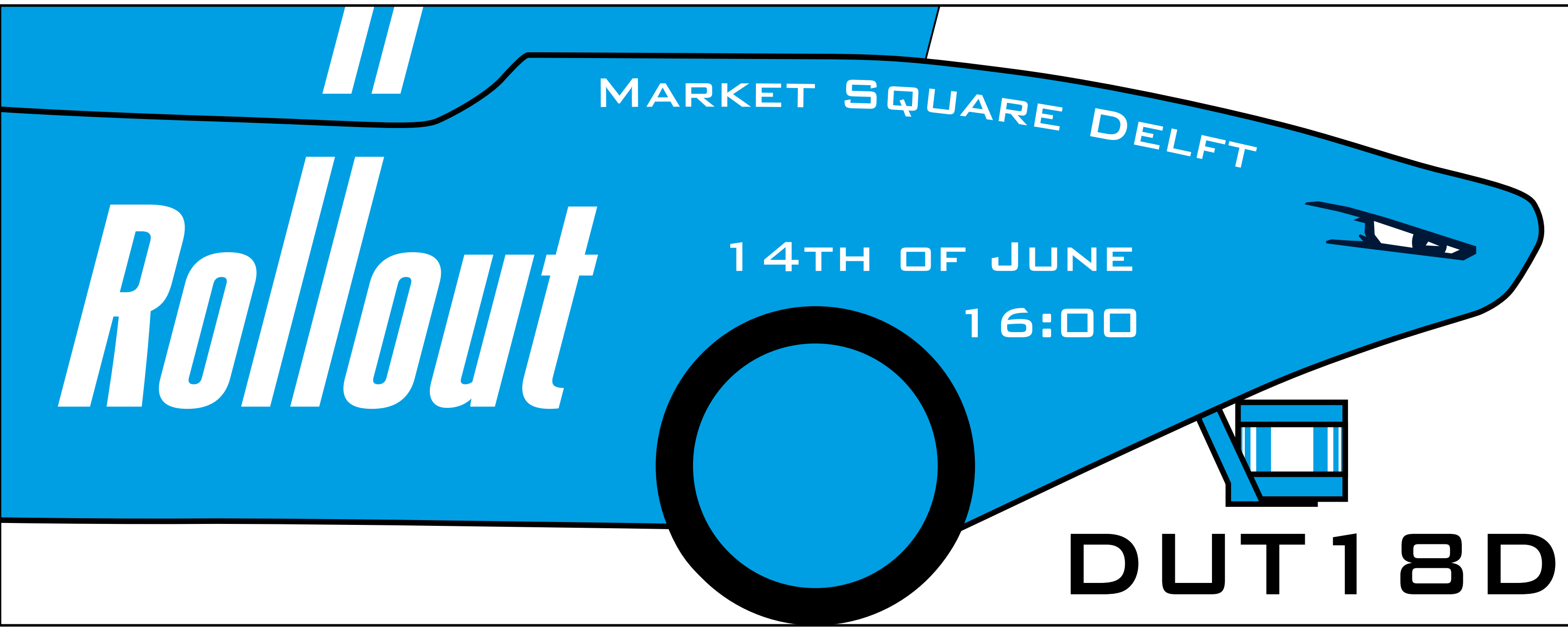
WELCOME

It's only aproximately three months until the competition season starts. And only a few days until our car is fully assembled. The team is seemingly hyped and can't await the rewarding feeling seeing the car run on the track autonomously. Our first autonomous meters will be the most important milestone for us and a lot of engineering hours went into it. Soon we can reveal the full car to the world at our rollout event. If you, dear reader, are as excited as we are, then save the date!



On an engineering note, we have made great progress in the past months and it is exciting to see how well we developed as a team. Our workflow and working schedule aligns more and more and progress gets more efficient each day. We are all eager to see if we can keep up the pace and transfer this efficiency to our testing season. Our autonomous stack is only waiting for its hardware carrier to show the full potential in the real world on a high performing race car.

While we are working so hard to meet our deadlines, we also have a little something to show. As a new team, people do not really grasp who exactly we are and what we do. What better way is there than telling a piece of what we do in a video?

So, Madames et Monsieurs, may I grant you a first exclusive view on our video series, from us, about us and with us:

THE HOT PHASE

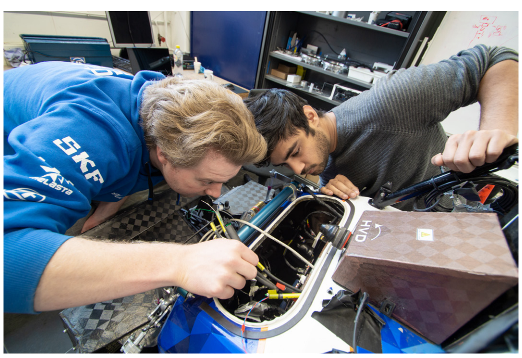
We have already come a long way. Starting with our requirements analysis, concept, data gathering and design phase, we find ourselves in the last sprint to get our car ready for the testing phase. Lathing and milling machines are running hot and we need to keep an eye out, that our engineers keep their workplace organized to ensure everyone can work as efficient as possible.

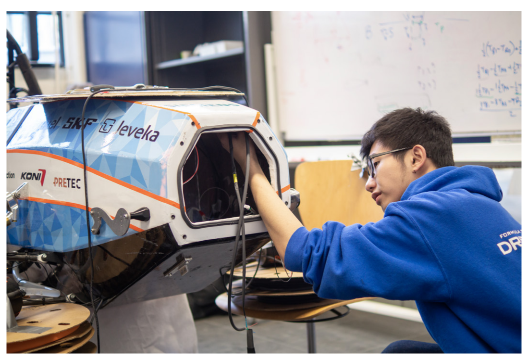
Putting the pieces together

It has become very busy in our workshop. A temporary extra table ensures that electronics can test our pcbs, while our mechatronics department manufactures the last brackets and pieces. A large assembly of emergency brake system and steering actuation is now only waiting for integration testing to validate the functionality already outside the car. The wiring guys check the looms if every pin is correctly routed and the embedded software department is diligently debugging written code to mitigate all the initial, premature failure modes. The car was even banned from the workshop to make room for the hardworking engineers to be as efficient as possible.
Integration testing is our last step before the full assembly. Making sure all the interfaces between the parts work well together and don‘t behave unexpectedly is critical. This is especially important for an autonomous vehicle. While a driver can react to direct feedback from the car, an autonomous vehicle needs to monitor continuously the sanity of the system. If there are issues with unobserved parts, such as purely mechanical components like the suspension, which software can not detect by itself, the outcome can be devestating. The last resort is posed by an ASR (autonomous system responsible) who observes the vehicle and operates the RES (remote emergancy system) from a distance in case anything happens to trigger the EBS.

Once we know that our systems work reliably and as they should, we will start the full assembly on the car. A “bok test” will mark the final assessment with the hardware in the loop. We will power up the car and run prerecorded data and specific inputs while the car is placed on a buck with elevated wheels to check if we get the expected output behavior.

Hopefully everything is working out well and we can free it from its restraints and let it go on our testing track soon!





MAXGRIP EXCHANGE DAY

In April, we hosted a group of 80 employees from Maxgrip, one of our generous sponsor. It was a great opportunity for the team as we got to know the company better and for the the sponsor as they got to know more about the driverless project and the challenges we face.

The event

On April 5th, we hosted a gathering of eighty employees from MaxGrip. MaxGrip is a consultancy firm and a software house engaged in managing capital-intensive assets for any business so that the company can direct its focus fully on its core business.

Our team manager, Rutger van den Berg, kicked off the event with a general presentation about the driverless challenge. Rutger shared his insights on the various departments in our team giving a brief overview of what we do and how we do it. He also shed some light on our collaboration with the MIT and how that adds to our development cycle.

The crowd was then divided into groups and assembled in Dreamhall where Cyril Trap and Sabri Mercimek guided the groups on a tour of the Dreamhall where they talked about the different dream teams such as Delft Hyperloop, Vattenfall Solar Team, Project March and Forze Hydrogen Electric Racing. Our guests also got to see our small but humble driverless workshop where they feasted their eyes upon our beloved DUT18D for the first time. At the workshop, we were joined by other driverless team members where we talked about the different sensors and actuators on the car which would help the car drive autonomously.

While one of the groups was busy with the Dreamhall tour, the other group attended a technical presentation led by Achin Agarwal and Chadi Salmi. The technical presentation was about the LiDAR processing pipeline, which is one of the integral sensors in our system. A live demonstration of LiDAR was also given in which people were shown how the world looks like to an autonomous car to help them develop a basic understanding of the sensor.

We wrapped up the evening with food and drinks at the Sports & Culture building, organised by MaxGrip. We were able to have a light hearted discussion about the future of autonomous cars while having some great food and drinks. It was a pleasure to host maxgrip and we hope we were able to answer all questions they had related to our driverless challenge.

TESTING DAYS

We all know how difficult it is to build the hardware and software needed to make a car drive itself – if it wasn't, we would already have autonomous vehicles running around on the road. As with any difficult engineering problem, rapid testing and iteration is critical to identify problems early on. At MIT, since we aren't able to test on the DUT18D we built a 1/7th scale version of the car using the largest RC car we could find on the market. The car, that we call the testbed, has the same sensor suite as the actual car but allows us to push new code and immediately test it in the real world – not just in a simulation environment. Over the past few weeks, we've been taking the testbed out for testing every week and learning quite a lot from these test runs.

We've had two primary testing grounds so far. When the weather is nice, we prefer to test outside on asphalt to simulate the competition environment as closely as possible. In this case, we use one of the empty parking lots near a residential dorm at MIT. If the weather isn't quite as nice, we use the indoor running track at the MIT Athletic Center which gives us a large, open space with limited extraneous objects to confuse our perception pipeline. Our most common testing day is Saturday, which starts off with a team standup at 10am, followed by a couple of hours of putting final touches on changes we're testing that day. After that, we'll start getting the car ready in the shop – making sure batteries are charged, our testing case is ready, and the pipeline is initializing with no errors. We'll load the testbed, ~100 cones, and the testing case in a rental car and drive over to the testing environment.
Each testing day has focused on a specific set of variables or new features we're testing. At a high level, our testing days have progressed in the following order:

1. Baseline boundary generation, state estimation, and LiDAR cone detection, simple tracks
2. Baseline boundary generation, state estimation, and LiDAR cone detection, complex tracks
3. Motion correction for cone detections, increased speed on runs
4. Moving from simple to complex controller, increasing cone spacing to regulation length
5. Future: continually increasing speed to test robustness of system

These testing days rarely go as planned, but working through them has helped us make the system more robust so that when competition time comes around, these problems and bugs have already been addressed. As we push towards integrating the software stack with the actual car in early May, it's become even more clear that the continuous testing leading up to the integration has significantly reduced the potential complications for us when we start running these same tests with the DUT18D.

Technical Update

Electronics

To connect all sensors and devices, the electronics department has been busy with making new wiring to add to the DUT18D. Proper wiring is crucial for a reliable car, as it a common source of failure. The wiring should be waterproof and be able to handle all the forces that can be experienced while driving. One disconnected wire can mean the difference between a beautiful autonomously driving car and a beautiful car that has to pushed from the track. Next up, the batch of PCBs that came in has to be tested. This includes both making sure the errors from the previous year's PCB have been solved, and testing the new PCBs that provide the necessary functions needed for autonomous driving according to the rules. As the wiring and electronics is coming together, we are running warm for the integration testing. During this phase, all devices will be assembled into the car and tested to see if they function as a whole. In the next few months, we will continue with finishing the wiring and we will begin making some extra PCBs.

- Rami Younis
Chief of Electronics

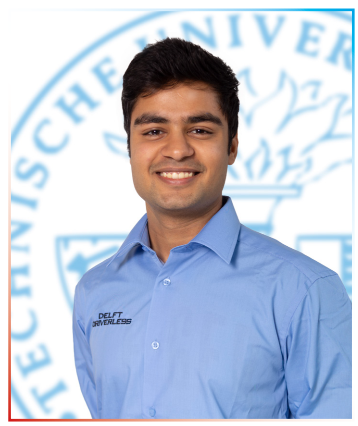
Controls

The car can only be controlled using Torque and steering setpoints. The objective of controls is to make sure that the car is able to achieve the set points outputted by path planning. It does so with the help of a yaw rate controller and an acceleration controller.

The input sensor data is first filtered and reviewed for possible errors. If there are any errors found, they are dealt with by turning off the relevant subsystem. These processed sensor readings are then used to estimate the current state of the car which in turn helps to control the yaw rate and the acceleration. The controls system also include power management strategies. The power limiter makes sure that the car's total power does not exceed 80 kW such that we can push the motors as much as possible while keeping within the bounds of the competition rules.

For the past month, we have been working on modifying the DUT18D controls to interface with the new inputs from path planning. We have also been working on modifying our simulation so that it can also incorporate the controls block so that the entire autonomy stack can be checked in the simulation. Over the course of the next couple of months, we will try to validate our simulation model with the actual test data we collected and also tune our controllers.

- Achin Agarwal
Chief of Controls



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