

# DRIVERLESS

MAGAZINE

“There is a bug in the math  
that I need to fix”

- *Chief Pathplanning*



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DELFT  
DRIVERLESS  
FORMULA STUDENT TEAM

MIT  
DRIVERLESS



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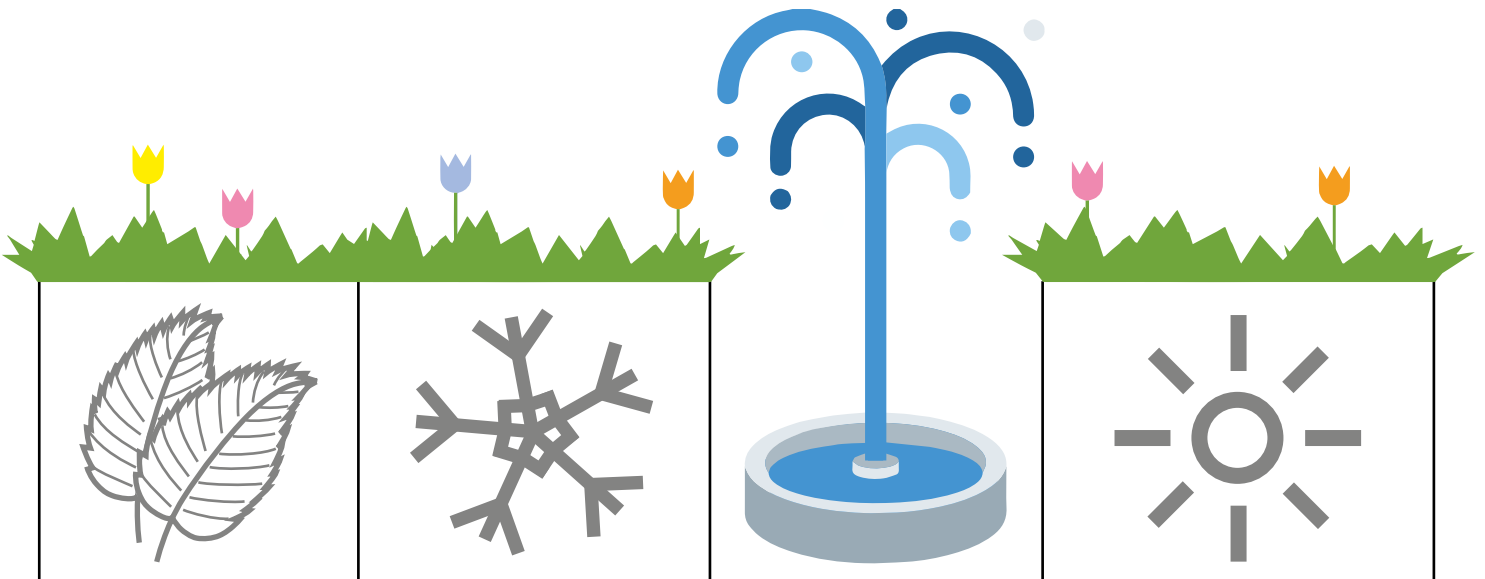
# WELCOME

*March brought a lot of changes. On March 1st, Cambridge was covered in snow and the Charles River was frozen over. Two weeks later, the snow had vanished and the sailing team held its first practice on the freshly thawed Charles. Across campus, students began studying for midterms and making plans for Spring Break, which falls on the last week of March and marks the official halfway point of the semester.*

*As our team prepared to leave campus for spring break, it was apparent that a lot changed in addition to just the weather. On March 21st, we achieved the milestone of our testbed vehicle completing its first autonomous run, with some minor hiccups in controls. As sweet as it is to have some nicer weather, reaching this milestone was even sweeter for us, and we went into the break excited about the progress we've made.*

*Across the pond, the weather was of course changing too, and the characteristic stream of bicycles reappeared around Delft, where we finalized the mechatronic design of the full size vehicle. We will be integrating our PCBs into the vehicle in early April, just in time for several MIT teammates to visit Delft, integrate everything, and run our first autonomous lap with the full sized vehicle. We hope to do all of this by May 1st so that we will have time to continue iterating and improving our stack before things like finals, internships, and graduations start to distract us from what really matters - making our vehicle as fast as possible!*

*In this newsletter, you'll find stories about MIT's visit over to Delft in January, an autonomous racing workshop in Hamburg, our sponsor visits in Cambridge, and finally technical updates from our state estimation and mechatronics subteams. This is the first newsletter that we've distributed across the networks for both schools (previous ones only went out only on the Delft side), so we welcome all readers, new and old, to this Driverless newsletter.*



# THE BIG GET TOGETHER



*Collaboration over a large distance can be tough. As software engineers, we don't think about that very often. Buried in our code, forgetting the world around us, relating to our fellow developers simply by an avatar and user-name in the commit history. Some people call it being in the „zone“.*

*At the end of January our team members from Delft and MIT finally all got the chance to meet each other in person when a group of MIT engineers traveled 5.500 km from Cambridge to Delft. Exciting days were lying ahead of us!*

## WEEK 1

Starting from the 20th of January when most team members arrived at Amsterdam Schipol, our first objective was to socialize. Since none of the MIT students ever saw the vehicle in real life yet, our workshop was the obvious choice for a casual environment and offered a beautiful scenery with our car in the middle of us all. The MIT visitors were so eager to see the car and they asked so many questions, which were a struggle for the Delft hosts to even keep up with!

We then had the official kickoff event. We knew how fast 2 weeks can pass by, therefore it was imperative to us to plan our time efficiently to get the most out of it. Going through the tight timeline, explaining our goals to the team and getting all those souls pumped for what's about to come marked the end of our

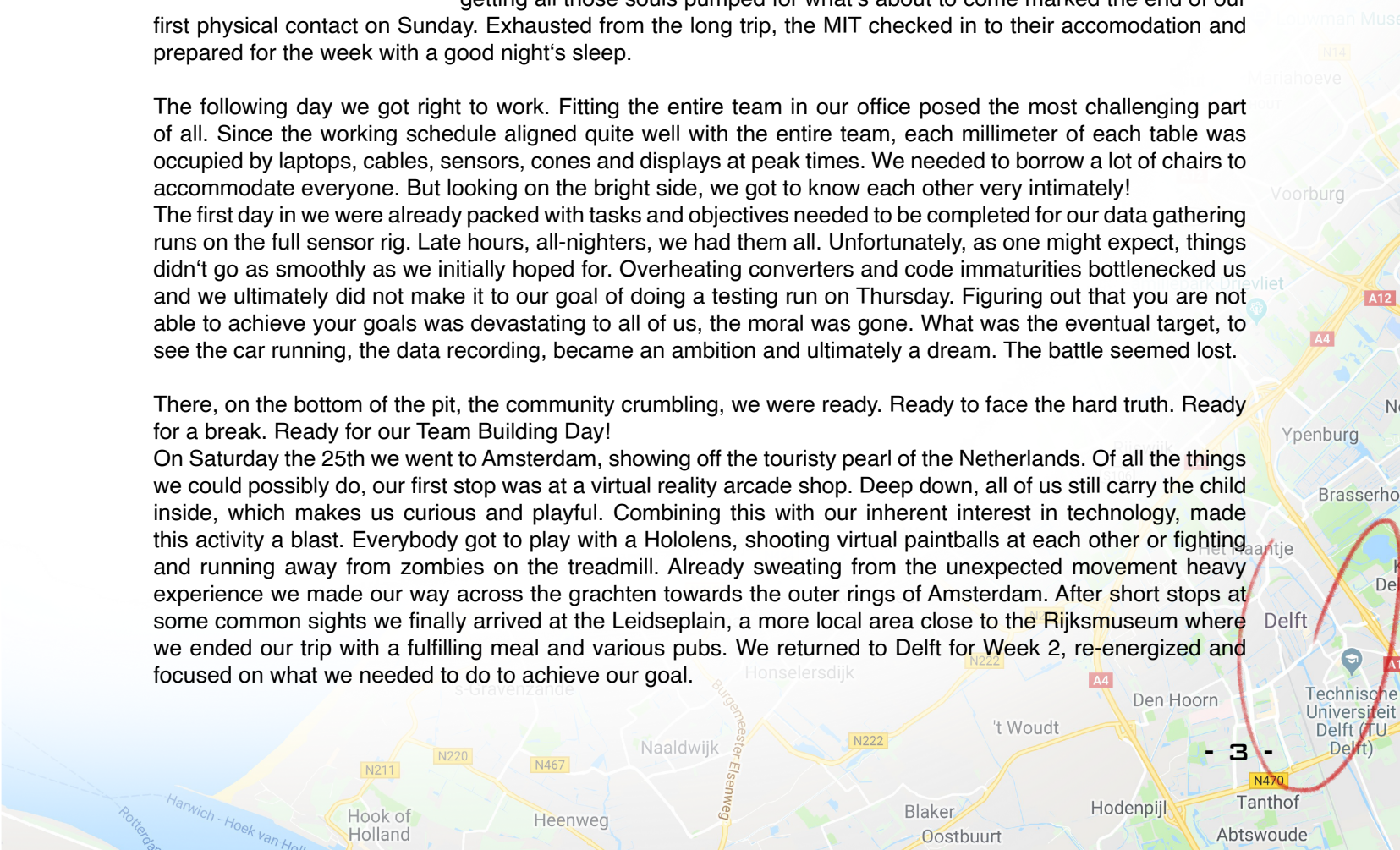
first physical contact on Sunday. Exhausted from the long trip, the MIT checked in to their accomodation and prepared for the week with a good night's sleep.

The following day we got right to work. Fitting the entire team in our office posed the most challenging part of all. Since the working schedule aligned quite well with the entire team, each millimeter of each table was occupied by laptops, cables, sensors, cones and displays at peak times. We needed to borrow a lot of chairs to accommodate everyone. But looking on the bright side, we got to know each other very intimately!

The first day in we were already packed with tasks and objectives needed to be completed for our data gathering runs on the full sensor rig. Late hours, all-nighters, we had them all. Unfortunately, as one might expect, things didn't go as smoothly as we initially hoped for. Overheating converters and code immaturities bottlenecked us and we ultimately did not make it to our goal of doing a testing run on Thursday. Figuring out that you are not able to achieve your goals was devastating to all of us, the moral was gone. What was the eventual target, to see the car running, the data recording, became an ambition and ultimately a dream. The battle seemed lost.

There, on the bottom of the pit, the community crumbling, we were ready. Ready to face the hard truth. Ready for a break. Ready for our Team Building Day!

On Saturday the 25th we went to Amsterdam, showing off the touristy pearl of the Netherlands. Of all the things we could possibly do, our first stop was at a virtual reality arcade shop. Deep down, all of us still carry the child inside, which makes us curious and playful. Combining this with our inherent interest in technology, made this activity a blast. Everybody got to play with a Hololens, shooting virtual paintballs at each other or fighting and running away from zombies on the treadmill. Already sweating from the unexpected movement heavy experience we made our way across the grachten towards the outer rings of Amsterdam. After short stops at some common sights we finally arrived at the Leidseplain, a more local area close to the Rijksmuseum where we ended our trip with a fulfilling meal and various pubs. We returned to Delft for Week 2, re-energized and focused on what we needed to do to achieve our goal.

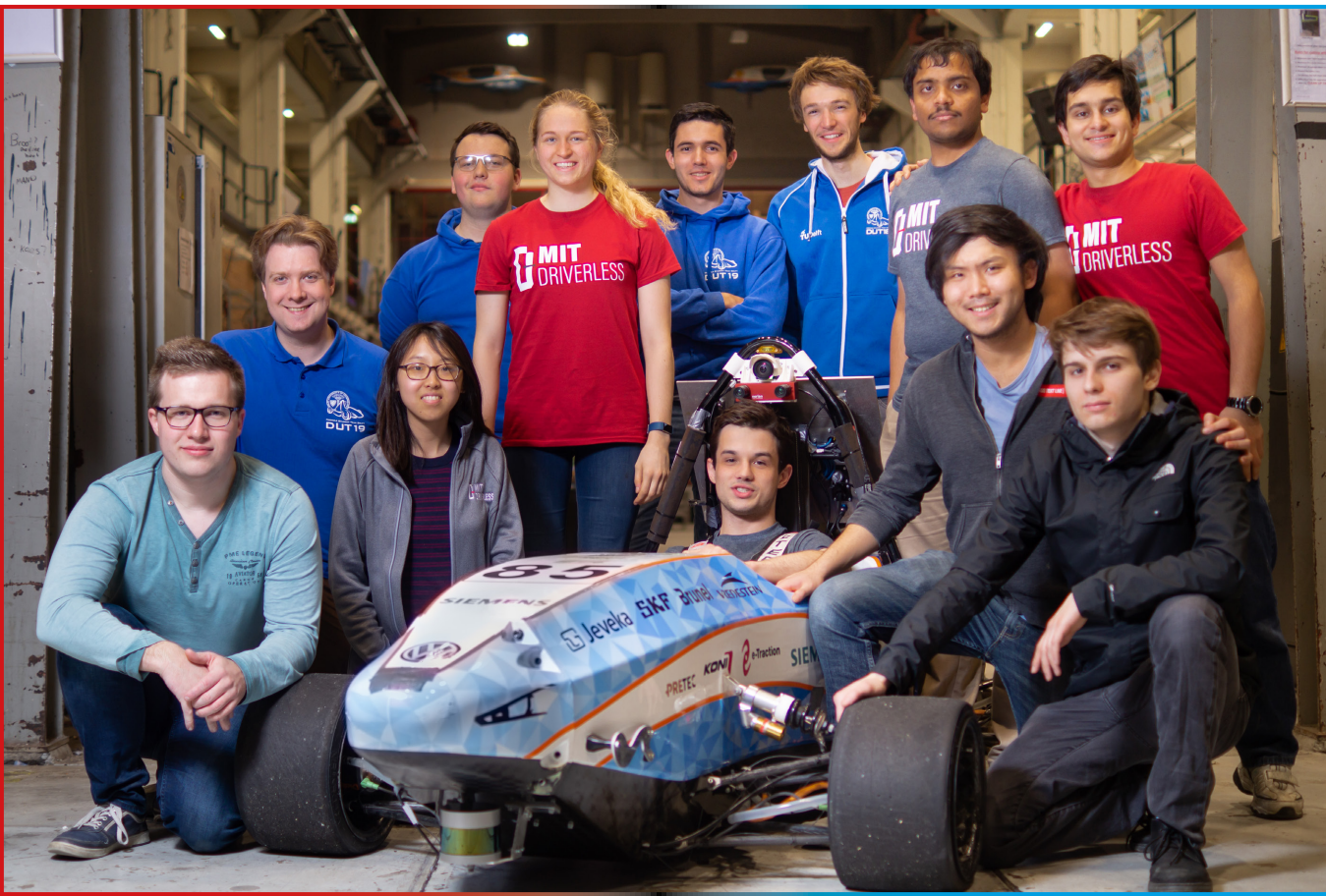




We opened the second week with a workshop day where we really learnt a lot from and about each other. We felt that we had made a ton of progress in Week 1, and so we wanted to keep this going even after the team is separated again. Hence, we sat together, talked about how we can adjust our workflow to benefit from all the things we picked up during our time together. May it be our git workflow, how to resolve or even identify misunderstandings over chat correspondence. Retrospectively, we are very glad that we took the time to address this issue. After that, our veteran Jeffrey from the previous year's Delft team prepared a presentation on how Design Judging at a competition works, how we need to prepare for it and what we can expect. As if that were not useful enough, he also took us to the workshop and gave us an introduction of the drivetrain assembly, by showing us how to take it apart and how it works in detail.

Gathering new motivation and excitement from the past days, our team got back to it. We were able to mitigate the problem of overheating converters, integrated the pipeline on our embedded compute unit and were ready to head out. Wednesday came along, the big day, and we loaded the trailer with cones, gear, tools, a stack of laptops, extension cords and chargers. It was a cold and windy day at Valkenburg, the old military airfield where we are allowed to test our car. The accumulator did not like these temperatures at all, and neither did we. We had to take shifts on debugging our scripts, so our fingers wouldn't freeze solid. But eventually after a hard day's work and many test runs around the track, we left the site with all the data we needed. Finally a win for the team!

Slowly the trip came towards an end. But not without a big deadline coming up: the rules quizzes. A measure from the competition executives to elicitate which team gets one of the precious slots out of all the applicants. The 1st of February, a date which meant a lot to us, was slowly creeping in. We did our best to prepare for it while still meeting all of our self made deadlines to get the car running. When the day was there, we gave it all, everybody silently keyed up, solving the engineering questions, and searching for rule explanations. The quizzes are notoriously difficult, yet we managed it somehow. We got a starting slot at Formula Student Italy, EAST and landed on the pole position on the waiting list of Formula Student Germany. Relieved and exhausted, only hours before their flights took off, we found ourselves in the workshop celebrating the past two weeks, finally opened our bottles of dutch beer and headed out to our closing party, in a beautiful chapel. This marked the end of our awesome trip together.



# AUTONOMOUS RACING WORKSHOP

*Autonomous driving is on its rise and pushing this technology further requires smart minds the industry is craving for. However, sharing knowledge and community effort in research topics has proven to be one of the most effective ways to reach the goal and this is very difficult considering company secrecy. This is why we are so grateful for the open minded community we entered in the Formula Student Driverless realm, with its pioneers e-gnition, who organize the annual get-together of the ARWo.*

## GOOD OL' ST. PAULI

From the 22nd to the 24th of February the autonomous racing workshop took place at the Technische Universität Hamburg. When we arrived friday evening, most of the teams were already in the cafeteria. Fortunately we were in time for the kick-off event and more importantly to pick up our goodie bag! After some welcoming words of the staff, we got to talk to the other teams, introduce ourselves and have a drink together. A well appreciated beginning of the weekend, since we didn't know how tightly scheduled the upcoming two days would be. Every participant was encouraged to upload topics and pressing issues themselves and share them on a platform where others can sign up for. This made the event very interactive and ensured that nobody left unsatisfied or with open questions. We were really positively suprised about how much effort other teams put in, not only to design an autonomous race car but helping other teams to join the challenge!

Another highlight for us was definitely the open discussion about the future of our beloved driverless category in the upcoming european formula student seasons. It is great that this event provides a platform exclusively for our community to get a



voice between the well established and humongous amount of combustion and electric teams.

Of course we tried to get the most out of this weekend and each and every one of us attended a discussion in almost every timeslot available. Exhausted by the day, we still couldn't resist the scheduled Hamburg tour in the evening. The locals guided us up the Elbphilharmonie and down the old Elbtunnel before we headed for the Reeperbahn and the Grosse Freiheit where we called it a day with some freshly tapped beer.

All in all it was a truly inspiring weekend, which gave us a lot of motivation for the entire year. Once more we would like to thank e-gnition for calling in this event and organizing it year by year. A shout-out to all the new friendships we made and teams we were able to meet, which have been so supportive!

Ecurieaix,	fastforest,	Scuderia Mensa,
GFR,	starkstrom,	Dart racing,
Greenteam,	elbflorace,	Stuba green team,
Raceyard,	E-motion,	Bremergy,
HTW berlin,	AMZ,	CAT racing,
Hawks racing,	revolve,	BRS Motorsports,
FST Weingarten,	Starcraft,	Chalmers,
Infinity racing,	Bodensee racing,	e-gnition
KA racing,	EOS racing,	
URE,	e-Motorsports,	

*If you read this, good luck guys and see you soon at the competition!*







## SPONSOR DAY

*Once a year the team hosts our top sponsors in the shop. It's a great time for us to meet the people supporting our team as well as for sponsors to meet our team members. In February, we hosted two platinum sponsors in Cambridge.*

In February we hosted two of our platinum sponsors, Magna and Waymo, in Cambridge. Our first visit was with Ben Saltsman and Haley Rusicka, who represented Magna. Ben (Director of Advanced Product Development and an MIT alum) and Haley (Marketing Coordinator) both made it to campus despite a winter storm that continued all the way through our shop visit. As the snow fell outside, our team enjoyed some delicious barbeque with Ben and Haley as we gave them a one-hour update on our progress to date in computer vision, state estimation, and path planning.

Afterwards, Ben shared information about Magna. Even though I knew that Magna was the largest tier 1 automotive supplier in North America, I was personally blown away by the reach of the company's services, which we learned includes everything up to complete vehicle manufacturing. We wrapped up the evening with tour of our shop space as well as with meeting a few friends from MIT's electric vehicle racing team. Magna also surprised our team by inviting us to the Formula E event this summer in New York - it was an exciting opportunity and many of us are planning to attend the event.

Five days afterward we hosted Waymo, and in typical Boston fashion the weather had turned from snow to sunny and warm. We had Simon Verghese, Brandon Luders, and Katie Lai representing Waymo. We followed the same format that we used for Magna's shop visit - first an update about MIT Driverless, then a presentation about Waymo and a short shop tour. Simon (Hardware Engineering) talked about Waymo's approach to autonomy and their progress so far, Brandon (Software Engineering) shared how Waymo does machine learning, and finally Katie (Recruiting) gave a quick update on Waymo's hiring process. I think I speak for the team by saying it was fascinating to hear about how Waymo is approaching one of the biggest engineering problems of our time.

It was a pleasure to host both companies and we look forward to hosting our other platinum sponsor (Samsung) on campus soon!

# TECHNICAL UPDATE

## STATE ESTIMATION



The goal of state estimation is to estimate the pose of the vehicle and the positioning of the cones that surround it. As input, our State Estimation stack takes time synchronized sensor measurements from IMU's cameras, GPS, etc., and cone location observations relative to the vehicle. Our stack simultaneously reconciles and fuses cone observations from separate perception pipelines while producing an estimate of the vehicle pose at high rate. The requirements on our pipeline are quite strict, as passing on errors in the crop up in initial cone detection or vehicle positioning can be

catastrophic. To that end, our team has been spending the past few months testing our state estimation stack for robustness and continually iterating on observation fusion techniques so that our overall system may be robust to the failure of individual components or pipelines. Over the course of the next couple months we will continue to validate our software stack on our testbed in MIT and complete transitioning to the full-size vehicle.

- Andrew Haeffner  
*Chief of State Estimation*

## MECHATRONICS

In order for our beloved DUT18 to evolve itself and become fully autonomous it has to be able to steer itself in the right direction. This month we have been hard at work to produce the necessary brackets, gears, spacers, mountings and more. Almost all of these have been or will be produced in house by our team members. We make use of a variety of different production techniques ranging from lathing, milling and general workbench equipment to 3d printing. For example last week Theo van der Zon, mechatronics part-timer, has been lathing the gear of the steering actuator to spec additionally to making a keyway to axially constrain the gear. For the most complex parts we have made use of a 5 axis CNC machine (Huge thanks to Julius Keur for helping us out).

The steering actuation is but one part of the list that the Mechatronics department occupies itself with on a daily basis. Even Though we trust the

DUT18 will be capable of evolving into a magnificent autonomous racecar, we take the safety of our team members and the crowd very seriously. Therefore the remote emergency brake will be implemented. The mechanical production of this emergency brake is being worked on at the moment. The emergency brake is made mechanically redundant by the use of two valves. If for whatever reason power to even one of these valves is lost, e.g. by pressing the remote emergency button, the valve will close and the brakes will be applied.

In the next few months we are going to assemble the steering and braking system inside of the DUT18. Additionally we are going to make sure the DUT18 is not afraid of the rain by designing and producing a watertight casing for it's sensor.

- Chadi Salmi  
*Chief of Mechatronics*





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