# DRIVERLESS
## MAGAZINE

**"We are in a vicious tango!"**

*- Chief CV to Chief SE*

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DELFT DRIVERLESS
FORMULA STUDENT TEAM

MIT DRIVERLESS

## Delft

**Chief Engineer/ Team Manager**
Rutger van den Berg

**Operations**
Bart Tromp
Efe Kulaksizoglu
Yannick Schulz
Akshaya Bomanwar

**Engineers**
Chadi Salmi
Cyril Trap
Achin Agarwal
Hermanis Ozols
Yannick Schulz
Jeffrey Montagne
Rami Younis
Youri Blom
Gilian Breysens
Sabri Mercimek
Bjorn Romijn
Edward Neate
Anneliese Schmidt
Thijs Raymakers
Yikai Zeng
Theo van der Zon
Mihail Ivanov
Titus Naber
Raj Kumar Muniyandi

**Art Director/ Photographer**
Yannick Schulz

## MIT

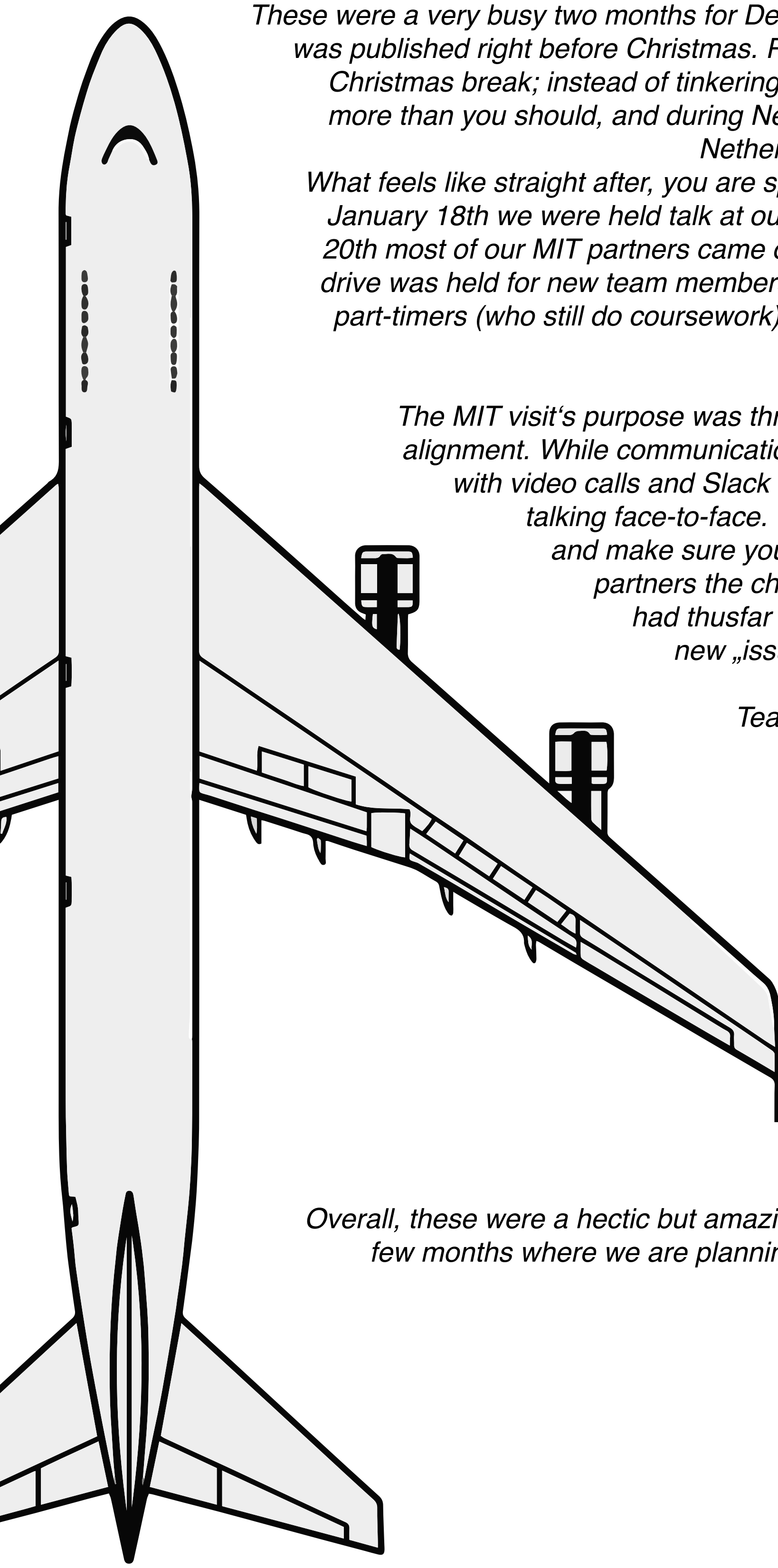
**Chief Engineer/ Team Captain**
Luke Kulik

**Team Manager**
Shaurya Agarwal

**Operations**
Kevin Cheung
Andrew Foster
Camila Metello
Brendan Stiffle
James Fok

**Engineers**
Allen Wang
Adam Potter
Kieran Strobel
Mohammed Kabir
Sibo Zhu
Lucas Igel
Kevin Doherty
Finn Xu
Kathleen Brandes
Andrew Haeffner
Mengyuan Sun
Nick Stathas
Raphael Chang
Ravi Rahman
Bouke Edskes
Emily Zhang

# WELCOME



*These were a very busy two months for Delft Driverless. The last edition of this magazine was published right before Christmas. Project wise, everything winds down over the Christmas break; instead of tinkering with the car, you go to see family, eat way more than you should, and during New Year's you light some firecrackers (in the Netherlands that is).*

*What feels like straight after, you are sprinting back into the work flow. On top of that; January 18th we were held talk at our sister team's Design Presentation, January 20th most of our MIT partners came over for a two week trip to Delft, a recruitment drive was held for new team members, there were exams during this period for our part-timers (who still do coursework). All of that and you have a busy two months indeed.*

*The MIT visit's purpose was threefold: teambuilding, testing, and project alignment. While communication over the Atlantic has worked great thusfar with video calls and Slack messaging; nothing quite beats meeting and talking face-to-face. You can really get the feel for one-another, and make sure you are on one page. Plus, this finally gave our partners the chance to look and work on the actual car they had thusfar only seen pictures of. And with this, plenty of new „issues" arose that will be rectified in the coming months.*

*Teambuilding was also a big thing on the agenda during the stay: every day we ate lunch and dinner together, we held a board game night, and we all went to Amsterdam for a big teambuilding day. Here, on top of showing the Americans all our fancy sights, we played around in a Virtual Reality room and found some time to relax.*

*Finally, the MIT visit was also a great opportunity to test the software under real world conditions with everyone present, more on that further ahead in this newsletter.*

*Overall, these were a hectic but amazing two months and we are excited for the next few months where we are planning on conducting fully autonomous tests.*

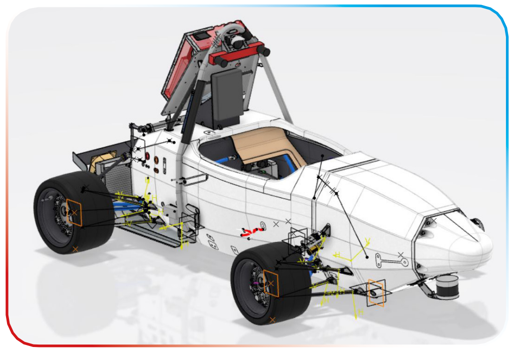
# THE DRIVERLESS CHALLENGE

*When designing a driverless racecar from an existing platform such as the DUT18, it is, unfortunately for us, not simply done by adding a lot of expensive sensors and smart software to get the vehicle to move. Replacing the human in the loop requires a substitute for the drivers inputs, such as for the pedals and steering wheel as well. This is the objective for our electronics and mechatronics department.*

## Mechatronics

Probably the most essential part of the system, the ability to turn the front wheels must be possible by some type of an actuator. One of the most challenging parts about the nature of the actuation is, that it must be built on top of an originally fully mechanical steering system while maintaining the ability to use the steering system manually (as originally intended).

Next to steering there are a couple more actions a driver typically has to do. Accelerate, which for our fully electric car is just as simple as sending the correct setpoint to the motor controllers and brake. There are two ways to brake, electrically by using the motors in reverse to regenerate the battery or mechanically by using the hydraulic braking system. While the former provides enough deceleration power for all the challenges we face, the latter still needs to be utilized in case of emergency. If the vehicle reacts unintentionally, the vehicle needs to return to a safe state by a remote signal within a time limit.

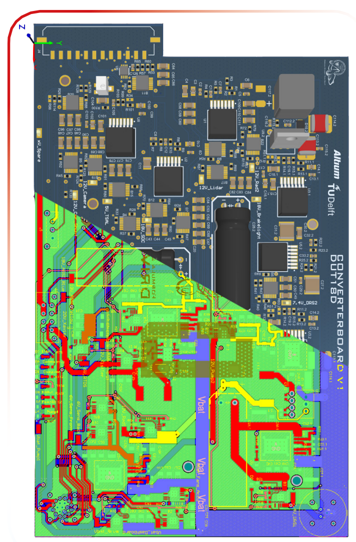


## Electronics

All the fancy sensors, computers and actuators, that are used to make the car autonomous won't work without power or ways to communicate. That is one of the parts where electronics come into play. Contrary to the existing implementation, the requirements for a driverless car basically throws over the carefully optimized power management of the DUT18. Low voltage systems, such as the LiDAR, cameras and processing units now consume much more energy, while the events we take part in desire less charge to supply the tractive system (high voltage system).

For the subsystems to communicate correctly, we also need separate circuit boards to collect data, provide functionality to actuators and a flawless and maintainable wiring in between.

While several PCBs (printed circuit boards) of the original implementation need adjustments to function with the extended use-cases of the autonomous system, there are also complete new challenges to us, such as the emergency brake system.



# EARLY DATA GATHERING DAYS

*Anyone, who recently read about the current development of autonomous systems probably didn't miss the fact, that a lot state of the art algorithms are largely data-driven. It is the basis of good performance for neural networks and any optimization is impelled by valuable and clean samples. Hence, delft driverless rushed to the testing ground to populate our database with diverse results.*

## Data gathering

The planning for the testing day began 2 weeks before the actual date. The main objective was to gather as much data as possible for computer vision and LiDAR algorithms with different parameters. We headed out to Valkenburg at 8 am in the morning only to face disappointment due to the strong wind currents and intermittent rainfall (unfortunately dutch weather is hard to plan with).

Hasting to still get some dry hours out of it, we unloaded the DUT18 and set-up the track with cones. For most of us it was the first time to see any Formula Student car running, hence we got a briefing about safety matters and the flag system from our experienced driver Jeffrey. Second on our checklist is the "shakedown". It basically means, Jeffrey drives a few laps at different velocities and settings to make sure everything is in working order and we can record our data safely and sound.

However, things didn't go quite as planned after that. Even after testing the data gathering pipeline in the workshop over and over, there were some complications with the sensors in the car. On top of that, water droplets on camera lens and LiDAR wasn't exactly what we had in mind for our first day of data gathering. Although the team got home with rainy sensor data and partly with a cold, we still learnt a lot and enjoyed seeing the car running.

We spent the next six days planning our second run. We packed our things and headed out once again with the hope of a sunny day. This time, we were not disappointed. The testing ground was dry, the sky was clear, some even pulled out their sunglasses. It was great to enjoy our coffee and lunch next to this beautiful scenery, while listening to the powerful, high pitch sound of the revving motors on our wonderful DUT18. It was so bright that we even struggled to validate our data during visualization after our runs. Without any major complications, we were able to get our workable clean data and rounded off the afternoon with a magnificent sunset on our last acceleration run. All in all it was a nice change to our first day and we were able to draw new energy and motivation for our endeavor.

# A DAY IN THE MILKDROP

*MIT is a sprawling campus of buildings, labs, and dorms across central Cambridge. Within this network, MIT Driverless lives in building N51 (MIT likes to refer to all its buildings by cardinal direction and a number. No names allowed!) in a workshop space called Milk Drop. The space houses many of MIT's tech heavy teams like Motorsports and the Marine Robotics Team. The team is 25 students strong, and every Friday and Saturday we get together in Milk Drop for a full day of work together. Let's go through a normal workday in the Driverless shop.*

It's 8am, and all of Milk Drop is understandably empty since no student gets up that early on a Saturday to go work on autonomous vehicles. Just kidding, the entire Path Planning team is already at the shop plugging away on our three overpowered desktop computers in the office. Coffee is flowing, headphones are on, and the team has already had a productive day before anyone else gets in. Around 10am, the rest of the team starts trickling into the shop. Getting in early definitely has its advantages, mainly getting some of the prime seating in the common working space where most of us sit (the office itself only has space for 5 or 6 people). The first hour is usually taken up by people making coffee, raiding the snack chest as breakfast (there's a 50 gallon plastic box with everything from nuts to chips to beef jerky), and most importantly following up on all the Slack conversations from the past week.


Once the full team is in, every subteam has their own style of working that stays pretty consistent. Path Planning is holed up in the office, Computer Vision is in a corner with headphones on, State Estimation is running around talking to different teams, and testing is tinkering with our model RC car testbed on one of the tables outside the office. The Driverless team is the largest team in Milk Drop, so even though the coworking space is for all the teams it's usually overtaken by us on Fridays and Saturdays. If someone watches us from afar, it may seem a bit chaotic with people up on whiteboards, subteams meeting with each other, and the team leads running around talking to different subteams. It's a controlled chaos though, and it's what makes the process of working on a difficult problem like autonomous vehicles challenging and rewarding.

Our team has a wide range of personalities, from overly extroverted members to quieter ones, and with our counterparts at Delft the full team has no shortage of interesting conversations and pairings. While we're mainly in the shop on Fridays and Saturdays, the work never stops during the week. Slack, email, and interesting problems to solve keep us engaged every day as move closer to having a fully autonomous vehicle for August!

# Technical Update

## Perception Computer Vision


One of the methods we use to detect cones uses cameras. To a human, it's pretty obvious what a cone looks like, and you can get a pretty decent idea how far away it is. You usually won't even consider how you came by this information. For a computer, this is not quite as trivial. We can detect cones in the image without too much effort – just look for a vaguely cone shaped area in the right color. But this doesn't tell us how far away it is. Our driverless car has three cameras, and two ways to determine distances.

At range we use a pair of side by side cameras to do stereo vision. This is basically the same way a human can perceive depth – there are two views of the same object, and the difference between the two can be used to calculate the distance.

For shorter range detections this is less effective, because the cameras are optimized to see far away. The third camera is focused on a wider area closer to the car. Here we can use the fact that we know the size of the cones, we know the size of a cone on the image, and we know the properties of the camera to determine their distance.

Right now we've got the basic computer vision framework running. We're currently working to increase the range at which we can accurately detect cones, and to reduce the computation time needed to process the images.

- Kieran Strobel
  *Chief of Perception CV*

## Pathplanning

The path planning team has developed a significant amount of software capabilities. We currently have: reconstruct track boundaries from cone detections even with false positives, one simple and one more complex model predictive controller, and a sampling based path planner. Our system can currently run on simulation and a very short distance on our smaller test-bed car. We are currently working on ensuring our software system can handle and recover from every failure mode that is recoverable (e.g. the car should decide to stop itself if the track boundary can't be properly constructed in time and collect more data). This will require extensive simulation and testing with real data collected from the car. Essentially, we gather data from manually piloted runs and make it "think" it is actually driving a car. We are also beginning development on a "system identification" pipeline. This involves collecting data on how the car moves in reaction to our commands to improve the decision making of our algorithms.

- Allen Wang
  *Chief of Pathplanning*

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