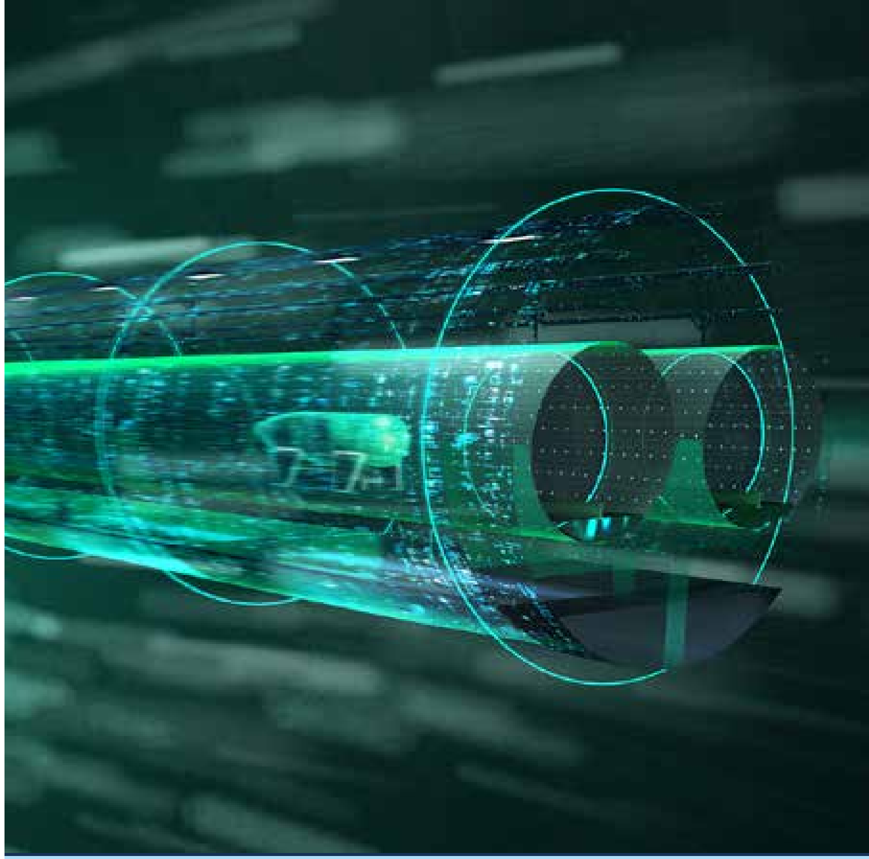
ERIKS and TU Delft students collaborating on Hyperloop

CREATING THE FUTURE...

...BY REINVENTING THE WHEEL



Innovating on the edge of what is possible. That's what ERIKS has been doing over the past 12 months in an intensive partnership with 38 students from the Delft University of Technology. Together, they designed and built a pod with the aim to win the annual Hyperloop competition, organized by Elon Musk's space transport company SpaceX in California. Thanks in part to ERIKS, the team from Delft came second in this prestigious competition, after a frantic race against the clock - a world-class performance. "You could say that this would never have been possible without ERIKS."

WHAT IS THE HYPERLOOP?

The Hyperloop is an energy-efficient transport system in which pods travel through a vacuum tube at high speed like a kind of a pneumatic dispatch system. The idea that the system could eventually transport people at the speed of an airplane and with the convenience of a metro line captures the imagination. In theory, capsules in the tunnel could reach speeds of 1,220 kilometers per hour in the future. At that speed, you could get from Amsterdam to Paris within half an hour.

We have not reached that point yet. And this is exactly the reason why Elon Musk holds an annual competition to further develop the system.

The vacuum tube: only for the very best

Teams from all over the world are trying to build a capsule, or 'pod', that is good enough to be allowed into the 1.2 km vacuum tube on the SpaceX site. The team that shoots through the tunnel fastest, wins.

This competition sounds simple, but is very complicated in practice: the design is subjected to more than a hundred tests on different components during a week of intensive testing. Only if you pass the tests, do you get access to the tube. To be invited by SpaceX in the first place, months of preparation are needed. Of the 20 teams that were judged good enough to take part in the test week, only three teams made it to the competition day. Delft was one of the top three best teams and - supported by ERIKS - had to work very hard to achieve this. During the project, ERIKS provided essential advice on the drive system and proposed high-tech solutions for such things as developing the drive wheels, support wheels and battery casing.

COMPETITION DAY

On the day of the competition, the Delft pod reached a speed of 142 km/h. Because the competition took place in the afternoon, the tube was hotter than expected. This caused the motor to overheat, activating the safety mechanism, after which the motor shut down before reaching top speed. The Hyperloop team from Munich won with an incredible record speed of 466 km/h.

Partnerships are crucial

Nevertheless, Pieter-Bas Bentinck, a student of aerospace engineering, looks back on the Hyperloop adventure with great pleasure. “Although some things went wrong, this was a great learning experience. Throughout the project, we learned about things that have never been done before.”

“Partnerships are crucial, because we are students and have a limited budget”, he continues. “We had partners who only provided financial support, but the people at ERIKS even made their time, expertise and components available. What’s more, they were involved in the project at a very early stage.”

“We were sucked in”

“ERIKS became increasingly involved during the course of the project, says Head of Communications Daan Heijbroek.” “We were really motivated by the enthusiasm of the students. First we thought, ‘we’ll give them some money and see what happens in L.A.’. But in the end we didn’t transfer a penny; we paid everything in kind with manpower, time and components.”

A long trip

The competition in July was the final part of a trip that ERIKS and the students embarked on in September 2017. Project leader Paul van der Stigchel, Manager Engineering at ERIKS, was the link between the students and the various departments of ERIKS from the start. “Students and coworkers really had to push the limits in this project. It was great to see the enthusiasm that coworkers showed for helping in this project, even outside office hours.”

KEY TECHNICAL MOMENTS
IN THE RUN-UP TO THE COMPETITION AT SPACEX

1 Crucial advice on the motor in the design phase

From the very beginning, choices had to be made that would later prove to be crucial. Van der Stigchel: “Together, we looked to see where we could help from the start. In the first instance, we still had to choose between an electric motor with wheel drive or a linear induction motor. At the motion control department in Schoonhoven, the students told us that their goal was to win.” That might sound logical, but there are also teams whose goal is just to make it to the test week in L.A. “Going for a win meant that we had to focus entirely on the top speed, because that was the only criterion for victory.”

Want to win? Go for wheels!

“We said that, to have a chance of winning, the team had to choose an electric motor with wheel drive. If you want to reach the highest top speed, it is important to accelerate as fast as possible. What’s more, we knew that it was not possible to make adjustments to the tube by fitting magnets. So the capsule had to transport its own energy. The bottom line was that the design had to have the best possible power to mass ratio: as much power as possible at the lowest possible weight.”

Clear advice

“We therefore advised against using a linear induction motor,” continues Van der Stigchel. Linear drive based on induction has an efficiency of about 20 percent, compared to 80 to 90 percent for wheel drive with an electric motor with permanent magnet. You have to make up that difference by taking extra batteries with you in the capsule. That would increase the weight again, so you need even more power. As you’ll understand, this gets you nowhere fast. So based on our advice, the students opted for an electric motor with wheel drive.”

PAUL VAN DER STIGCHEL:
“WE HAD TO COME UP WITH SOLUTIONS ON THE EDGE OF WHAT WAS POSSIBLE.”

2 Vulcanizing the perfect wheel

After selecting the electric motor with wheel drive, the race against the clock really started. Choosing wheels led to one of the biggest challenges of the project, which would put the ingenuity and stress sensitivity of ERIKS and the students to the test. Wheels had to be designed that could withstand high speeds and were suitable for the extreme conditions in the tunnel. “In the end, we spent most of our time researching this specific challenge,” says project leader Van der Stigchel. “The pressure was really on and sometimes our colleagues had to work late evenings. We even provided advice on the final adjustments during the test week in L.A., through our colleagues in Norwalk, California.”

“To 200 degrees in 15 seconds”

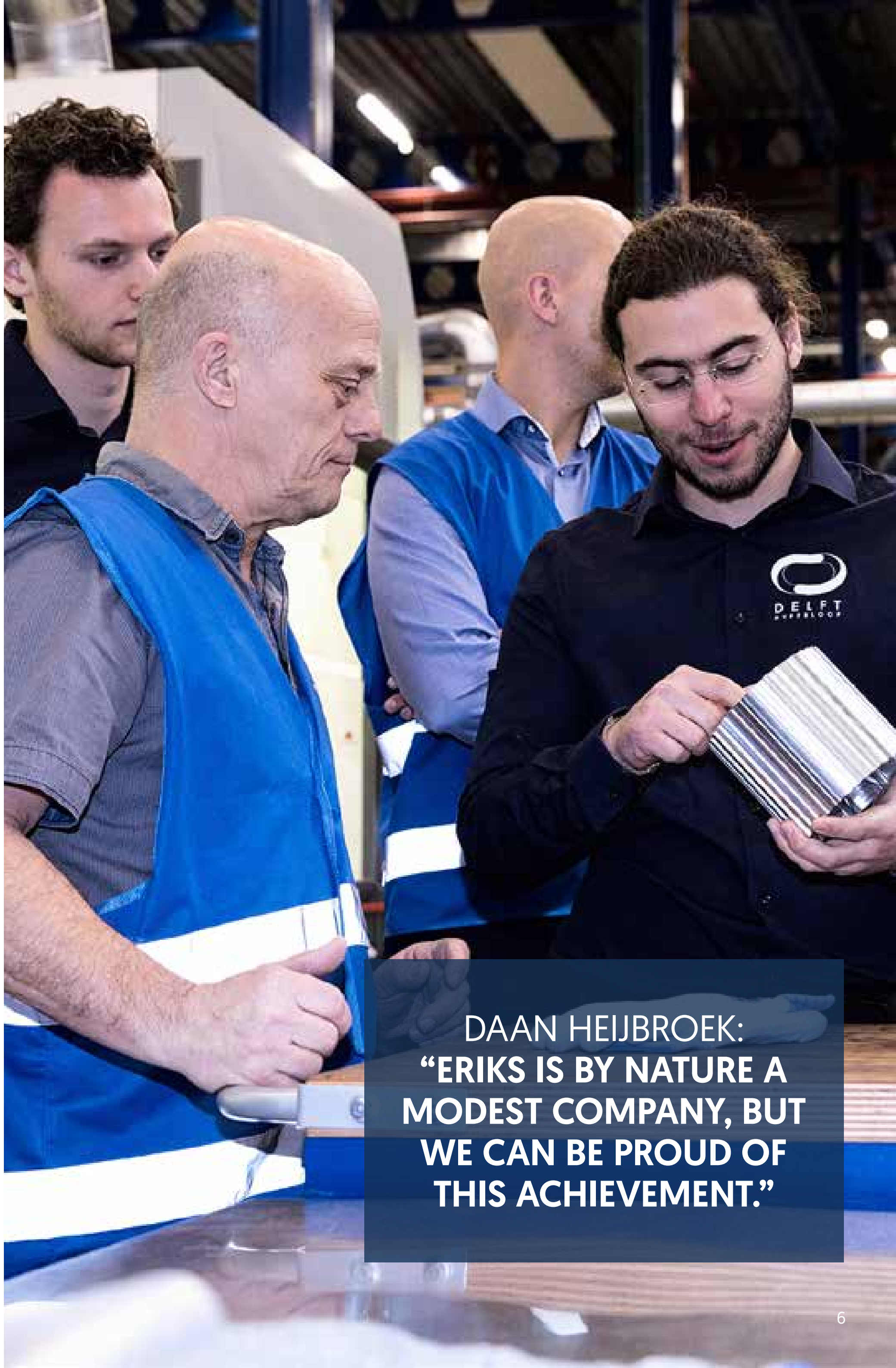
The emphasis on speed made the wheels crucial to this design: the load on the rubber would be enormous due to the high centrifugal force that would be released. “The RPM could get up to 17,000, which means the temperature of the tires could rise to 180 to 200 degrees in 15 seconds”, says Pieter-Bas Bentinck of the Delft Hyperloop team. “It was important to develop wheels with as much grip and torque as possible. At the same time, the rubber had to remain firmly attached to the aluminum rim.”
Van der Stigchel continues: “In short, we needed a type of rubber that is stiff, but also provides grip and adheres well. In the Elastomer Research Testing Center rubber lab in Deventer, we developed three new compounds by adding fibers to the rubber. The students chose one. Mind you, we can also use these new types of rubber for other projects in the future.”

140 bar

Now that the material was chosen, all that remained was to fit the tire around the aluminum core. That too sounds easier than it was. The team could not have done this without the knowledge and skills, but also the facilities and materials, of ERIKS’ rubber technology department in Alkmaar. Molding specialists designed and produced a mold to vulcanize rubber to the rim at 160 degrees and under no less than 140 bar pressure. In addition, coworkers recommended applying a thin layer of coating to the sandblasted rim for the best adhesion between core and rubber.

Reinventing the wheel

But you can’t just reinvent the wheel as simply as that. The first production batch went wrong. The core of the rim was hollow, which caused it to be deformed by the high pressure in the mold. On the second wheel, the core was solid, but the heat made the rubber come off during the intensive load tests. This was solved by giving the rim itself a new structure, so that pieces of rubber could push themselves into the rim like anchors. Bentinck: “In total, four versions were made in four months. That made for a very tight schedule, because a lot of production went into it. We received a great deal of help from ERIKS throughout that process.”



A good match

“The solutions that were needed went just a little further than we are used to in our daily work,” says Heijbroek about the partnership. “We wanted to prove to ourselves and to the world that we can keep up with the best. Because the innovative character, the Hyperloop project is a good match for ERIKS.”

“100-hour working weeks”

The partnership had yet another important advantage, says Heijbroek: “The intensive cooperation allowed colleagues at ERIKS and the students to get to know each other well. They now know what ERIKS stands for. This is important because these talented students will soon be able to work anywhere. We are very impressed by their skills and ambition. They do not balk at a 100-hour working week, and they always deliver something extra; Elon Musk’s assignment was a fast pod, Delft delivered a total concept. We share the same enthusiasm and passion for technology, and that was great fun to see. This project really brought back the student in us. Everything was last minute, but lines of communication were short and there was an opportunity to make mistakes and learn from them. I think this partnership was a great benefit to us.”

3 The support wheels give balance through strength

The Delft students' design had a chance of winning only if the support wheels could keep the capsule stable at high speed during the competition. Here the difficulty consisted in using the right material. ERIKS was able to contribute its experience in this area to the development. Bentinck: "ERIKS advised us to use a hard material that was very shock-resistant. Because the wheels were not subject to torque and did not need to drive the capsule, they needed less grip. The material could therefore be harder."

Withstanding a lot

"But these wheels have to withstand a lot," explains Van der Stigchel. "For this, we called in the knowledge of our Industrial Plastics department. At first we tried polyurethane wheels, but that material wasn't strong enough. That is why we chose Gesadur: a polymer-filled plastic. This material can withstand extremely high pressure because the fibers in the fabric are three-dimensionally linked. You might describe the fibers in the fabric as being knotted together."

4 Space technology

A prerequisite for completing the Hyperloop project is the ability to think out of the box. That was true for the wheels and the drive, and even literally for the battery.

The fact is that a battery will not work in a vacuum; the atmospheric pressure must be at least 1 bar. In the L.A. tube, the battery needed a sealed box where inside the pressure was locally higher. Bentinck: “It became a carbon fiber box on an aluminum plate. The experts at ERIKS sealed the box so that no air could escape.”

“Never been done before”

The hardest part was sealing the connector - the part of the battery that transfers power from the inside out. “Here the challenge was to go from pressure to vacuum. This technology is used in space travel, for satellites for example. But this connector had to transmit 200 kilowatts - much more than in space. That had never been done before.”

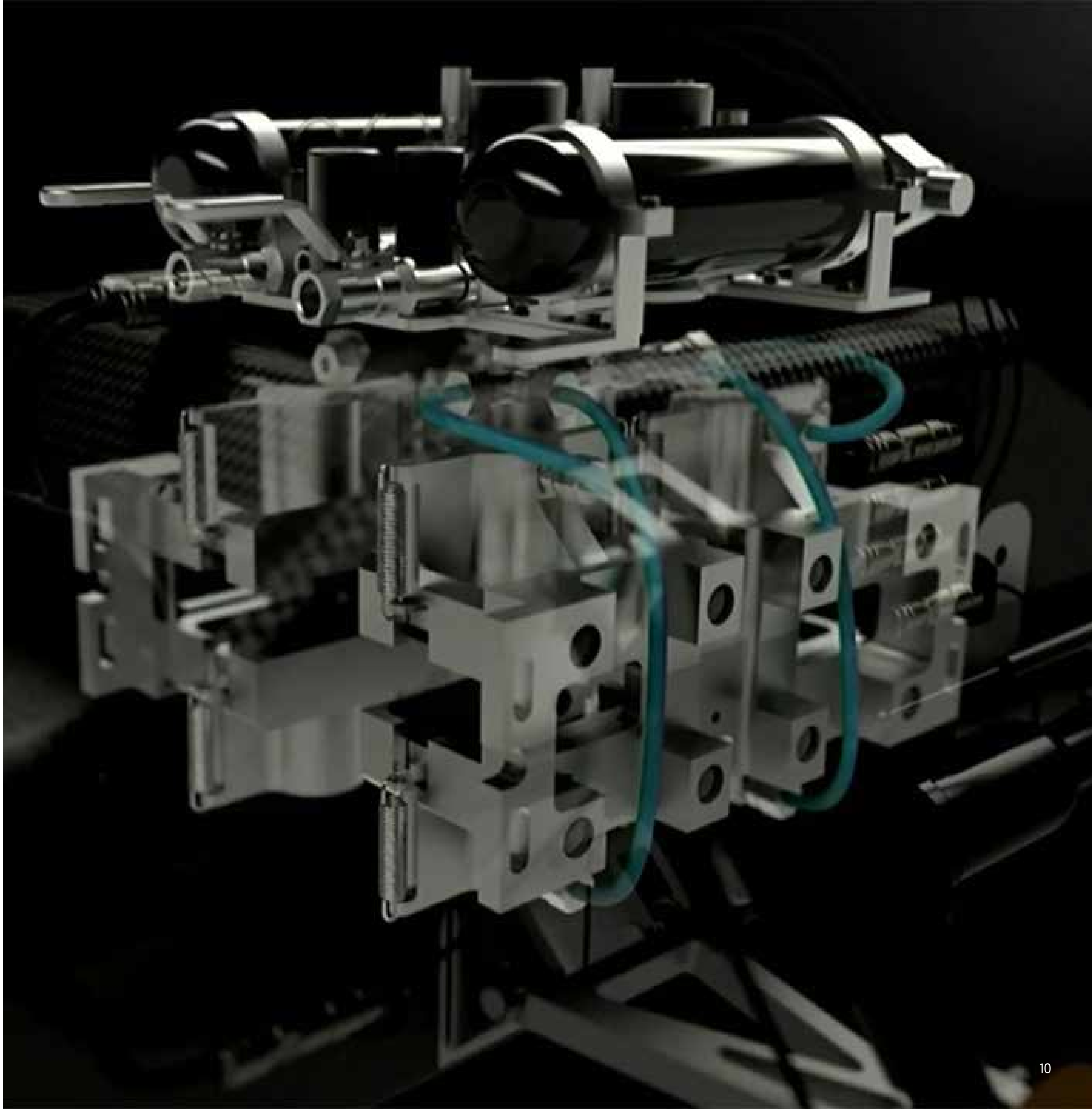
It was a big job, although ERIKS’ specialists did not have to think about it for as long as they did in the case of the wheels. “We do get questions about sealing more often,” says Van der Stigchel. “We have people in-house who have a lot of knowledge in this area, even though it wasn’t exactly an off-the-shelf solution.”

5 The threat of overheating brakes

A major challenge in the tube is making sure the pod brakes in time. Checks on the SpaceX tube are particularly strict in this respect. There is always the threat of brakes overheating because there is no air to cool them down. In the test week, Team Delft still had to make final adjustments to be admitted to the tube.

What do you choose?

During the development of the braking system, ERIKS helped to select the right components. The students used a double braking system, in which the calipers were operated by compressed air (60 bar). ERIKS advised the students and supplied pipes, ball valves, electromagnetic valves and pressure relief valves. Van der Stigchel: “ERIKS also supplied components throughout the entire project. In a project like this, you constantly need connectors, bearings, etc. The students had free access to our parts center in The Hague.”



PIETER-BAS BENTINCK: **"YOU COULD SAY THAT WE WOULD NOT HAVE SUCCEEDED WITHOUT ERIKS".**

In the nick of time

On the day of the competition, the motor, drive wheels, support wheels and battery passed the test with flying colors. During the test week, the brake system was found to be good enough after some adjustments. For the Delft students, taking second place felt like a victory in itself, because whoever balances on the edge of what is possible will sooner or later face setbacks. Whether Team Delft would return home disappointed hung on a hair's breadth. Two days before the big competition, the motherboard short-circuited. Bentinck: "The brain of the system was dead. It was only the night before the competition when we found an old motherboard that still worked. Of course, that was a great relief. We had almost given up."
"For us, the Hyperloop competition was a commitment, but also for the people at ERIKS, of course," Bentinck concludes. "We were very pleasantly surprised by their huge involvement: in the technical area, but also in the project as a whole".

Not being modest

Heijbroek: "The students had to learn a lot in a short time, while coworkers at ERIKS really had the opportunity to prove themselves on a project where the outcome was uncertain. I think we were able to show our added value. ERIKS is by nature a modest company, but we can be proud of this achievement. We really contributed to its success."