DELFT OUTLOOK
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TU Delft

RONALD PRINS
'To hack effectively, you don't necessarily need a degree'

DELFT TOP ATHLETES
THEY ARE GOING TO RIO

AHD HAMIDI
Cheaper vaccines for developing countries

THEME
Sports

Cover:
'Two Delft alumni will be rowing In the Holland Eight: Olivier Siegelaar and Peter Wiersum. By photographing them this way, the difference in size between a rower and a steering man becomes even more clear.
Photo: Sam Rentmeester

EDITORIAL
Frank Nuijens

Sports

The Olympic Games in Rio de Janeiro are fast approaching. Seven TU Delft students and alumni are participating, and we are pleased to introduce them to you. These days sport is not only practised, but also researched. The expertise of the university's mental gymnasts is brought together at the TU Delft Sports Engineering Institute, founded two-and-a-half years ago, where five faculties and many companies, including Adidas, Gazelle and DSM, work in partnership. 'Sport as science' brings a number of advantages. The controlled environment of the sports arena, for example, is ideal for experimental research. Scientists, like athletes, want to push back frontiers, so innovations are welcomed with open arms.

For scientists, sport is also a great way to make fundamental research visible and, above all, tangible. When Arend Schwab (3mE) uses a lab-bike to investigate how racing cyclists can whizz down a mountain at breakneck speed without crashing, this knowledge can also be used to help keep our ageing population on their e-bikes. And if putting an improved coating on a racing boat can win rowers a second of time, it can save an oil tanker many litres of fuel. Sports research is a multidisciplinary field, and it has thus found fertile ground in the high-density university landscape of the Netherlands. Our sporting expertise is competitive as a result – hopefully just like our athletes this summer.

Frank Nuijens
Editor-in-chief

PHOTOGRAPH: SAM RENTMEESTER

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COLOPHON
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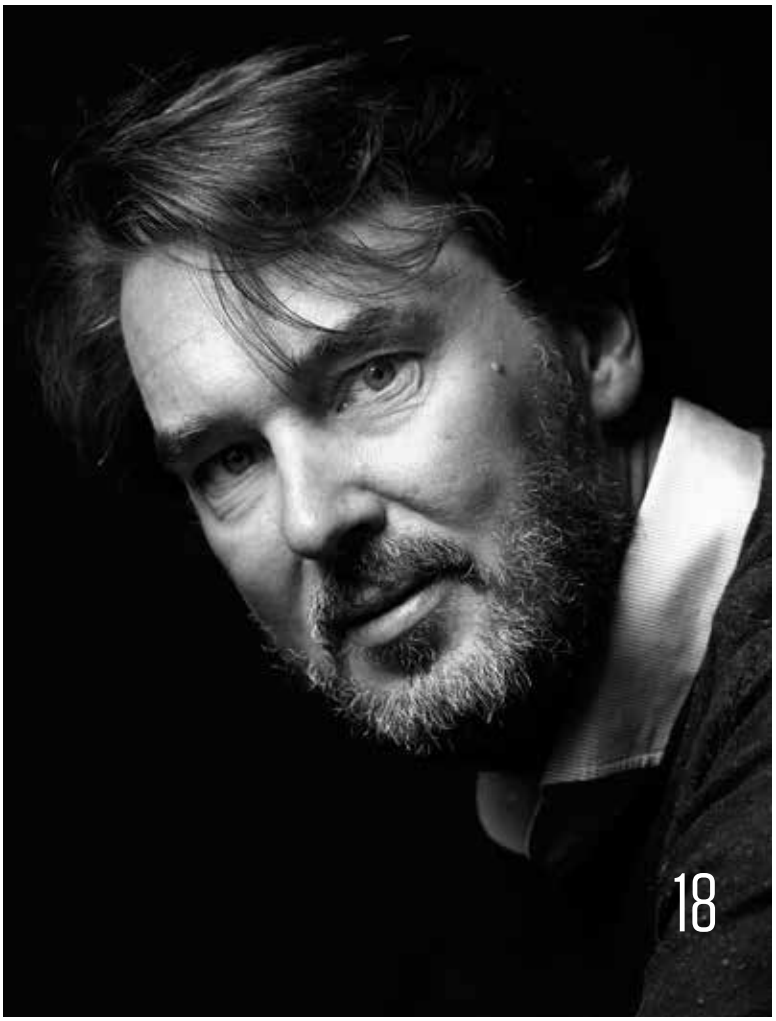


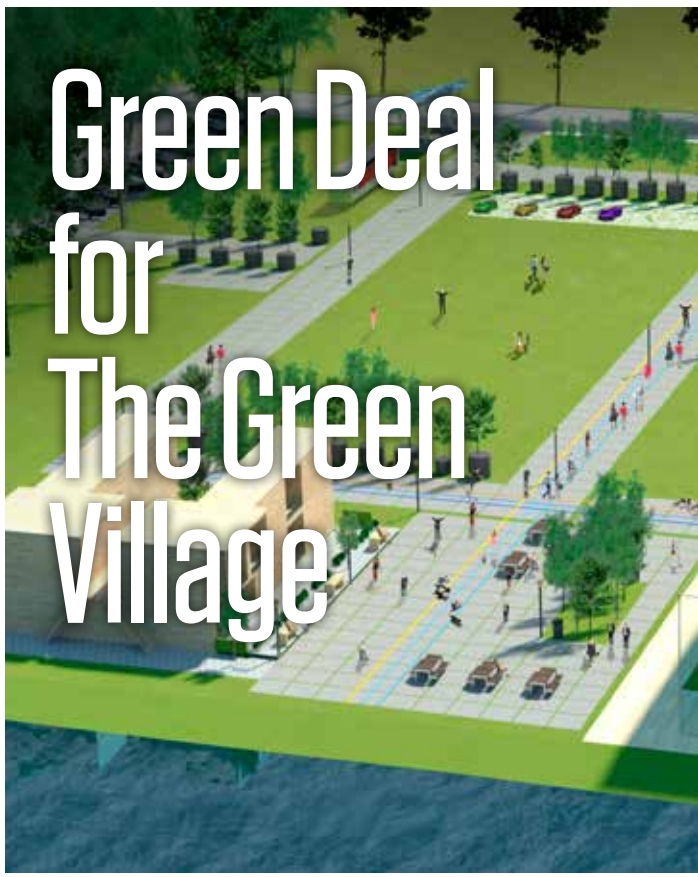
DELFT IN BRIEF

PHOTO: SAM RENTMEESTER

Smart bridges

Technopolis science park for high-tech start-ups had a first this summer. In early June, four plastic bridges were taken into use, fitted with lots of sensors. Although the start-up company MOCS had already supplied plastic bridges, the bridges and platforms behind the YesDelft building are the first with built-in sensors to measure strain, vibration, load and temperature. The sensors can be read remotely and are expected to provide a good impression of the technical condition of the bridges. Managers can also use temperature readings to decide when to grit the road surface.
delta.tudelft.nl/31738

PHOTO: SAM RENTMEESTER



Ytong returns

Almost a century after autoclaved aerated concrete was first developed, it has been rediscovered as the most energy-friendly construction material for both Egypt and the Netherlands. Dr Ahmed Hafez (A+BE) was even surprised about it himself. For application in Egypt, it was its thermal insulation value and low density (0.3-0.6 kg/litre) that made the difference. For the Netherlands, key factors were the minimal energy needed for production, the low CO_2 emissions, the potential for reuse and relatively low wall thickness (32 cm). So why is the material, known by its trade name Ytong, still used so rarely? Hafez believes that contractors are primarily driven by low construction costs and the sector tends to stick with the materials it knows.
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ARTIST IMPRESSION: GREEN VILLAGE

An end to inhibitive regulations and laws that hamper innovation. The Green Village, on TU Delft campus, aims to become a haven for engineers focusing on green energy. This is the intention of the signatories of the Green Deal: TU Delft, the Dutch government, the province of Zuid-Holland, Van Delfland Water Authority, the Municipality of Delft and various other market parties. During the signing ceremony on 2 June, the brains behind the Green Village, Professor of Future Energy Systems Ad van Wijk (3mE), presented the fuel cell of a Hyundai car that runs on hydrogen and can supply electricity to the grid. Van Wijk's group worked on the development of the fuel cell. The car is now like a miniature power plant on wheels. Van Wijk predicts a future in which cars operate as small power plants when parked.
delta.tudelft.nl/31730

Record number of Vidi grants

Ten experienced TU Delft researchers have been awarded Vidi grants by the NWO. 'An absolute record', said Rector Magnificus Karel Luyben. NWO has awarded a total of 87 Vidi grants worth up to € 800,000. TU Delft tops the list with its 10 grants. The recipients include seven men and three women: Simon Groeblacher (Quantum Nanoscience, Applied Sciences); Hayley Hung (Intelligent Systems, EEMCS); Leo van Iersel (Applied Mathematics, EEMCS); Alexandru Iosup (Software Technology, EEMCS); Merle de Kreuk (Water Management, CEG); Wilson Smith (Chemical Engineering, Applied Sciences); Heike Vallery (Biorobotics, 3mE); Menno Veldhorst (QuTech, Applied Sciences/EEMCS/TNO); Maarten Wijntjes (Human Information Communication Design, IDE); Hyun Youk (Bionanoscience, Applied Sciences). Read more about their research:
delta.tudelft.nl/31612

Lighter wind turbines

Wind turbine masts could be made 30% lighter. This is according to meteorologist Dr Maarten Holtslag based on his doctoral research 'Far offshore wind conditions in scope of wind energy' in the AE faculty's wind energy group. Vertical wind shear (fluctuations in wind speed according to altitude) and turbulence both cause fatigue in wind turbine blades, rotors and masts. However, and this is what makes the difference, they do not occur at full strength at the same time. If the wind shear is significant, turbulence is low, and vice-versa. Holtslag's work is part of the FLOW (Far and Large Offshore Wind energy) research programme that aims to reduce the cost of offshore wind by at least 20%.
delta.tudelft.nl/31790

Pain relief

In the best Dutch tradition, one-third of all childbirths take place in a home environment. But due to strict regulations set by the Dutch Ministry of Health, painkillers like laughing gas are not allowed there, while demand is ever growing. Industrial Design Engineering student Eva Schuurmans invented a solution: a system for providing laughing gas at home. Some companies have already shown their interest in Schuurmans' design. Encouraged by these enthusiastic reactions, she would love to get her design on the market: "I just want to make births in a home environment easier, but I cannot do it on my own. Additional expertise is necessary."
delta.tudelft.nl/31734

Mathematicians help fire fighters

Accidents, fires, strokes and other calamities. These are things that the emergency services encounter on a regular basis, but always arriving on time and ensuring that you have ambulances to ferry patients from one hospital to another can be a logistical nightmare. Mathematician Dr Pieter van den Berg has developed models for optimising the logistics of emergency response services. He was awarded his doctorate at the EEMCS faculty on 6 June for his work. The engineer developed a model for optimal distribution of fire engines within a given security region. In Norway and Canada he developed models for air ambulance services.
delta.tudelft.nl/31689

Robot arm for Duchenne patients

Robotic support can be useful if you suffer from muscular disease. But no one wants to look as if they are half-man, half-robot. Young people suffering from the muscular disease Duchenne, which affects one in 5,000 boys, often complain that their supports are too heavy and conspicuous. With them in mind, biomechanical engineer Dr Gerard Dunning developed the A-Gear robot arm. This spring-fitted tool that attaches to the body and is worn under the clothes can provide support to Duchenne patients in their day-to-day activities from the age of 10. Dunning received his doctorate for his design on 22 April. He developed the prototype with researchers from the University of Twente, VU University Medical Center and Radboud UMC.
delta.tudelft.nl/31516


PHOTO: SAM RENTMEESTER

Better and cheaper solar cells

Dr Olindo Isabella (EEMCS) has received a Horizon 2020 research grant for developing better and cheaper solar cells. The NextBase consortium, which Isabella was invited to join, consists of eight research groups and six industries (including DSM). Together they have received € 3.8 million to develop a new generation of crystalline silicon solar cells. The Delft research group will receive 10% of the budget. The new solar cells will enable modules to achieve 22% efficiency (the standard is currently 15 to 19%). The price will be lower than 35 eurocents/Wp. It is currently around 40-50 eurocents/Wp. The new solar cells, which will take three years to develop, promise to be both cheaper and better than existing cells.
delta.tudelft.nl/31791

New building block for quantum computers

A quantum computer uses bits that are not only 0 or 1, but can be both at the same time. Unfortunately, this quantum information is so fragile, that it is quickly lost. A team of scientists led by QuTech's Tim Taminiau at TU Delft have now demonstrated for the first time how errors in a quantum calculation can be tracked down and actively repaired, without losing the quantum information. By applying repeated quantum error correction using electron and nuclear spins in diamond, they were able to store sensitive quantum information for longer than without this error correction. Resolving errors in quantum calculations is crucial for the development of a working quantum computer. The scientists published an article about it in Nature Communications on 5 May.
delta.tudelft.nl/31604

Rectification

The interview with Professor of Public Housing Peter Boelhouwer from April 2016 contains an error. It incorrectly states that Groningen is hit by some thousand earthquakes every year. In fact, Groningen has been hit by more than a thousand earthquakes since 1987.

THEME

Sports

They go head-to-head on the water, but work together back at the lab: competition rowers Arnoud Greidanus (Proteus-Eretes) and Conno Kuyt (Laga) proved that zigzag strips can make a difference at the upcoming Olympic Games. See page 11. This is just one of the many sports research projects conducted at the TU Delft Sports Engineering Institute. Alongside top sport, it is also home to recreational and adapted sport.

PHOTO: SAM RENTMEESTER

TEXT: JOS WASSINK
PHOTOS: SAM RENTMEESTER

Data as the new doping

Never before have athletes produced so many figures. Sensors and statistics can improve sports performances, and early users are particularly at an advantage.

Skating coach Jac Orie was one of the first to discover this. Over the past fifteen years he collected training data from forty skaters: heart rate, lap times, and subjective intensity scores. Together with Leiden University data scientist Arno Knobbe Orie discovered the phenomenon of 'super compensation': after a heavy training session, athletes are first tired, then incredibly fit, before finally falling back to their base level. Orie uses this knowledge in his training sessions to allow skaters to peak at exactly the right moment. This led to Kjeld Nuis winning a gold medal in last winter's World Championship.

To measure is to win

Cycling team Giant-Alpecin is also monitoring its cyclists' performances. TU Delft student Marieke de Vries (Applied Mathematics) helps the team to identify anomalous performances in the huge data sets collected by the team managers: the cyclists' heart rate, pedalling force, speed, and track. If performance is lower than expected, the cyclist is probably coming down with something.
Another TU Delft student, Jeroen Roseboom, worked with embedded scientist Koen Muilwijk from InnoSports Lab The Hague on the current, wind, boat speed and boat position data of boats sailing across the Bay of Rio. The coach, collecting data from a dingy, noticed that strange values were appearing in the data at the moment of tacking. "There was a lot of white noise in the data," says Professor Geurt Jongbloed. Jongbloed is Professor of Mathematical Statistics at the Faculty of Electrical Engineering, Mathematics and Computer Science. Roseboom developed a correction for the measurement data based on a mathematical model. "These are measurements of current, wind and speed in relation to the water, which means that these data are interdependent. This redundancy can be used to improve the deviant measurements."
His colleague Professor Geert-Jan Houben (Professor of Web Information Systems at the Faculty of EEMCS) worked with Ortec Sports ('creating value from official data') on the input of football and hockey data. Some data, such as position in the field, speed, and heart frequency, are recorded directly through sensors. Other data, such as possession of the ball and number of successful passes, are recorded manually. But how reliable are these data? What can be done about missing data? And how many people do you actually need for tracking? To answer these questions Houben uses the knowledge he acquired when studying the use of crowdsourcing for the description of drawings at the Rijksmuseum. Houben: "We develop general theories that can be applied to concrete situations. Whether you are looking at a play situation or deciding which people to deploy for interpreting a drawing, the generic principles are the same."
As an example, Houben mentions the analysis of passes, which can range from fast and short ('tiki-taka' style) to long and far ('kick & rush'). For a coach, it is important to know where the ball that a striker kicks into the goal came from. If a pattern can be found, the coach will know where to place his defending players in order to intercept this kind of pass.

'Once everyone starts using data science, it will be the end of top sport'

Does this lead to a competitive advantage? Temporarily, yes, according to Houben. If only one of the teams uses this kind of data analysis, this team will

Devices like the little blue measuring instrument on the bike above, are generating a tsunami of data. The challenge is filtering the data.

have a clear advantage. “But once everyone starts using data science, it will be the end of top sport,” philosophizes Houben. “Because it is precisely the uncertainty that makes top sport exciting. And this is what you lose when you know everything.”

Pack of millions

Cycling app Strava counts more than eight million users worldwide, more than one million of whom are active (i.e. with recent posts). This makes this sports app, used by cyclists and runners to share their performances and routes with other users, one of the best known recreational sports applications.

“In amateur sport, the data per athlete are less comprehensive and less reliable than in professional sport,” says Houben. Data regarding age, gender, heart frequency, speed, track, altimeters and pedalling power are all saved so that you can compare your performance to that of others. But how reliable are these data? Houben pleads for data literacy so that people learn to use these applications better. “You shouldn’t blindly trust a training advice without knowing what it is based on.” His colleague Jongbloed also sees advantages: “If you see that on a certain track your own heart rate increases much faster than that of other athletes, it may be worthwhile to have it checked out.”

Intersecting lines

Our computational power is increasing according to Moore’s Law, but the quantity of available data grows much faster still. At some point these lines will intersect and we will have more data than we can handle. How can we keep sports data manageable and relevant?

“Devices are generating a tsunami of data,” says Houben. “It’s not that easy to make sense of it all. Our greatest challenge is filtering the data. Data should have a clear meaning and structure. Once you have achieved this, it is much easier to process the data.”

Jongbloed sees the presentation of the results as an important challenge. How do you translate statistical connections to advice for a coach or trainer? Visualisation can be helpful in this context. Clear visuals can make all the difference. But the question remains: How did a particular result come about? “This still requires a certain level of knowledge,” says Houben. <<

On 17 April, the Data Science & Sports Seminar was held in Delft, in which researchers, coaches and companies were invited to share their experience of using data techniques in the field of sports. Houben and Jongbloed were the TU Delft hosts. A report of the seminar can be found at delta.tudelft.nl/31441

From underwater bicycle to flying boat

For quite a few Delft Dream Teams, the sporting season revolves around the hunt for new victories and records.

In the past our teams have achieved quite a few top results with their projects centred on sustainability, innovation and technological advances. For example, last year, the Nuon Solar Team won for the sixth time the 3,000 km World Solar Challenge with their solar vehicle **Nuna 8**. The next edition of this challenge will take place in 2017. In September 2016 an improved version of the Nuna 8 will be tested in the course of the Solar Challenge in South Africa. The **DUT Formula Student** Racing Team, also active since 2000, has since 2011 specialised in ultralight four-wheel drive racing vehicles. This year they are getting back to work and they hope to be true to their motto 'Design, build, race & win!' on the circuits of Silverstone (UK), Hockenheim (Germany) and Barcelona (Spain). In addition to speed, Formula Student can also score on the following components: design, business presentation, acceleration, and sustainability. Last year, they came in first on two occasions with a 163-kilogram cart and a top speed of 127 km/hour.

Former professional skater Rintje Ritsma will be riding the NovaBike as soon as it is ready

The Human Power Team, a joint venture between TU Delft and Amsterdam VU students, has some catching up to do with its super fast **VeloX** recumbent bicycle. Their much advertised last year's attempt to improve on their own world record (133.78 km/hour) fizzled out due to bad luck and technical problems. In August, in the Nevada desert, former skater Jan Bos and former professional cyclist Rick Flens will be attempting to win the world speed record (139.4 km/hour) back from the Canadians. **Nova Electric Racing**, formerly known as NovaBike Racing Team Delft, recently switched from a combustion engine running on bio-ethanol to a fully electric drive. The team aims to demonstrate that it is possible to use renewable energy without compromising performance. To do so, they are taking part in the MotoE race and the Gamma Racing Day in August with the first-ever Dutch electric racing motorbike. The project's ambassador is former professional skater and speed lover Rintje Ritsma, who will be riding the motorbike as soon as it is ready.

Some races are due to take place between this article's deadline and its publication date. For example, the **Wasub6** will by now have made an appearance at the start in the propeller class of the European International Submarine Races in England. Last year, the underwater bicycle won for the second time the equivalent in Maryland, USA, with a world speed record of 13.7 km/hour. The Design Outline Award was won as well.

In the Shell Eco-Marathon, it is not speed that matters (it may not exceed 40 km/hour), but the maximally effective use of energy. Last year, the **Eco-Runner Team** Delft won the Rotterdam edition of this race with an extremely economical futuristic light-weight model. The goal for this year is London: a 5,000 km run on 1 litre of fuel. Energy source: hydrogen; driver: maximum 1.60 metres tall and weighing no more than 50 kg.

"A boat that can fly, with the manoeuvrability of a bicycle." This is a description the newest, electrically driven hydrofoil of the **Solar Boat Team**. This year the students are hoping to use the electricity generated by solar cells positioned on deck to generate a top speed of 55 km/hour. This might allow them to win the annual Solar Challenge in Amsterdam and Friesland in July for the third consecutive time.

Speed strips on oars

In Rio de Janeiro it will become apparent whether speed strips on oars can make the difference between winning and losing a race.

You may remember zigzag strips from the skating suits in Nagano (1998), where Dutch skaters won no less than eleven Olympic medals. Since then friction-reducing speed strips have appeared all over the place, including, since 2000, on oars. Although athletes and coaches are somewhat sceptical, the strips will nevertheless be used by the Dutch rowing teams in Rio. Two TU Delft researchers and competition rowers have demonstrated that the strips really do make a difference: a two-metre lead for a single sculler on a two-thousand metre lane.

Master's student Conno Kuyt and doctoral candidate Arnoud Greidanus presented their research results at the eleventh conference of the International Sports Engineering Association that took place at TU Delft from 11 to 14 July. This study was led by Professor of Fluid Mechanics Jerry Westerweel (Faculty of 3mE). To be clear: this study focused on air friction caused by the oars, not on the friction of the hull moving through the water.

The effect of the zigzag strips is that they make the airflow along the oars turbulent, which reduces the suction effect behind the oar. This reduces air friction by approximately 1 percent. The air friction of the oars accounts for approximately 10 percent of the total friction affecting a single scull. This means that the strips represent an advantage of 0.1 percent. In a race of 400 seconds, this adds up to 0.4 seconds. If you believe this to be inconsequential, you do not understand much about top sport.

"I have been known to lose a race by 0.07 seconds," says Greidanus. That was back at the 2012 World Championship in Plovdiv, where he and Joris Pijs only just missed the gold medal in their double scull. We know now that speed strips might have made all the difference. JW


PHOTO SAM RENTMEESTER

The effect of the zigzag strips is that they make the airflow along the oars turbulent, which reduces the suction effect behind the oar.

PHOTOS: SAM RENTMEESTER

Project Fastball

What is the ideal throwing technique for a pitcher? This is the question being considered by TU Delft researchers in 3mE's Biomechanical Engineering research group. "The request to research this came from the KNBSB, the Dutch baseball association," explains biomechanical engineer Professor DirkJan Veeger. "They have received lots of reports of shoulder and elbow injuries among pitchers." So, in 2013, TU Delft researchers and colleagues from other institutions such as VU University Amsterdam and a number of medical centres set up Project Fastball. They used three cameras to film pitchers in action from different perspectives. They used the images they captured to determine along with Dutch and international baseball coaches the ten most important aspects of a pitch. One is a small knee bend just as the pitcher releases the ball. "It is difficult to see the difference between good technique and poor technique," says Veeger. "We also discovered that the pelvis needs to come to a stop before the back. And your torso should be the last thing to pivot. But it's really millisecond timing." TWD

The ideal grip

As part of the signature course of the Advanced Prototyping minor, IDE student David van Nunen, member of the national fencing team, developed a personalised épée handle. The handle he created is easier to hold and more attractive.
The assignment was to make a prototype for a personal project. Van Nunen took a standard épée handle, known as the pistol grip, and adapted it using clay. "I used my phone to photograph the result from all angles. I entered the photographs into a computer program that created a rotating 3D model of it on the screen. I toyed with that until I had a new model and used another program to fine-tune it and eradicate any shortcomings. I then made a 3D print of the new model in PLA (Polylactic Acid) and tested it in training."
Based on the resulting analyses, he created a new improved prototype. Twelve prototypes later, the minor is over, but Van Nunen is continuing to test and develop the latest models. His aim is to soon start competing with the perfect grip he has designed himself.

'I have also made the grip more aesthetically appealing and it now looks more dynamic and modern'

"There are a wide range of grips available on the market, all with advantages and disadvantages. I am trying to combine all of the advantages in a single ideal grip designed to suit me. It might seem logical to base the design on parameters such as your finger length, but that is an idealistic approach. It does not work like that. There is also the factor of your specific fencing style and how you hold onto the grip."
He has made adaptations that have never been done before. "I have made the grip into more of a single unit and matched it to the hand more effectively to achieve a better hold. Although these may seem trivial details, they really make a difference. I have also made the grip more aesthetically appealing and it now looks more dynamic and modern."
He has no fears that his adapted grips will lead to accusations of mechanical doping: "I based my design on the regulations of the International Fencing Federation. It offers greater ergonomics and more comfort, but it will make only a very minor difference in terms of the fencing itself." JT

Children as designers

How can we make PE fun for children who do not like PE lessons? By getting them to design 'the sports hall of the future'.

Children are creative, and this can be put to good use in education. The TU Delft Science Education Hub (*Wetenschapsknooppunt*) brings school students and teachers in contact with researchers and designers. Taking subjects such as science and technology as an example: the idea is that engineers are the best people to help in this case. "We are now coaching over 100 primary schools," says researcher Remke Klapwijk (faculty of Applied Sciences).

Teachers apply a step-by-step plan to learn how to help children explore a problem, come up with ideas and, finally, present a prototype. For example, the Hague University of Applied Sciences came up with the idea to get children to design 'the sports hall of the future' for the physical education teacher training course. The Science Education Hub is working together with the Ackerweide Octant primary school in Pijnacker on this project, which is subsidised by the Netherlands Organisation for Scientific Research (NWO) and the Netherlands Initiative for Education Research (NRO).

'Children are expert in being children'

Industrial designer Fenne van Doorn concluded in her PhD research project that children can play a valuable role as co-researchers in the design process. "They are expert in being children," explains van Doorn. "You get completely different conversations when children interview each other."

Van Doorn and her colleagues listened to what their junior co-researchers had learned in the interviews about PE lessons. Eleven-year-old Floris, for example, said that he had interviewed a boy who likes playing computer games and shooting games. "I think we should make a game," he said. His classmate Michon, however, had spoken to three girls who wanted to play skipping inside.

At this point, van Doorn picked up a ball. "I am going to throw this to you. If you catch it, come up with an idea about how that boy and those girls can play together." Eleven-year-old Aryan caught the ball and called out: "A shooting game with skipping! When you've skipped 100 times you get a better weapon."

After she had heard a few more ideas, van Doorn got her 'box of ideas' out for a creative brainstorming session. The box contains cards that depict either a fairy-tale character or a superhero. Each child may take one of each card. Aryan took a mermaid and Wolverine, who likes to move like a wolf but is afraid of water. "How could they do something together?" asked van Doorn. "They need to work together to get over the water to another island," answered Aryan. How? "By putting floating obstacles in the water. Ariël builds and Wolverine jumps over them," explained Aryan and he drew it on a card.

An important objective from the point of view of the school was for children to learn to place themselves in the shoes of someone else, says school director Ingrid Schumacher. "How can you make it fun for people who aren't good at PE?" She believes the children were very much involved in the project. "It had a positive effect on their motivation to learn."

The Hague University of Applied Sciences will be sent the children's ideas before the summer holiday. "We are going to assess them and analyse the quality," says Klapwijk. "Is it possible that they have original, creative ideas that adults are not so quick to come up with and that are completely new? This is our claim: that companies benefit from actively involving children in the design process." CVU

PHOTO: MARCEL KRIJGER

PHOTO: SAM RENTMEESTER

Perfect sports wheelchair

TU Delft PhD student Rienk van der Slikke has developed a method to measure the response in terms of speed of a sports wheelchair when changes are made to the wheelchair. His aim is to be able to give athletes personalised advice.

To optimise a sports wheelchair, you first need to know what happens during a match. How quickly do the athletes accelerate from rest? How often do they turn, and how fast? According to Rienk van der Slikke, very little research has until now been carried out in this area, and certainly not in matches. He therefore first wants to properly analyse this.

Van der Slikke has developed a measurement method using sensors for his research project, which is part of a collaboration between the Hague University of Applied Sciences and human movement scientists at VU Amsterdam and the University of Groningen. He placed 'shimmers' on both wheels and on the frame beneath the seat: sensors that measure the rotational speed and acceleration. On a computer screen, he can then see how the wheels turn and the distance they travel.

Van der Slikke's particular area of interest is wheelchair basketball. "In basketball you know that it is important that one player moves more quickly than the other," he explains, "for example if you want to get the ball or block someone." But do you simply want the fastest wheelchair? According to the part-time lecturer in human movement technology at the Hague University of Applied Sciences, coaches want their players to sit as high as possible so that they are 'taller' than their opponents and can score more easily. However, the higher a player sits, the more slowly he reportedly moves. Van der Slikke wants to explore this relationship. "Imagine you let someone sit five centimetres lower – how much faster will he be then? Or, how much better will he be able to accelerate? If you sit a bit lower and you can reach a larger area of the hand grip on your wheels, you can accelerate more quickly and maybe get there just before your opponent."

'But do you simply want the fastest wheelchair?'

Another variable is the camber, which is the angle of the wheels in relation to the frame. On a normal wheelchair, the wheels are vertical, but most sports wheelchairs have slightly angled wheels. "This makes them easier to manoeuvre," explains van der Slikke. It is also possible to vary the position of the wheels. All sports wheelchairs have an anti-tip wheel at the back to prevent players from tipping backwards if they set off too quickly. This wheel makes it possible to set the large wheels quite a way forwards, so that the weight is placed more over the back wheels. "The advantage of this is less rolling resistance, and it is easier to manoeuvre."

Van der Slikke has carried out measurements on dozens of wheelchair basketballers, rugby players, tennis players and track sprinters, both during matches and on a test circuit. He wants to conduct further tests using various wheelchair settings with wheelchair basketballers on a test circuit to investigate the effect of the various settings: with and without extra weight, at various seat heights and with gloves for more grip.

As a spin-off, van der Slikke wants to market his measuring system in the form of a box mounted on the wheelchair frame. This will allow athletes to evaluate their own training and matches and, possibly, enable the early detection of injuries. CVD

Sailing on dry land

"The best in the world." That is what Dr Jouke Verlinden has to say of the Laser sailing simulator developed by TU Delft and Sentec. Dozens of students worked as part of their sports innovation minor on its development and on the improvements that have been made. The simulator gives sailors the impression that they are on a real boat as interactive techniques simulate the effect of waves and water and because they are able to exert pressure on the rudder. Since the introduction of the simulator in 2014, work has focused on simplifying the software. "The simulator was designed for scientific research," explains Verlinden. "However, now that we want to commercialise it, it needs to be more fail-proof." The sailing simulator has now also been fitted with motion tracking so that, using a camera, you can see how far you are hanging out of the boat. Verlinden: "The sailing simulator will be set up in several cities in the Netherlands during the Olympic Games so that everyone can experience what it is like to sail in an Olympic team." TVD

PHOTOS: SAM RENTMEESTER

Millions of soap bubbles containing helium are blown past an athlete. Shining lasers on him produces an accurate image of the air flow around the athlete.

Ring of fire

The ring of fire technique has been developed by Professor Fulvio Scarano (Aerospace Engineering), who wants the bubble blowing technique, or particle image velocimetry (PIV), to ultimately be used outside in sports stadiums. Professor Scarano's idea is that athletes – pass through a cloud of ultrafine helium bubbles during training and that at the same time lasers or LED lamps arranged in an arch over the track are shone onto them. Cameras and computers can then use this to display the air flow around the athlete. Scarano calls his invention the 'ring of fire'. "Athletes are not yet able to train their aerodynamic position," he explains, "but this is a waste of talent. I imagine future athletes wearing Google glasses that give them visual feedback about their air resistance just after they have passed through the ring of fire." The technology involved is highly challenging, but there is another problem: the soap bubbles make the track slippery. TvD

Measuring bike

"In a winding descent a cyclist like Vincenzo Nibali flies down the slope like a condor while Thibaut Pinot cycles down with clamped buttocks," said cycling researcher Niels Lommers in a recent press release. According to Lommers and his supervisor, Dr Arend Schwab of the TU Delft Cycling Lab of the Faculty of 3mE, courage is not the only relevant factor in a descent. From time to time you still have to break, even the most brazen cyclists cannot escape this fact. "And when you do have to break, make sure you break powerfully, and just before you enter a turn," says Schwab. Schwab and Lommers have developed a measuring bike which they can use to map the steering and breaking behaviour of the members of the professional cycling team Team Giant Alpecin. This bicycle can also measure how a cyclist hangs in the turn and what line he is following. This kind of insight can give the team a decisive edge over their competitors. In the long run Schwab wants to equip the bike with measuring equipment to determine the cyclists' level of fear. Under normal circumstances this can be achieved by measuring the electric resistance of the skin. But it is made difficult by the fact that athletes sweat so much. "This is a problem we still have to solve," says Schwab. TvD

For more cycling research, see delta.tudelft.nl/31487

View

In the future, Quidditch will no longer be the prerogative of Harry Potter, predicts Frans van der Helm, Director of the Sports Engineering Institute. The so-called superhuman sports, a blend of sport and gaming, are on the rise.

"Some of the research conducted at the TU Delft Sports Engineering Institute is focused on top sport. That lends the university a certain prestige. Top sport and world-class research go well together. Both demand the same mentality; research is also competitive. If you develop something amazing that allows speed skaters to shave 0.2 seconds off their lap time, it might lead to more medals, but it has no direct social impact. That being said, the clap skate was first developed for use by top sportspeople, but it was rapidly adopted by amateur skaters. I also have my own pair of clap skates. What is developed for top sport quickly finds its way into amateur sport. The data science from sports app Strava, for example. That produces a wealth of data. Nowadays, amateur cyclists have their own heart rate monitor and SRM pedals to measure torque. This allows you to assess your strength and see how good you are in comparison to others. I also use the app to discover enjoyable routes that other cyclists have already tried out. That stimulates me to go for a ride.

Research into recreational sport is focused primarily on the Faculties of Architecture and the Built Environment and Industrial Design Engineering. They are busy developing ideas to encourage people to get active. For example, challenging games that get children playing in the playground, instead of on their computers. Or concepts that offer elderly people a pleasurable, safe environment in which to walk. They need to be able to rely on finding a bench or toilet every now and again, so it is also a matter of urban planning.

The Sports Engineering Institute also collaborates with the Keio University in Japan, Stanford University and the Swiss Federal Institute of Technology (ETH) in Zurich on new types of sport, the so-called superhuman sports. These are sports powered by technology that also require physical exertion; a blend of gaming and sport. Think of Quidditch, from Harry Potter. Keio University has already created several videos about superhuman sports. We would like to put on a joint demonstration at the 2020 Olympic Games in Japan. We are putting student teams together so that we can participate in the initial demonstrations at Stanford next year. We have already developed drone combat and duels between people on springs, encased in a sumo-like air balloon. They walk and bang into each other. It is a physically demanding sport and it can be quite spectacular if they fall over, as they bounce up high. But they can't hurt themselves, as they are protected by the air balloon.

And when it comes to adapted sports, we are conducting material research for blade runners and various types of wheelchairs for use in wheelchair basketball. The ultimate objective of rehabilitation should no longer be that people go home, but that they take up sport." JW

‘There are a lot of scare stories about breaches of our privacy’

The ‘Netherlands’ most powerful nerd’ has a new title: TU Delft alumnus of the year. Ronald Prins, co-founder and technical director of Fox-IT, has become a Dutch celebrity thanks to his cybersecurity expertise. His company keeps state secrets safe and hacks major companies to test their digital resilience. But, in his view, the internet is no panacea. “If the internet fails, we have no plan B.”

TEXT SASKIA BONGER PHOTOS SAM RENTMEESTER

CV

Ronald Prins graduated in 1995. After studying, he joined the judicial laboratory, the forerunner to the Dutch Forensic Institute. There, he conducted digital investigations, domestically and abroad. In 1998, he moved to the Homeland Security Service (now the AIVD) where he exerted a lot of influence on the development of the Information and Security Services Act, which was ultimately enforced in 2002 and is currently being amended in the Council of State. In 1999, he and his partner Menno van der Marel founded Fox-IT. The company's work includes online security testing and digital forensics. It also secures state secrets and government communications. Fox-IT was acquired for EUR 133 million by the British NCC Group in 2015. Prins and Van der Marel continue to manage the company. Prins focuses on external communications, often appearing as an expert in the media. He is married with four sons.

You are alumnus of the year and will be the first to join the TU Delft wall of fame. Happy about that?

"It is a surprise and something that makes me proud. I have obviously done something right. But I never felt myself to be an amazing student. It took me eight years to graduate. I was up to other things: listening in on the police and cracking software packages. I deliberately lived on the 14th floor in Ronald Holstlaan, because at that height I could hang my antennae from the balustrade. I could intercept half the country from there."

Were you a diligent student?

"Not at all. I often spent the whole night listening to the police scanner. I had minimal contact with other students and never joined any associations. I had a completely different network. My girlfriend already had a job and I spent a lot of time on my hobby. When I heard strange beeps on the frequency band, I realised: this is interesting, an observation team is trying to hide here. It made it easy for me to sound them out. Their secret is not so much what they say, but who they are following."

As a student in your 2CV, you were already trailing a van to see who they were following?

"I had a Honda Civic. And they did not have a van. Sometimes it was twelve cars and a helicopter. That is what fascinates me: secrets happen on the street every day and people have no idea about it. I find it exciting trying to get them out into the open. Once I was caught. Although they did not like what I did, it helped keep them on their toes. If I could do it, with no ulterior motives, criminals were capable of it too. This also proved to be the case when I later worked at the predecessor to the NFI (Netherlands Forensic Institute, Ed.). Criminals had big lists of police number plates. As a student, I used to collect that information for fun, but at the NFI, I found out that they have a whole team working to prevent it."

It sounds like you made a career of your hobby. Would that have been possible without studying at TU Delft?

"To hack effectively, you do not necessarily need a degree. At Fox-IT, we have a lot of guys like that. It's a shame that you need a university degree to work at other companies in this field. Of course, you do need academics. Customers want well-written reports and we need to be able to communicate with the world outside. But you also need a few gifted amateurs. The main thing I learnt at Delft was to think methodically and analytically. You also develop a common language."

Would you ever want to be a professor?

"Possibly, but not with too much focus on the technology. What fascinates me now is the public governance aspect of cybersecurity. In the summer, I am going to Harvard, to attend a summer school on cybersecurity and policy-making. As a government, how do you get to grips with the digital world? That is what interests me now. For example, the amendment to the information and security services act is just a single point solution. You need to have much bigger agendas. Currently, we are merely tinkering. The world is changing and we are just modifying existing solutions slightly. Perhaps what you really need is a genuinely rigorous approach. It would make a good subject for a doctorate. But, knowing me, I probably lack the discipline required."

Can the university world keep pace with the internet world?

"It amazes me how often the government turns to the universities when they face a security issue. But it's very much an empirical field. It's difficult to set up a lab and simulate a situation in which North Korea is hacking Sony. But in some areas, the academic world is making real progress. TU Delft, for example, is doing excellent work on quantum cryptography. It will be a building block that will benefit us a lot. But I have also had students in tears, guys working here part-time and determined to specialise in a totally sound and academically worthy field. But the professor blocks it and suggests something really theoretical instead. This is not Leiden. You have Fox-IT on the other side of the motorway, make use of it."

You are always talking about guys. Are there no girls?

"Very occasionally, but they are often very unsure about what they want. Perhaps they are more interested in having a social life."

Is that not possible if you work for Fox-IT?

"Of course, but many guys opt to work through the night on major projects. They stay on site, ending up at a hotel. They just don't want to stop.

That is what hackers are like. When you are working on a problem, you lie awake at night thinking about it. You'd be better off at your keyboard."

What idea was it that made you launch Fox-IT in 1999?

"I used to play squash a lot with Menno, my partner and good friend. He suggested starting up a business. We had no well-crafted business plan, but we wanted to focus on forensic research. We taught the police how to conduct digital investigations and gave lessons to journalists. Running training courses is perfect for a start-up – you have few overheads and there's cash flow straight away. The police then approached us, asking if we could help secure their data. That's how we began to build up security expertise."

Do you sometimes see start-ups at YesDelft that interest you?

"I earned a bit of money from the takeover of Fox-IT (in 2015, by British company NCC Group, Ed.) and am considering which start-ups I could become involved in. I have to admit it is extremely difficult deciding which one is likely to succeed. I also find it difficult to identify the secret of Fox-IT's success. We did what the market was asking for. As we were starting out, the dot.com bubble burst. That made security important."

In the media, you are often outlining doomsday scenarios, of hackers opening up sluices, for example. Do your warnings have an effect?

"I see them as realistic scenarios. We conduct penetration tests at sluices and they always work. Slowly I am starting to see things change, although whether this is because of my warnings, I have no idea. Perhaps it is realistic that people only take action when something goes wrong. There is also such a thing as too much security. The main point is how dependent we are becoming on the internet. This is not a really serious security issue in the sense that the Iranian government may suddenly disconnect us. But if the power suddenly fails, and the internet crashes, we will discover that we rely on the digital world and have no plan B."

What could plan B be?

"Still having flows of funds in cash. If the internet crashes, it is no longer possible to bank electronically or pay for your shopping. Motorway camera systems will no longer work, bringing the country to a standstill. We secure the communications at embassies. I notice that the Germans still have large radio antennae sitting on the roofs. This means they have back-up in a crisis. We have cut all of that, even at Defence. If the internet stops working, we will be in trouble. We have to carefully think about that, or at least accept the risk we are taking."

'If the internet stops working, we will be in trouble'

Another risk of a digital society is the undermining of our privacy by online surveillance.

"Currently, all kinds of bad guys are breaching our privacy. I would prefer to see the government given more space to take control online. Of course, there need to be proper safeguards to prevent the government actually breaching our privacy. There are lots of scare stories about it. In fact, the police have no interest in tapping the man in the street."

As a citizen, how do you know what the government is up to?

"Citizens need to know what governments are capable of digitally, what resources they have to encroach on people's privacy and when they are used. The government needs to be transparent about it, as do the security services. But it is crazy that I keep having to come and explain why it is important for the AIVD (General Intelligence and Security Service) to have more powers. Why don't they do that themselves?"

How far should these powers go?

"I feel that there should be a balance between people's freedom and the technology that the government can deploy. Technology can make you so powerful that citizens no longer even have a chance to make the odd mistake. We must not have a situation in which every breach of the law is automatically prosecuted. That would be like living in a police state. There always needs to be room for leeway and room for people's own responsibilities." <<

IN PERSON

Lucas van Vliet

DEAN OF THE FACULTY OF APPLIED SCIENCES

Professor of Image Analysis, Lucas van Vliet has been appointed acting dean of the faculty of Applied Sciences, now that the current dean Tim van der Hagen is President of the Executive Board. Van Vliet has been a professor at TU Delft since 1999 and at Leiden University since 2012. He combines these positions with the chairmanship of both the Delft Health Initiative and the Medical Delta Programme Board.

Miren Vizcaino

CIVIL ENGINEERING AND GEOSCIENCES

Will the ice on Greenland start to form again if we stop emitting greenhouse gases? Or will it simply continue to melt? These are the questions that Dr Miren Vizcaino aims to answer. She has been awarded an ERC Starting Grant by the European Union to achieve this. “As much as 90% of Greenland is covered by ice. This is an enormous amount of water, enough to make sea levels rise by around 7 meters. This is why it is important to make predictions.”

Marileen Dogterom

BIONANOSCIENCE , APPLIED SCIENCES

The Royal Netherlands Academy of Arts and Sciences (KNAW) has invited Prof. Marileen Dogterom, to become a member of the Academy. Members are nominated by other researchers for lifetime membership. “It is a great honour”, she says. Together with 17 research groups from six universities and institutions, Dogterom recently submitted a research proposal for the development of a synthetic cell that will show elementary signs of life.

Gijsbert de Zoeten

SUPERVISORY BOARD

Minister Bussemaker has appointed Gijsbert de Zoeten as a member of the Supervisory Board. He succeeds Maarten Schönfeld whose second and final term of office is coming to an end.
De Zoeten studied Business Administration at Groningen University. He started his career at Unilever in 1989, where he is now the financial director of Unilever Europe. In addition, he supervises the quality of the Controller programme at VU University Amsterdam, of which he himself is a graduate.

President of the Executive Board

Professor **Tim van der Hagen** took office as President of the Executive Board on 1 May. One of his key aims will be to reduce the workload for staff. In addition, he sees great opportunities ahead in view of the numerous different disciplines at TU Delft: “We need to make better use of our range of different disciplines: science, engineering and design. Although academics already collaborate regularly, I believe that many of them still remain in the confines of their own building far too often. There is room for greater collaboration.” Tim van der Hagen was appointed Professor of Reactor Physics at TU Delft in 1999. He was the director of the Reactor Institute Delft from 2005 until 2012. Since 2010 he has been dean of the faculty of Applied Sciences. He is a former member of the General Energy Council and the Top Team for Energy and is currently a supervisory director at the Energy Research Centre of the Netherlands (ECN) . He is also a member of the Advisory Council for Science, Technology and Innovation (AWTI) and chairs the Supervisory Board of Holland PTC, the Delft-based treatment and research centre for proton therapy due to open soon.

After Delft

Maritime engineer Thierry Schmitter (47) was an active mountain climber until he broke his back in an avalanche. What followed was a sports career at paralympic level.

PHOTO: SAM RENTMEESTER

Name: Thierry Schmitter
Place of residence: The Hague
Marital status: Married, five children
Studied: Maritime Engineering (1988-1994)
Association: Delftsch Studenten Corps

When growing up, Thierry Schmitter wanted to become a mountain guide or windsurfer, but his parents felt that he should study first. After considering civil or mechanical engineering, he discovered that it is also possible 'to learn to build boats' at TU Delft. "I started maritime engineering full of romantic visions."

In 1994, he graduated with a thesis on the loading and unloading of containers using trains, before taking temporary work at the Chantier de L'Atlantique shipyard in Saint Nazaire, France. He took a sabbatical to spend a year climbing. He is originally from the mountains of Grenoble and it had always been his ambition. His aim was to climb K2 led by Ronald Naar a year later. Having succeeded in all of this, he relocated to Winterthur in Switzerland, where he joined diesel manufacturer Wartsilä Marine as a marine architect. In the meantime, he had an opportunity to train as a mountain guide. Four years in, disaster struck. After climbing a frozen waterfall, Schmitter slipped along with a snow field. The avalanche that followed dragged him with it, breaking his back.

He was left in a wheelchair; his dream was over. "I was lucky to have gained my degree from TU Delft. As a Francophone engineer, I had a great career prospects. My work involved marketing for the French-speaking parts of the world, but I was office-bound because I was not mobile enough." Schmitter resigned. "I found it hard having other people decide what I could and could not do." In late 1999, he applied to the European Patents Office in Rijswijk. After in-house training, he was able to assess patent applications. "If you understand the technology, it is possible to learn the legal side of the profession, but not the other way around."

'My habit of never being satisfied always leaves me wanting to achieve more'

Schmitter refused to accept his disability. While recuperating, he quickly realised that there are plenty of opportunities for sport. Para-alpine skiing, for example, but that was not possible in the Netherlands. He had friends with a catamaran, which enabled Schmitter to sail with relative stability. He got to know different types of boats for paralympic sailing and ended up sailing competitively. "I have a habit of never being satisfied, which always leaves me wanting to achieve more."

He won world championship titles and two paralympic bronze medals, but after three Paralympics, he was up for a new challenge. "I had seen a boy kite-surfing sitting down. So, I thought: I can do that, and do it better. I am now the only kite foiler who does it sitting down. You do not sit on a board, but on a wing under water. My maritime engineering insights really come into play. I even help to design kites and lighter materials." CVD

TEXT: JIMMY TIGGES
PHOTOS: SAM RENTMEESTER

I go to Rio

The Olympic Games will be held in Rio de Janeiro in August and Delft top athletes cannot wait to take part.

Name: Olivier Siegelaar (29)
Degree Programme: Alumnus, Mechanical Engineering
Sport: Rowing (Laga)
Boat: Holland Eight

Situation

"We already qualified last year for the games, which was quite an achievement in itself as you need to end in the top five to do that. The selection has been made, it will be the same team. That lets us focus on the rest, which is hard training. In between training sessions, I'm a stock broker at Roca Markets."

Position

"I'm in position five – the power house of the boat. In the centre of the boat you have a good overview and can give instructions to the others. The role comes automatically, but everyone has the same amount of input, technically and physically."

Opportunities

"I think that six very good teams will start in the final in Rio, which is great. The more training hours we put in, the greater our chances."

After Rio

"I have been accepted at Oxford, where I am going to do an MBA. Of course I want to take part in the famous Boat Race, but I have no idea what lies beyond that."

Who: Annette Duetz (23)
Degree Programme: Bachelor's in Applied Physics
Sport: Sailing
Boat: 49erFX, with Annemiek Bekkering

Situation
"In 2015 we unexpectedly lost our place in the national selection to another team. Our mast broke on the first day of competition both times during the selection tests. We then had to leave Team Delta Lloyd and so we needed to arrange everything ourselves as the water sports association has limited funds. Now we are in the Talent team, where we can do our own thing. It turned out in May that the other team was unable to get through, so we are going after all."

Motivation
"When we lost our selection place I first wanted to finish my studies. However, two months later we realised that we were not yet finished and we decided to be the best FX sailors and not to think about the Olympic Games for a while."

Ambitions
"After Rio I want to complete my Bachelor's and make a start on my Master's, after which I will probably continue sailing."

Who: Ellen Hogerwerf (27)
Degree programme: Master's in Mechanical Engineering
Sport: Rowing (Proteus-Eretes)
Boat: Eight

Situation
"We did not qualify for the games during the World Championships last year. We came sixth – one place too low. However, we managed to qualify at the end of May during the Olympic Qualification Regatta in Lucerne."

Olympic experience
"In London in 2012 I was in the double scull and we were placed eighth. We were surprised to make selection as we had a new, young team."

Motivation
"To get the most out of myself. Improving bit by bit each time is hugely motivating, on top of which it is also lots of fun. We are rowing outdoors a lot of the time, we visit some beautiful places and we have a great group."

Study
"That's on hold for a while, I am now rowing full-time."

>>

Who: Bart Lukkes (24)
Degree Programme: Industrial Design Engineering, Master's in Strategic Product Design
Sport: Rowing (Proteus-Eretes)
Boat: Lightweight men's four

Situation

"The boat has qualified but my personal situation is uncertain as I have replaced Tim Heybrock, who is over-trained. As the most experienced rower in the team, and the only one with Olympic experience, Tim has the advantage. The fact that I am even in this situation is absolutely fantastic for me."

Motivation

"I have talent, and it is great to see where that can lead. Several years ago I moved from an amateur club to Proteus as they have more professional coaching and materials and also because of the support I received from TU Delft."

Study

"Industrial Design Engineering involves a lot of project work, which is difficult to combine with top sport. However, my studies are important to me as otherwise the only focus in your life is rowing."

Who: Chantal Achterberg (31)
Degree Programme: Alumnus, Life Science & Technology (TU Delft), Human Movement Science (VU)
Sport: Rowing (Proteus-Eretes)
Boat: Quadruple scull

Situation

"In 2012 I was in the Olympic eight. Our new coach wanted to put two good women's teams together for the run-up to Rio, the eight and the quadruple scull. We already qualified for Rio last year with these teams. We are therefore one team, rather than competing with one another.

Motivation

"London was a fantastic experience, and I still hadn't had enough of rowing afterwards. Training six days a week, twice a day is not always so great, but you know what you are doing it for."

Study

"I have finished my studies and now row full-time. It is great to be able to focus on one thing. I have an A-status, which means I can live from it. Even so, I want to stop after Rio. I would like to carry on, but I also want to do other things such as have a job and a family."

Who: Peter Wiersum (31)
Degree Programme: Aerospace Engineering
Sport: Rowing (Proteus-Eretes)
Boat: Holland eight

Olympic experience
"I joined the eight just before Beijing together with Olivier Siegelaar. We had a young team, which meant that fourth was a good result. In London the situation was different, and we had the best rowers in the boat. Again we have an experienced team."

Situation
"I work as a coach with several teams in Amsterdam. Beyond that, I try to set myself other rowing challenges."

Motivation
"I still enjoy the sport very much and I love to really go for something with a team like this and to focus on it completely. The Olympic Games are also special – on the first day after the games everything feels a bit lifeless."

After Rio
"It's difficult to say. I don't know what will happen if we achieve what we want in Rio."

Who: Sjoerd de Groot (28)
Degree Programme: Civil Engineering
Sport: Rowing (Proteus-Eretes)
Position: Reserve, men's team

Situation
"My exact role was unclear until July. I now know that I will be going to Rio as the reserve for the men's team: the eight, the quadruple scull and the double scull."

Preparation
"Until Rio I will row with Rogier Blink in the double scull. It is of course a shame that I did not make the selection, but I am happy that I have found a way of getting the best out of myself and still taking part in the Olympic experience."

Opportunities
"There is of course a big chance that I won't row, but I hope to experience as much as possible of the Olympic Games."

Study
"After Rio I first want to finish my studies. I am currently working on a few subjects that I do not need to attend classes for."

This is a summary of the 'I go to Rio' column published in recent weeks in Delta. Read the longer versions at delta.tudelft.nl

R

PATENT

OCT-15-030

Energy-efficient radio platform

Inventor:
Dr Przemyslaw Pawelczak

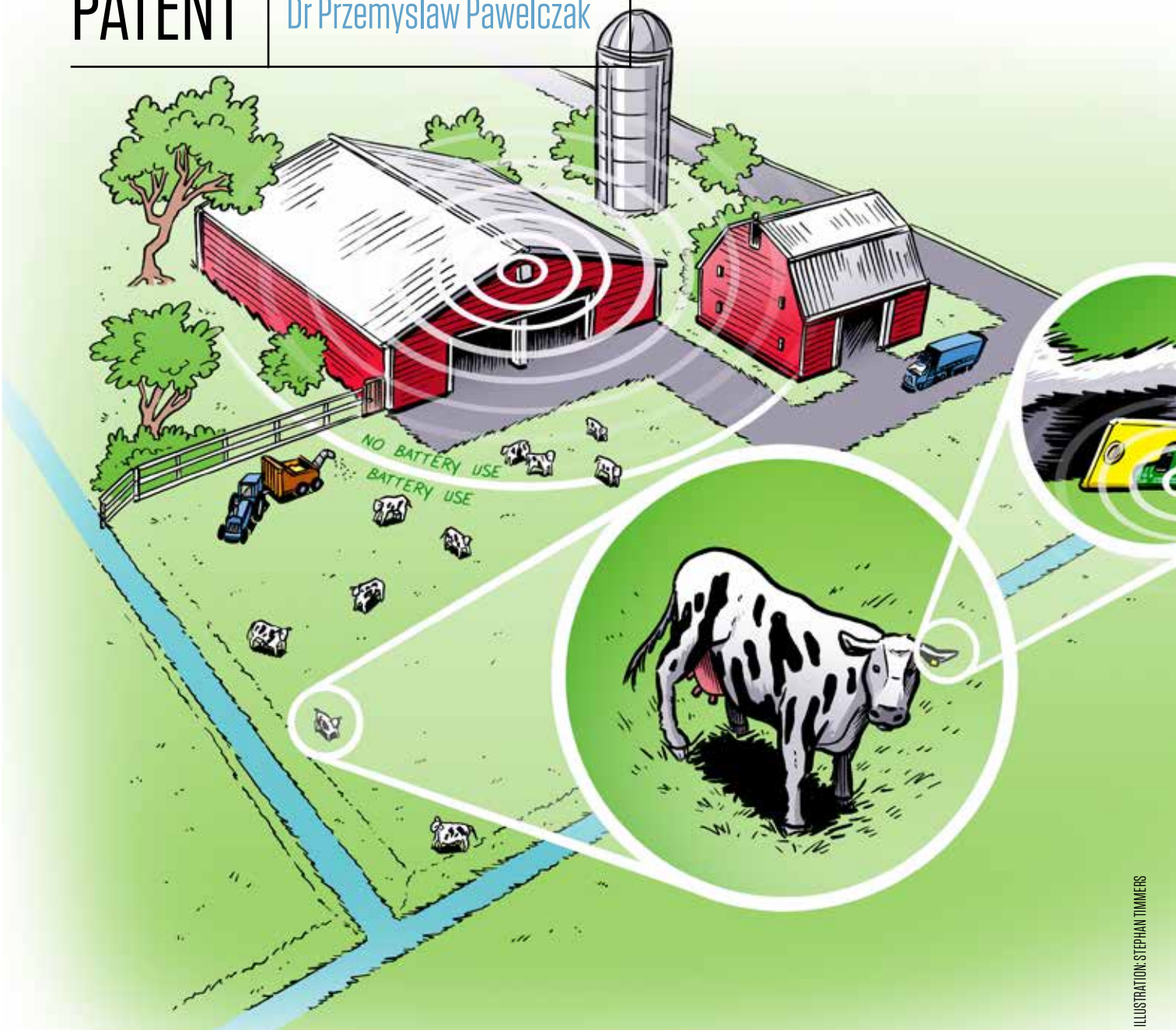


ILLUSTRATION: STEPHAN TIMMERS

Dr Przemyslaw Pawelczak and his students have devised a new system for small sensors that reduces energy consumption to a minimum. “The less reliant on batteries you are, the cheaper and better the result,” explains the scientist, originally from Poland.

His invention is called BLISP, which merges two existing acronyms for mobile communication: WISP (Wireless Identification and Sensing Platform) and BLE (Bluetooth Low Energy). The latter is a passive radio technology that is wireless and does not need batteries, like the public transport card used in the Netherlands. This maximises its energy efficiency, but it offers only limited reach (2 to 20 metres). In a situation where, for example, a cow leaves the shed and the farmer no longer has any data (about the cow’s condition), BLISP switches to active wireless radio technology, which can cover greater distances. The only disadvantage is that it consumes more energy. “It’s a flexible system,” explains Pawelczak, “the ideal switching point depends on whether someone wants to keep energy consumption to a minimum or maximise the amount of data received.”

The most serious application of the BLISP technology is to monitor data on cows in the shed, such as their temperature, heartbeat, or how much they move. But to the software developer, it does not really matter what exactly is measured using the technology. His expertise is focused on optimising a hybrid radio platform. OH

Fact-doping

‘Sport is physical exercise with arbitrary, self-imposed, absurd handicaps,’ wrote Hugo Brandt Corstius. And that’s true. Constraints that the voluntarily handicapped immediately do their utmost to overcome – within the rules, of course, but more often in contravention to them. Forbidden fruit, deals and drugs are as old as sport itself, if not older.

Sport is a wonderful, unambiguous world, in which white and black always defeat grey. A staged battle with just one true winner and a great many losers. Just like the Roman arena, which was also popular entertainment through and through. Thumb’s up, thumb’s down, with death as the final whistle.

Sport is popular thanks to the contrast with the fans’ lives. A chattering, open-plan office full of nuance, where one is hard-pressed to discover anything approaching the glorious. Not the clarity of the field, the track or the ring, but the average ordinariness of the modern housing estate. Nothing wrong with that – that’s what life is – but clearly the fans want more.

Increasingly, the fans themselves are looking for a battle. Or rather, they are creating one: cursing rather than supporting. For/against. Making a stand, preferably anonymously. He who thinks of Black Pete with nostalgia is a racist, while he who thinks the smiling servant has had his day is a traitor. Like the swarms of idiotic fans running along the cyclists on the Alpe d’Huez, yelling their way to fifteen seconds of fame.

This yearning for polarisation is clearly reflected in politics. Give the people what they want, bread and circuses. Give them the image of decisiveness, the idea of strong leadership and the illusion of rapid solutions with no drawbacks. Like sprinters on the starting block. Come across as invincible, that is what draws voters. Fuck the facts, we want heroes.

Exaggerate a little here, take something out of context there; or simply a completely incorrect version of the facts, without any shame. Facts so distorted that even their own mother would not recognise them. And the reward is not derision or mockery, but something more valuable than gold, frankincense and myrrh put together: media attention.

In the United States, research shows that of all the candidates, the person who tells the most ‘inaccuracies’ has a great chance of becoming president. In 4.6 hours of speeches and conferences, that is one inaccuracy every 5 minutes. Republicans think he is their dream leader. As though Lance Armstrong had injected himself ostentatiously with EPO on the start line, in front of the cameras.

When lies defeat truth, when ‘facts’ without any substantiation can live a productive, fruitful life, the guardians of reason and truth hang back in a doped-up peloton. Forget the winner’s stage or an honourable mention; all that remains is to wait for better times. A tip: do not hold your breath as you wait, as it might yet be a while.

Ir. Remco de Boer is a communications specialist in technology and science.

‘Access to technology is very important’

Meningitis and sepsis: two diseases caused by the bacterium Haemophilus influenzae type B (Hib). Until 2007, vaccines were too expensive for developing countries. Ahd Hamidi helped pioneer the development of a much cheaper vaccine. It is partly thanks to her that 200 million children in developing countries can now be vaccinated.

Intravacc, formerly RIVM (National Institute for Public Health and the Environment), is the home base for Ahd Hamidi, TU Delft alumna and technology transfer expert. When she started working at the RIVM in 1998, she heard that colleagues wanted to make a new Hib vaccine for developing countries. She immediately signed up as a process technologist. Last month, she was awarded her doctorate for her analysis of this work.

Hib diseases

“Europe and America had already had a Hib vaccine for more than ten years. Developing countries had to do without, because it was too expensive. In 2000, 400,000 children aged between 1 and 59 months died of Hib-related diseases, such as meningitis, pneumonia and sepsis. Thousands of other children suffered lifelong damage, such as deafness. The challenge was to reduce the cost price and enable vaccine manufacturers in developing countries to have access to the technology.”

Me-too product

“We had to use a new process to manufacture the cheap Hib vaccine in order to work around existing patents. Often it’s the steps in the process that are patented rather than the end product. Our aim was to make what is known as a me-too product. It is identical to an existing vaccine in terms of its quality, but created using different procedural steps. In the case of Hib, you can divide the process into three sub-processes: growing the bacteria in a bioreactor, purifying the antigen, the polysaccharide, and conjugating the polysaccharide with a protein. For each step, we checked whether there was already a patent. If so, we chose an alternative step. This enabled us to work more cheaply. For a long time, UNICEF had to pay $3.5 per dose. With our partners, we were able to reduce the price to $1.19.”

Conjugate vaccines

“Until the late 1990s, our partners – the major manufacturers in countries such as Indonesia, India and China – only had access to conventional vaccines. Conjugation technology is innovative and a specialist field. For them, developing it themselves was a bridge too far. Thanks to the Hib project, our partners gained access to this technology and were therefore able to make other conjugate vaccines as well, such as meningococcal A. That vaccine is now available for African children via one of our partners, at a very low price. It shows that access to technology is very important.”

Monopoly

“Our vaccine is not used in Europe and America. For many pharma-

Photo: ANP Foto, George Mallering

A child is vaccinated in Pernambuco, Brazil. By making vaccines with other process steps, they are affordable for developing countries.

ceutical products, it is difficult to back out of a contract with one of the big pharmaceutical companies. Can we dissolve these contracts? If you asked me, my response would be: why not? Compare the cost price to the market price and there can be a big difference. Take cancer drugs, for example. For these, we pay thousands of euros per patient, whereas the cost price is much lower. Often the prices are high because the manufacturers have a monopoly. Technology transfer creates increased competition and a reduction in price. For every product, if there are sufficient people willing to pay a specific price, that price will be maintained. From an ethical perspective, that should not be the case."

Ethically responsible price

"People should look at what the product actually costs, including research, development, production and marketing costs. A generous margin, perhaps 40%, can possibly be added to that cost price to enable investment in further research. But we have no idea how the big pharmaceutical companies work. Their costing models are a mystery. If we wanted to, we could calculate what an ethically responsible price would be, as we did in the case of the Hib vaccine. Of course, that should be the job of the government, before entering into price negotiations with pharmaceutical companies. How can you negotiate properly if you have no idea of the real value of the product you want to buy?"

'Often the prices are high because the manufacturers have a monopoly'

PhD

"After the Hib project, I was up for a new challenge. I spent almost three years working as a consultant, including in India. At the end of 2009, I got another job at Intravacc. I felt the need to safeguard the work we had done.

>>

I approached Luuk van der Wielen and Marcel Ottens (Bioprocess Engineering department, Applied Sciences faculty) with an idea for a PhD. I had already graduated and done a PDEng (Technological Designer programme, Ed.) under their supervision. We discussed what needed to happen to complete a PhD. They said: 'you should create a mathematical model of the process'. That would be interesting, because it would enable us to check whether the data we have generated in the lab is accurate, whether the cost price is right or can be reduced further."

Mathematical model

"When we started modelling, we did not know if it would be possible to reduce the cost price further. Based on this model, the price could be reduced by another third. This does not involve any major stages, but small reductions in the fixed costs. Every option can contribute a little bit. It would be great if we could present our findings to our partners and enable them to choose what they consider to be of interest. But it is even more important to be able to apply the software and tools we used on other vaccines on which not so much work has been done to reduce the price. That could prove a great success."

Polio vaccine

"I am now working on another project. We have developed a polio vaccine and are in the middle of the transfer phase. In a few years' time, our partners will need to market it. The aim is to completely eradicate polio, but this is difficult with the existing vaccines. The inactivated intramuscular vaccine always used in the Netherlands is too expensive. With the oral vaccine, used for mass vaccinations, it is not possible to completely eradicate the disease. The problem is that the strains in the intestines of one in a million children can mutate back to the wild type. These children will develop polio. In itself, this is not so bad if you wish to reduce the number of cases from millions to just a few. That has worked very effectively, as the statistics show. But eventually you end up only encountering cases that have been caused by vaccination, which then becomes a problem. To complete the process of eradication, you then need to switch to an inactivated vaccine."

PHOTO: MARCEL KRUGER

Polio eradication of existing vaccines is difficult.

Noble

"Working for wider society, with a global impact really appeals to me. This is why I first opted for bioprocess technology. This work, serving a noble objective, gives me fulfilment." <<

CV

Ahd Hamidi (Morocco, 1972) joined her parents in Rotterdam at the age of 18 in order to study chemical engineering. She graduated in 1995, starting a two-year PDEng in Delft in 1996. Two years later, she joined the RIVM. At the end of 2006, she and her husband established a consultancy firm, working in India and other countries and for the World Health Organisation (WHO). Three years later, Hamidi rejoined the RIVM, now Intravacc. She is married with three sons.

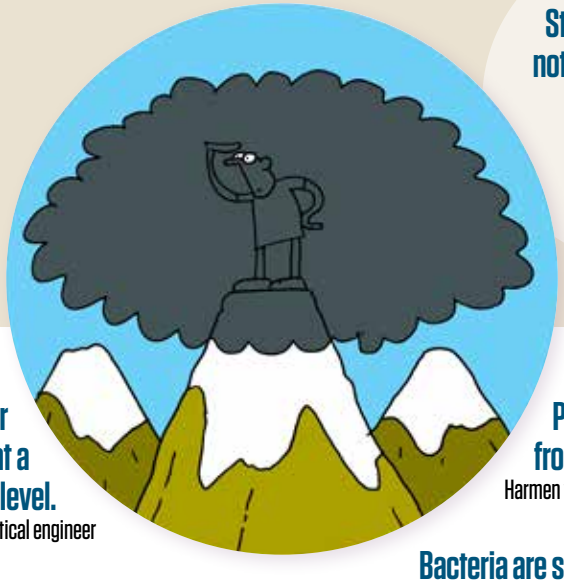
HORA EST

If universities of technology are to remain relevant, engineering programmes need to focus more on the fundamental principles of design.

Ties van Bruinessen, marine engineer

"Engineers play an important role in innovation. In order to develop new solutions, they need to be able to work creatively, apply new technologies and collaborate with different players. In many TU Delft programmes, the focus is on more fundamental technical knowledge, such as mechanics and mathematics, hydromechanics and construction theory. Ship and aircraft designers and civil engineers are often expected to learn how to develop innovative products on the job. Incorporating the fundamental basic principles of the design process in every engineering programme will ensure that engineers gain a better understanding of the processes of design necessary for new knowledge. This will enable engineers, and TU Delft, to remain relevant for society and the labour market."

Standing high does not ensure seeing far.
Yong Guo, computer science engineer



It is not wise to invest more funds and efforts in higher education while neglecting it at a grass root level.
Fahim Raees, mathematical engineer

Programming should be taught from kindergarten on.
Harmen van Rossum, microbiologist

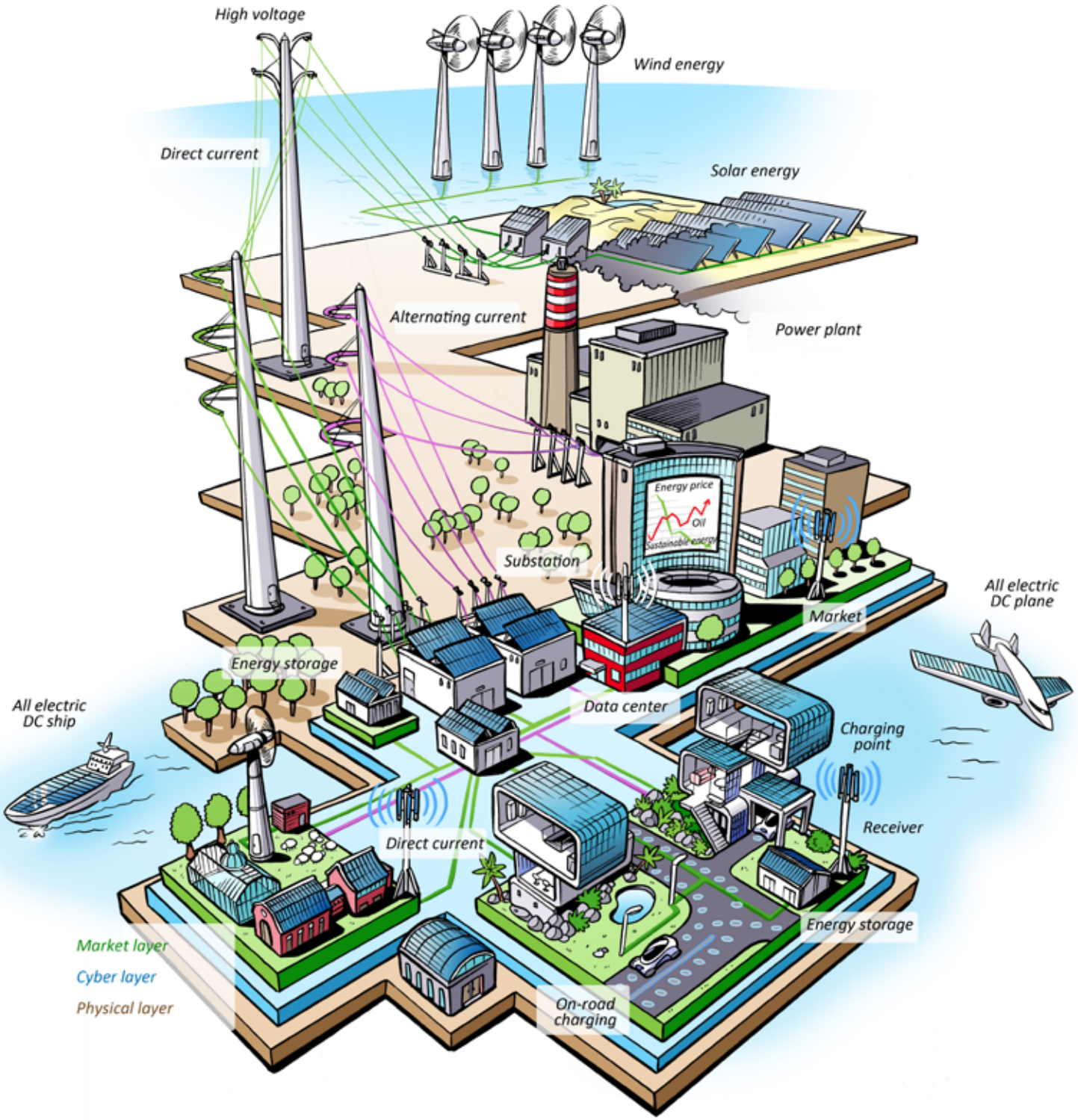
Bacteria are superior to humans.
Michela De Martino, bionanoscience

The presumed shortage of engineers in the Dutch society is not typified by a shortage of highly-educated talent, but by a lack of highly valued technical jobs.
Maarten Vincent van der Seijs, transport engineer

Faith is having confidence and assurance about what is not seen, and is therefore complementary to science rather than contradictory.
Simeon Calvert, transport engineer

The main enemy of understanding is the illusion of understanding.
Esmaeil Najafi, computer science engineer

Cars take up an alarmingly disproportionate amount of urban space.
Daniel Sparing, transport engineer


High voltage
Wind energy
Direct current
Solar energy
Alternating current
Power plant
Energy price
Oil
Substation
All electric DC plane
Market
Energy storage
All electric DC ship
Data center
Charging point
Receiver
Direct current
Energy storage
Market layer
Cyber layer
Physical layer
On-road charging

AC to DC

Laura Ramirez Elizondo and Pavol Bauer believe it is time for a complete overhaul of our electricity grid. Laura and Pavol are running the Direct Current (DC) Distribution Smart Grids research project, which recently received two million euros from the EU.

TEXT: TOMAS VAN DIJK ILLUSTRATION: STEPHAN TIMMERS PHOTO: MARCEL KRIJGER

Although the large coal-and gas-fired power stations in the Netherlands are currently indispensable, they will have a minimal role to play in 20 years' time. Researchers in the DC Systems, Energy Conversion & Storage research group (faculty of Electrical Engineering, Mathematics and Computer Science (EEMCS)) believe our electricity supply is going to change radically in the years to come.

A poster hung at the entrance to the research department depicts a cartoon that is a fairly good representation of the researchers' vision of the future. We see industry, a power plant, an urban area, wind turbines at sea and solar energy parks. There are just a few high-voltage cables connecting the wind parks to land and providing the factories with electricity from the power plants. There are almost no high-voltage cables in or going into the city. The city dwellers are self-sufficient and connected to a DC grid. All the roofs and lots of the walls are covered in solar panels, with here and there a wind turbine on a roof or between the houses.

According to Dr Laura Ramirez Elizondo and Prof. Pavol Bauer, the leaders of the Direct Current (DC) Distribution Smart Grids (DCSMART) project, residential areas will generate their own electricity, which they will exchange with each other through low-voltage DC grids.

What will be the future role of energy companies? "Their role will change enormously," says Ramirez. "The direct link between energy companies and the consumer will be very different. I think that energy companies will largely take on a service provider role. They can help manage the grids and connect households to these grids."

The researchers are focusing primarily on what needs to happen to make the transition to a sustainable low-voltage DC grid possible, where DC stands for direct current.

The century of direct current

According to the scientists, alternating current has run its course and the 21st century will be the century of direct current. This would turn the dream of Thomas Edison, who pioneered the world's first electricity supply, into reality. Starting in 1882, he supplied a few dozen customers in Manhattan with 110 volt direct current. The problem with direct current was that it was difficult to transport over large distances as it could not be transformed into higher voltages. However, this is now possible thanks to power electronics. A competitive battle developed between Edison (direct current) and the American business man George Westinghouse, a strong supporter of alternating current. This battle would go into the history books as the 'war of the currents' and was settled to the advantage of alternating current. Even so, it seems that Edison will posthumously get his way, because we are all going to generate our own electricity.

"Alternating current is a relic of the past," explains Ramirez. "Decentralised generation technologies such as solar panels produce direct current and storage technologies such as batteries and electric cars use direct current. This is all low-voltage and we can generate and use the electricity at the same place. If low-voltage grids work using direct current, we do not need to convert the output of the technologies into alternating current."

This also means that we no longer need adapters. All our equipment, from laptops to toasters and televisions, work using direct current. Transformers currently convert the alternating current that comes out of the socket into direct current for this equipment, even though solar panels also produce direct current. It really makes no sense to convert electricity from DC to AC >>

'It will probably take about ten years before we see the first development projects in which whole residential areas are connected to smart DC grids'

Dr Laura Ramirez Elizondo: "Alternating current is a relic of the past."

and back to DC again. However, this is not the only motive for the researchers. Ramirez: "I think we can make the world more sustainable using low-voltage smart DC grids, as these grids make the transition to fully sustainable electricity using wind and sun easier. Furthermore, they require less thick cables and remove the need for large adapters. This reduces the amount of material required. Plus, in areas in the world in which the money is not available for the construction of traditional high-voltage infrastructure – such as many places in Africa – DC can still make electricity grids possible."

Algorithms

A switch to direct current still presents some big challenges. To give an example, direct current grids need to be made more resistant to problems such as short-circuits. This is one of the areas that is being worked on within the European project. The researchers are also working on algorithms to balance supply and demand in DC grids. The electricity produced from solar panels and wind turbines can vary greatly, and a solution needs to be found for this.
The new focus on low-voltage means that some changes have also been made to the EEMCS high-voltage laboratory. Solar panels, electric cars and home batteries were added to the current high-voltage equipment. For one project, the Delft researchers simulated a Dutch household. The aim was to evaluate the effectiveness of home batteries for smart energy management.
When can we expect the transition to take place? Bauer: "It will probably take about ten years before we see the first development projects in which whole residential areas are connected to smart DC grids. It helps that electric cars are becoming so popular, because charging a car requires a lot of power. Our present electricity grid will no longer be able to cope with all the electric cars after a while. Distributed DC grids can therefore be created in their place. It would not surprise me if DC grids are created especially for electric cars."
The team is also working on a demonstration project in Haarlemmermeer, where a few horticultural companies are switching to a DC grid. The companies will use combined heat and power with a gas turbine to produce their own heat for the greenhouses and to generate their own electricity. "Our input in this project is the intelligence," explains Ramirez. "We want to set the turbines so that they produce the right amount of residual heat for the greenhouses while also generating as much electricity as possible. We also need to maintain the stability of the DC grid using control algorithms."
The researchers also plan to work on a residential area with DC grids, for which they will apply for an EU Marie Curie subsidy. If they are successful, they can work on concepts for smart DC grids at the local area level. "We will then look into lots more applications, including ships and aeroplanes that work on direct current," says Bauer. "Over 30 European research partners have joined us to work on this project." <<

The DCSMART project has been accepted in the ERANET (European Research Area Network) research programme and was awarded a two million euro subsidy earlier this year. In addition to TU Delft, TU Eindhoven, Direct Current, Fraunhofer-Gesellschaft in Germany and Centre Suisse d'Électronique et Microtechnique are also involved in the project.

THE FIRM

Resolving all the problems surgeons face is far from easy. Tim Horeman has already set up three businesses and is now working hard as a TU Delft post-doc on publications and practical solutions.

Tim Horeman has a glass of champagne in hand as he answers the phone. This biomedical engineer has secured a grant of EUR 300,000 with his latest business: PediaPack. He is joining forces with two companies from abroad to develop instruments for child laparoscopy, enabling children to be operated on with minimum chance of tissue damage. "This has happened a lot in the last month – I could get drunk from all this champagne. Somehow or other, all my efforts seem to be paying off, after eight years of blood, sweat and tears."

It is now eight years since Horeman graduated and established Medishield, having secured a patent. In the company, he works with ir. Willem Nerkens developing medical sensors, training systems and surgical instruments.

His latest company started in 2015. Surge-On Medical markets endoscopic instruments that facilitate knee surgery. "I have an idealistic drive to solve the problems clinicians face. Papers or laboratory concepts do not offer enough help to healthcare. The aim is to offer surgeons safe and certified instruments. This involves a level of commercialisation."

Besides this, Horeman is a practical man at heart. He started out in technical vocational school and only came into contact with the medical world by chance. As a trainee mechanical engineer, he built a special container for rubidium 131 capsules, which contain

PHOTO: SAM RENTMEESTER

radioactive substances. "That was my introduction to the medical world. I immediately found it interesting creating things as small as possible and giving them as much functionality as I can. I wanted to do more and heard at TU Delft that a biomedical engineering programme had recently been established."

He has secured a doctorate at the 3mE faculty, where he works as a post-doc four days a week. Does this mean he only spends one day a week on his companies? "You sometimes see entrepreneurs secure a lot of money and then sit on it, essentially eating up their business. Personally, I combine the commercial objective of our medi-tech start-ups with research activities, such as demonstrating how efficient our innovations are. That means that I do not have to allocate all of my hours to the same budget. The only disadvantage of this combination is the increased risk of heart attack, because it can be quite a challenge, working 70 hours some weeks." OH

Name:	Tim Horeman
Study:	Biomedical Engineering, TU Delft
Companies:	MediShield BV, Surge-On Medical BV, PediaPack BV
Established:	2009, 2015, 2016
Product:	MediShield develops medical sensors, training systems and surgical instruments; Surge-On Medical develops controllable endoscopic instruments for use in knee surgery, etc. that can be cleaned.
Mission:	Developing innovations to make patients better and surgeons happier.
Turnover:	"You have a duty of confidentiality towards investors, so I cannot reveal that. All the technology we have developed is worth around EUR 6 million, in view of the investments and sales since 2009."
In five years' time	"Medishield will be market leader in objective measurement systems for training in endoscopy. Surge-on-Medical and PediaPack will have their first instruments on the market."

ALUMNI NEWS

Students showed alumni the campus.

During the career event students were helped by alumni.

A successful Alumni Day

On 2 June TU Delft held a special day for alumni, so they could take a look round and find out about the technology of the future.

Alumni Campus Tours

The Alumni Day kicked off with a trio of special alumni campus tours. Enthusiastic students gave alumni a tour of today's campus. Old memories were revived with visits to past labs and workplaces, but alumni were also impressed by new applications, rooms and buildings.

Opening of the Alumni Walk of Fame

Later in the day, board member Anka Mulder opened the Alumni Walk of Fame in Mekelpark, under the watchful eye of Prometheus. The warm sounds of a swinging brass band, snacks and drinks and the announcement of the Alumnus of the Year all made it a fantastic event! The Walk of Fame consists of plaques (designed by Industrial Design Engineering student Martijn Verbeij) showing the five Alumni of the Year named to date. In coming years, more and more inspiring alumni will take their place on the Walk.

Cyber Security Seminar

Professor Michel van Eeten, Professor Jan van den Berg and the Alumnus of the Year, Ronald Prins of FoxIT, spoke in turn on bullet-proof hosting (hosting focused on criminal activities), on the dilemmas surrounding privacy and security, and on examples from practice. The conclusion was that we have to make agreements on how we interact in cyberspace. After all, expectations and perceptions of normal behaviour in cyberspace should be the same as those in the physical world.
The seminar was followed by a KIJK pub quiz, in which members of the audience first competed against each other and then against the three experts. Unfortunately, even the best members of the audience were not good enough to beat the experts.
Ronald Prins concluded the event with a nice, personal and warm speech. He thanked his staff and especially his partner for all their efforts, and he is very proud to have been awarded the title. The full speech can be found on the Delft University Fund's Facebook page (facebook.com/ufonds).

Career Café

Yet another event took place at the end of the day, when around 150 students and doctoral students were helped to reflect on their career options, their strengths, and the types of jobs and work environments that would suit them. This proved extremely valuable for all the students, so we would like to thank all of the alumni who volunteered to take part!

Alumnus of the year Ronald Prins and board member Anka Mulder opened the Alumni Walk of Fame in Mekelpark.

Delft University Fund celebrates International Festival of Technology

The Alumnus of the Year, the Marina ten Damme grant and the Royal IHC Teamwork Award: the Delft University Fund awarded no fewer than three prizes during the three-day International Festival of Technology (IFoT) at TU Delft.

Alumnus of the year: Ronald Prins

During the celebratory opening of the Walk of Fame, where plaques show all five Alumni of the Year named to date, board member Anka Mulder announced the Alumnus of the Year 2016: cyber-security guru Ronald Prins. An extended interview with Ronald, 'the most influential nerd in the Netherlands', can be found on page 18.

Marina van Damme grant 2016: Lidewij van Twillert

Industrial designer Lidewij van Twillert was awarded the Marina van Damme grant. Together with Enny Kurniawati and Laurien Anne Korst, she was nominated from a total of eighteen entrants. According to the jury, 'Lidewij presented her plans as a dream that really could become something big.'

Van Twillert (27) graduated from the faculty of Industrial Design Engineering in 2015. She runs her own fashion brand, Mesh Lingerie, and designs personal lingerie products with the aid of 3D body scanning. Van Twillert's win nets her a grant of 9,000 euros. She wants to use this to gather knowledge on manufacturing and marketing clothes.

delta.tudelft.nl/30662 and 30609

Royal IHC Teamwork Award 2016: iGEM Team

In the Dream hall, where student teams work on projects such as Nuna, the Velox recumbent bike and the Solar solar-powered boat, the iGEM team was awarded the IHC Teamwork Award. Together with two student teams: Hyperloop and Eco-Runner Team Delft, the students from the iGEM team, which participates every year in the international iGEM bacteria and yeast design competition, could pitch their project during a ceremony. The teams had been nominated from a total of 17 entrants. iGEM walked away with the 7,500-euro prize.

With their 'Biolinker' printer, the students managed to win the highest distinction, the Over-graduate Grand Prize, at the annual international iGEM competition in Boston, the US. The Biolinker is a printer that prints live bacteria that are genetically designed to form biofilms.

The Hyperloop team and the Eco-Runner Team Delft were awarded the runner's up prizes of 2,500 euros. According to the jury 'there are clear market opportunities for the iGEM team. They are changing the world, using K'NEX.'

delta.tudelft.nl/30485, 29963 and 31098

Alumni Activities

29 August - 3 October
Online course in Strategic Design

29 August – 2 September
European Conference on Artificial Intelligence

5 September
Opening of the Academic Year

5 September
Presentation of the Delft University Fund's 'best teacher' prize

14-15 September
Convention 'The Sand Motor Five years of Building with Nature.'

28-29 September
IDE Masterclass 'Human factors, Comfort and Design'

29 September
Start-up event London

3 November
Good Friends Dinner

Careers advice

Alumni who graduated within the last five years can come to the TU Delft Career Centre for one-to-one careers advice. Then make an appointment with Maaike Mulder-Pol via the TU Delft alumni portal. Consultations last one hour, are held in Dutch or English, and take place at the TU Delft Career Centre. If you are abroad for a long period, the consultation can be held via Skype.

CONTACT
Do you have questions or comments, or would you like to pass on a change of address? Alumni Relations TU Delft:
alumnibureau@tudelft.nl
www.alumni.tudelft.nl

The lab of...

Van Iterson hall

On the final day of the large-scale and highly complex move to the new Applied Sciences faculty building, doctoral candidate Romaaike Schellekens is completing an experiment in the fermenter in the Van Iterson hall (former Biotechnology building), before dismantling the apparatus and packing it. The research into water treatment technologies being conducted here is a continuous process that can be interrupted for two days at most.
delta.tudelft.nl/31484

PHOTO: SAM PENTMEESTER