DELFT OUTLOOK
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TU Delft

HollandPTC
The first Dutch proton clinic

COMBUSTION ENGINE
Is the end in sight?

Paulien Herder
'In our country, the industry is yet to feel the effects of the CO_2 problem'

THEME
Sensors

Cover:
Give Rolf Hut a phone to take apart and he's like a kid in a sweet shop. A telephone is packed with sensors that you can use for all kinds of things that they weren't necessarily designed for.
Photographer Sam Rentmeester

Editorial
Saskia Bonger

Sensors

This Delft Integraal doesn't actually contain sensors that track your reading habits... yet. But the magazine is brimming with stories about sensors. Although it's a cliché, they are increasingly dominating our lives, and we're nowhere near the end of the possibilities. Partly thanks to research at TU Delft.

Take 'MacGyver researcher' Rolf Hut (CEG). Later on in this edition, he'll explain what else you can use the sensors in a smart phone for, apart from the standard applications: for example, to perform measurements in rivers. Huts churns out an unending stream of ideas. He even had a brainwave during the interview with Delft Integraal. How about if the mobile speech recognition programme Siri, that likes to listen in, could gather data about rainfall? Apparently, researchers are constantly finding new uses for standard sensors.

The Delft invention WaveDroid, a buoy with smartphone technology that can be used to measure coast erosion, is currently being tested all around the world. The technology costs a tenth of the price of its conventional counterpart.

And that's just the start of it: heat measurements in The Hague, vibration recordings in Groningen, breathing measurements to diagnose diseases, and so on. All useful and practical applications, designed to serve our every need.

The question is: where will it all end? Perhaps with the smart dust referred to in the future vision of researcher Przemyslaw Pawlczak (EEMCS). "When they're cheap [and small] enough, you'll be able to disperse sensors from an aeroplane," he explains. A step too far, or nice and convenient? That's something society will have to decide when the time comes.

Saskia Bonger, editor-in-chief

PHOTO: SAM RENTMEESTER

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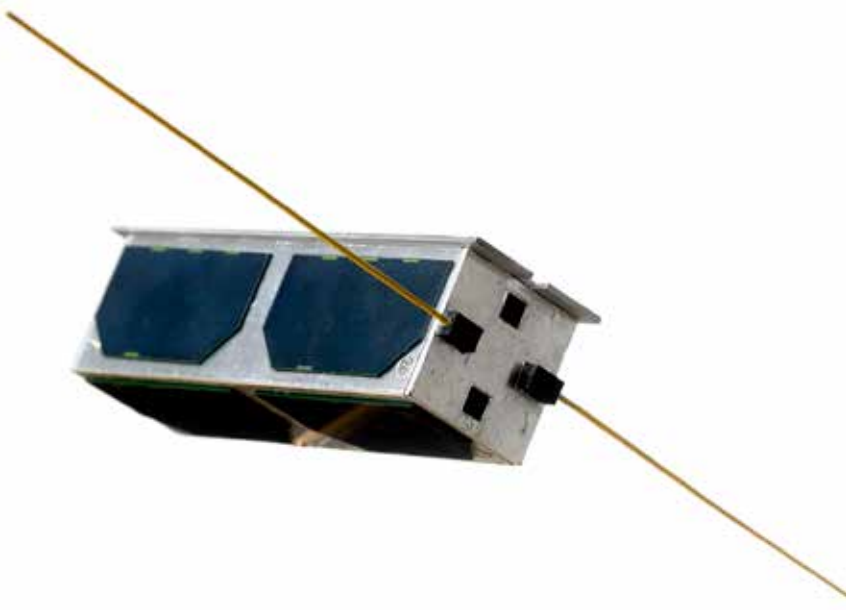
DELFT IN BRIEF



Walking on robot legs

It was a tense moment for the 31 students from Project MARCH and their paraplegic patient Ruben de Sain. Before the inquisitive eyes of the press, De Sain switched on the exoskeleton and rose to his full height of 1 metre 90. He then covered a distance of 20 metres walking down the hall, only using crutches. This was the demonstration of the exo skeleton (robot legs) that the students and De Sainhopeto take to the Cybathlon Experience in Düsseldorf in October, where De Sain will have to negotiate a number of tricky hurdles, including slopes and uneven surfaces. On their return, the team will set to work preparing for the second Cybathlon competition in Zurich in 2020.

delta.tudelft.nl/article/ruben-walked-again-exoskeleton

Shrinking satellites

Next April, the first TU Delft mini-satellite will celebrate its tenth year in space. The CubeSat Delfi-C3 measures just 10 x 10 x 30 cm, and the on-board smart phone electronics are still in good working order. The platform became a success thanks to its ability to provide cheap earth observation for agriculture and infrastructure. The new generation of PocketSats being developed by the space system engineering group of the Faculty of AE are as small as a sizeable torch and weigh just 500 gram. The size and low costs enable the satellites to be operated as a swarm, either enlarging the area they can observe or prolonging the observation time. This is creating opportunities for earth observation for companies or NGOs. The group expects to launch its first 'torch' satellite into space towards the end of next year.

delta.tudelft.nl/article/science-shrinking-satellites

Hustle and bustle on campus

Some 5,000 new students will soon be wandering around the campus. They include 3,200 Bachelor's students and 1,543 international Master's students. This brings the total student population in Delft to over 22,000, which is more than last year. In order to teach all these students, TU Delft is not only using all its classrooms, but also the Pathé cinema and the head office of the Duwo student accommodation organisation.

Photo: Thomas Zwart

Playing piano with your brain

So-called brain computer interfaces are set to turn our lives upside down, says electrotechnical engineer Prof. Wouter Serdijn (EEMCS). At a chip conference in Washington (USA), he speculated about potential applications of bidirectional brain computer interfaces. If these chips are implanted into the brains of people with a prosthesis, they will hopefully regain feeling in their paralysed limbs. Elon Musk is also working on these chips. He predicts that they will enable us to communicate through telepathy. Serdijn sees one major obstacle: "The electrodes are too big and too far away from the neurons. I can imagine that we'll be able to play the piano using our thoughts in the future. That would be great for an ageing population, as most people become less dexterous in later life."

Measuring the world

"Do you really think you make choices of your own free will? Our lives are controlled by algorithms." These words were spoken by Professor Dirk Helbing (computational sociology ETH Zurich and TU Delft) during a lecture at TU Delft. Helbing is an expert in the field of behavioural manipulation using digital technology. "Google receives some 700 thousand new search commands every minute. We leave traces of everything we do, all of which is analysed by computers using machine learning algorithms." Yet Helbing is still positive, claiming that all the data we generate can also be put to good use. He developed the digital open source platform Nervousnet, a repository for data. "Our smartphones comprise various sensors, including a speedometer, a gyroscope, a barometer and a light sensor. Pool these resources and we can measure the world."

delta.tudelft.nl/article/you-can-influence-algorithms-now-dictate-your-life

Website as district nurse

After a transplant, kidney patients need to measure their blood pressure and creatinine levels on a daily basis to catch early signs of the donor organ being rejected. In a series of experiments in the intelligent systems (EEMCS) research group, Dr Wenxin Wang tested various communication methods with a group of fifty patients from the LUMC. The tests showed that patients who had a relapse were particularly sensitive to the style of communication. They preferred a formal style, with plenty of background information. According to the Dutch Kidney Foundation, the research will be used in the Medical Dashboard of the LUMC.

delta.tudelft.nl/article/virtual-nurses-empower-patients

Photo: Marcel Krijger

Irradiating salt

Cheap electricity, no long-lived radioactive waste and no left-over plutonium for building nuclear weapons. There are so many reasons for using molten salt thorium reactors instead of uranium reactors. In theory, that is... But how feasible is the technology needed for these plants? This is what researchers from TU Delft hope to find out in collaboration with colleagues from the Institute for Transuranium Elements in Karlsruhe (Germany) and the NRG Hoge Flux Reactor in Petten. In an irradiation experiment that started in Petten last summer, they will spend two years irradiating fluoridated salt to see how it reacts and which by-products are produced.

delta.tudelft.nl/article/cheap-nuclear-electricity-without-long-lived-radioactive-waste

Games table

In March, Dr Hester Anderiesen was awarded a PhD by the Faculty of IDE for research into playful design. Since then, her Tovertafel (magic table) and company Active Cues have proved a runaway success. The Tovertafel is basically a projector suspended over a table, which projects moving images of flowers, fish or birds onto the table below. Infra-red sensors detect hand movements, to which the system then responds. Tests have shown that the Tovertafel activates and entertains elderly people with dementia. The company has also developed a version for people with learning difficulties (model UP) and autistic children (model Unique). TU Delft students recently made a video about it.

delta.tudelft.nl/article/video-magic-table-activates-people-dementia

Learning from Hurricane Harvey

Photo: Zachary West

In the wake of the havoc caused by Hurricane Harvey in Houston in late August, Prof. Bas Jonkman (CEG) decided to set up the Delft Harvey Research Team in the Faculty of TPM. As a first step, the researchers will gather data about meteorology, flooding and emergency response in the Texan capital. The data will be processed into a report, which will also consider the socio-economic and planning aspects of the various districts affected. The researchers will then translate their findings into the situation in the Netherlands, and present them to those working in flood prevention.

delta.tudelft.nl/article/tu-delft-sets-harvey-research-team

Cement from waste

The geopolymer team of the Faculty of CEG is working on a simultaneous solution to two global problems: the high CO_2 emissions from cement production (5% of the annual total) and the ever-growing mountain of waste and by-products. In a video shown on TU Delft TV, PhD candidate Marija Nedeljkovic explains how a mix of different industrial by-products can be activated with a base to form a cement that bonds material. After hardening, geopolymer cement is of a similar or even better quality than traditional material, says Nedeljkovic. It has already been used to build a bench

and a concrete canoe, and a bridge is currently being constructed from this eco-cement.

delta.tudelft.nl/article/waste-concrete

THEME

Sensors

Sensors are everywhere, and they're getting smaller all the time. They float in the sea, are suspended in the air or buried in the ground, and we even carry them in our pockets. This photo shows the Delft invention Wisent, which allows the remote programming (even wireless) of sensors without a battery. As its inventor Przemyslaw Pawlczak explains on page 15, the possibilities are now endless.

Photo: Sam Rentmeester

PHOTO: IFIXIT

Your phone is a supercomputer

Self-proclaimed geek Rolf Hut develops measuring equipment from consumer electronics. He loves smartphones, because they are packed with sensors.

According to Dr Rolf Hut (department of Water Resources, CEG), we are on the brink of a revolution. "Have you followed the news about the latest iPhone, the iPhone X? It has facial recognition technology. Scientists will develop apps to take advantage of this feature. That's a given." If you can recognise faces, you can also recognise plants, birds and insects, the Delft researcher argues. Field work for biologists will never be the same. "Biologists going into the field to make detailed drawings of a few plants will soon be a thing of the past. Soon you'll send a whole class into the woods. With smartphones the class can identify all the flora and fauna in no time."

Birthday card

The MacGyver researcher, as colleagues call Hut, makes measuring equipment from consumer electronics. For one of his first tricks he used sensors from the speakers of musical birthday cards. He transformed these parts into rain sensors that register falling raindrops.

Hut is now closely following developments in the smartphone industry. His field of research overlaps with virtually every branch of science that involves measuring and monitoring. Agricultural technology is one such

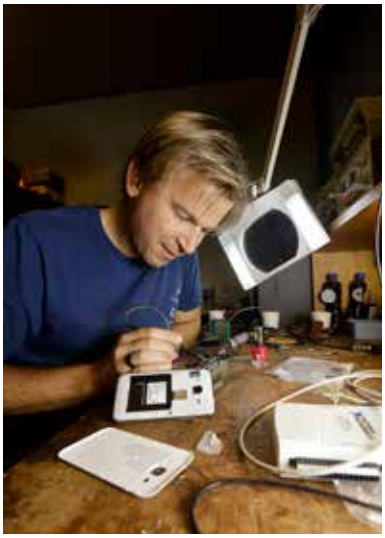
area. The technology behind Bluetooth beacons, which museums use to manage audio tours based on the pace of visitors, could help farmers to measure the soil humidity of their fields.
"We're experimenting with this in our lab," Hut explains. "The beacons broadcast a radio signal. Based on this signal, smartphone apps can perform specific tasks, such as providing an explanation about a work of art in a particular space. The apps determine the distance to the beacon. We buried a number of those beacons in sand. When we add water, this weakens the beacon signal. We can use this fact to also measure the percentage of moisture in the soil."

Brainwave

It's simple, but you have to come up with it. The same applies to the floats that travelled down the Irrawaddy in Myanmar early this year to measure the river's dynamics.
"We used large pieces of polystyrene on which we mounted GPS trackers that recorded their position to a local SD card every minute, and made contact every 15 minutes to upload their data. Basically, we used telephones, stripped down to prevent them from being stolen."
Halfway through the interview, Hut dismantles a smartphone to point out various sensors. He's busy with screwdrivers and pliers when he suddenly drops everything and runs to his computer. He's had a brainwave.
"I need to work out whether we can do something with Siri, the iOS voice recognition program. I'll send myself a reminder by email."

Goldmine

"If you always have Siri enabled on your phone, which a lot of geeks do, your phone registers background noises continuously. These noises



Rolf Hut: "Nevertheless, the strength of virtually all applications lies in the fact that smartphones combine sensors with telemetry." (Photo: Sam Rentmeester)

sound different when it rains. Who knows, we might be able to recognise that."
Siri could be a goldmine. A classic example of big data mining using smartphones. According to Hut, this type of data analysis is really taking off.
One of Hut's colleagues was recently able to obtain 220 million temperature measurements. Hut: "Phone batteries have tiny thermometers attached to prevent overheating. If a battery starts getting hot, it switches itself off. KNMI researcher Aart Overeem used measurements from these sensors to make heat maps for cities such as London, Paris, Moscow and Buenos Aires."

Citizen science

Analysing data that are stored centrally is one of the methods of obtaining large quantities of data, which can be used to intricately chart things like temperature, noise, humidity and pollution. Another method is citizen science, in which you actively involve citizens in your research.
"I think the iSPEX measurement campaign, led by Frans Snik of Leiden University, is an excellent example of this. The aim of the project is to measure particulate matter in the atmosphere. Over the last few years, thousands of volunteers used their phones to take photographs of the sky on clean days. They did so using an attachment and an accompanying app that measures light spectrums. The idea behind it is that certain colours of light do not penetrate the atmosphere as deeply because they are absorbed by particulate matter."

Supercomputers

According to Hut, "today's phones are supercomputers." And as an added bonus you can use them to make calls or send information. Of course, that seems rather obvious. "Nevertheless, the strength of virtually all applications lies in the fact that smartphones combine sensors with telemetry," says Hut.
"Ten years ago, sending data was a real bottleneck for a lot of measurements. You had to install GSM modems on site – in fields, along rivers or in cities – in order to transmit the measurements. You needed people with a background in electrical engineering to get the modems up and running, and it was a major job thirty years ago. You had to lay cables and make arrangements with the phone company. Now you simply throw your telephone with sensors into the river."

> Siri could be a goldmine. A classic example of big data mining using smartphones

PHOTOS: SAM RENTMEESTER

New light on breath analysis

Exhaled molecules contain health information. A new optical sensor system may become a standard in the future.

Human breath can contain thousands of different organic compounds, which can give information about gastrointestinal diseases, respiratory infections, asthma, diabetes and certain cancers. However, the concentration of these compounds is low, around one part per million (ppm). While this can be measured using gas chromatography or mass spectrometry, this is too expensive for clinical use.

A new sensor system uses infrared light to detect organic molecules. This sensor was developed by Dr Adonis Reyes Reyes during his PhD research (Optics Research, Faculty of Applied Sciences). The infrared radiation bounces back and forth hundreds of times in a cavity with breath gases in order to increase absorption. The unabsorbed light

A new sensor system uses infrared light to detect organic molecules

of different infrared wavelengths is unravelled using a high-resolution spectrometer. By comparing this light with a reference beam you can follow the absorption for each wavelength. An analysis using known absorption spectra then shows which compounds are contained in the breath gases and how much.

During a small-scale clinical test, Reyes Reyes was able to demonstrate a higher concentration of acetone in the breath of adult diabetes patients (Type-1) than in the control group.

Reyes Reyes sees opportunities for using optical gas analysis in medical diagnostics, alcohol testing and security. “We can expect to see the first portable and highly sensitive gas analysis devices in the market in the next ten years,” he wrote in his thesis. JW

More information: delta.tudelft.nl:‘New light on breath analysis’

Weatherstations for African farmers

A network of twenty thousand low-budget weather stations should give Africans greater certainty about weather and water. That is the aim of the Trans-African Hydro-Meteorological Observatory (TAHMO) project of Oregon State University (US) and TU Delft.

One of the initiators is Prof. Nick van de Giesen (CEG). The project, launched in 2013, has not always run smoothly, he explains. “We now have almost five hundred weather stations spread across countries including Ghana, Senegal, Uganda, Rwanda, Kenya, Chad, the Democratic Republic of Congo and Nigeria. Our sensors had small electrical leaks, which caused the batteries to run out quickly. And we discovered that we are competing with businesses in some countries. We regularly receive angry responses to our work.” The dream is to have thousands of functioning weather stations throughout Africa in a few years’ time, mainly managed by schools. Farmers will be kept up to date on weather and precipitation via text and voice messages or smartphones. TVD

Also read: delta.tudelft.nl ‘Een weerpaal voor weinig’ (Dutch only)

The photo shows what is needed to build a weather statoin. Most parts station can be bought at a common DIY store.

Hague heat

Is The Hague the hottest city in the Netherlands? Commissioned by the city, Franklin van der Hoeven spent three years taking measurements, in collaboration with inhabitants.

Photo: Sam Rentmeester

Cooling off in the hot city centre of The Hague.

Cities are considerably warmer than their natural surroundings during certain part of the day and the year. This is positive in the winter, but not in the summer. This phenomenon is known as urban heat islands. Dr Franklin van der Hoeven (Architecture and the Built Environment) previously studied this in Rotterdam and Amsterdam, after which The Hague didn't want to be left behind. Especially as a 2012 study by the Netherlands Organisation for Applied Scientific Research (TNO) showed that The Hague had the strongest heat island of all Dutch cities.

Heat islands impact health. "The death rate during extremely hot weather is far higher than during a cool summer, says Van der Hoeven. "July 2006 far exceeded any previous summer months with a thousand more deaths throughout the Netherlands. There were 59 deaths in The Hague, compared to the average between 2000 and 2015. Compared to the summer of 2007, there were 90 more deaths."

Van der Hoeven already demonstrated that the heat island played a role in this for Rotterdam. He expects similar findings for The Hague. To determine the temperatures to which people are exposed, 120 households in The Hague were given weather stations, which use sensors to measure air temperature on balconies and in gardens.

Satellites can measure the surface temperature on rooftops, parking

areas and tree crowns. “TNO used remote sensing analysis to measure the heat island with regard to the daytime surface temperature,” says Van der Hoeven. He wants to look at heat islands with regard to daytime and night-time surface temperature as well as air temperature. This will include an additional measurement, because the makers of the Toon thermostat have promised to share the indoor temperatures. “In a way that does not compromise privacy.”
Van der Hoeven wants to determine which heat dataset best explains the

120 Households were given weather stations

extra deaths. “We then want to use that heat indicator to determine which use of space generates heat. We will look at five factors: the amount of paving and vegetation, surface water, the building shell and shade. These factors can be influenced. Asphalt is in a class of its own.”
Satellite images from July 2006 and more recent dates show that The Hague’s pre-war districts with many flat roofs are the warmest. “This won’t change much. If you don’t remove the asphalt and demolish the buildings, the heat island will stay as it is. Unless The Hague introduces tough climate adaptation measures.”
Measurements show that the temperature increases significantly from time to time, creating a heat island. “But it is no worse than in other cities. If I could give The Hague just one tip, I would say: replace flat asphalt roofs with solar panels so that you generate energy. Then you’ll have that energy just when you need it for mechanical cooling. Wouldn’t it be great to use those roofs for your climate targets?” CVD

Making hydrogen visible

Hydrogen is the only CO_2-free fuel. Because it is both colourless and odourless, hydrogen gas is difficult to detect. A patented sensor makes H_2 visible.

The first hydrogen filling stations have already opened, and hydrogen also plays an important role in the chemical industry. Unfortunately, detection of the gas remains difficult. Standard units, such as those used to monitor battery charging areas, work electronically and constitute a hazard due to the potential for sparks.
This concern does not apply to the optical detector developed by Dr Christiaan Boelsma during his PhD research (Materials of Energy Conversion and Storage (MECS), Faculty of Applied Sciences). The sensor itself consists of a coated tip of an optical fibre, with the electronics located a distance away.
Boelsma discovered that the optical properties of certain thin metal layers (less than 0.1 micrometres thick) on glass change in the presence of hydrogen. The hydrogen bonds to the metal to form metal hydride, causing a measurable change in the optical reflection or transmission.
Boelsma has patented two materials: hafnium (Hf) and a zirconium-magnesium alloy (Zr-Mg). Improvements must still be made with regard to the response time, which was initially around several hours at room temperature. Boelsma has already demonstrated that a top coat of Teflon can reduce the reaction time to half an hour. At 120 °C the reaction time is even as short as a few seconds.
Promotor Prof. Bernard Dam is now looking for industrial partners to further develop the patented materials to create a functional prototype. JW

More information: delta.tudelft.nl:‘Optical hydrogen detectors patented’

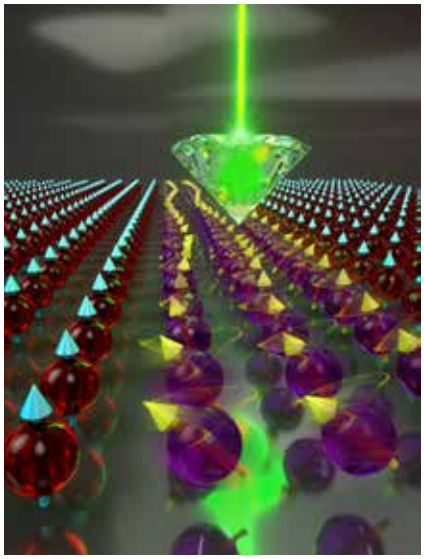
Magnetic measurements at **atomic level**

It doesn't get any more sensitive: measuring a magnetic field of a single electron or proton on the scale of a few nanometres. The atomic magnetometer to be built by Dr Toeno van der Sar should be able to do this.

Van der Sar developed the method at Harvard University, where he worked as a post-doc.
Last summer, he published the article 'Control and local measurement of the spin chemical potential in a magnetic insulator' in the journal Science. Here he revealed how he succeeded in measuring atomic magnetic fields with a diamond nanobeam.
At the end of August, he returned to the department of Quantum Nanoscience in the Faculty of Applied

The resolution and sensitivity of a single proton spin is unequalled

Sciences from which he obtained his PhD in 2012. A laboratory space was made available for him in the basement. In addition, Van der Sar is working on bringing in doctoral candidates and securing research funding. His research will be unique in Europe,



(Peter and Ryan Allen/Harvard University)

Spin wave under a diamont.

with a magnetometer that works at room temperature as well as under cryogenic conditions. The resolution and sensitivity of a single proton spin is unequalled. The magnometer will also be able to measure static fields as well as high-frequency fields into the gigahertz range. Van der Sar can already name numerous applications.
His magnetic sensor will first analyse 'spin waves'. These are waves in magnetic materials that are regarded as the information carriers of the future in the 'spintronics' that will replace electronics. He also expects to be able to measure the spin of a hole in graphene, for example, which may be used for elementary data storage in the future. He also hopes to be able to shed new light on electron transport. Van der Sar expects that electrical current may well resemble fluid flow, complete with turbulence and vortices. And it will also be possible to measure current distribution in electronic circuits. For example, does the current flow through the middle of a conductor, or does it take the outside? And, is there a smart way to use this knowledge?
The method takes its name 'NV-magnetometer' from the combination of a nitrogen atom (N) and a vacancy (V) in a diamond lattice. Such a pair has a spin, with states of -1, 0 or +1, which Van der Sar uses as a magnetometer at atomic scale. The energy levels of these spin states depend on the local magnetic field, and can be read with a combination of green laser light and microwaves that are transmitted to the NV centre via small on-chip antennas. The strength of the local magnetic field can be measured directly from the microwave frequency that succeeds in reversing the spin state of the NV-centre. What's nice is that this reversal of the NV spin can be detected via the unique, spin-dependent optical luminescence (in red light) of the NV centre. You will undoubtedly read more about this. JW

More information:
'Nanometre-scale probing of spin waves using single electron spins', Nature, 29 October 2014,nature.com/articles/ncomms8886
'Control and local measurement of the spin chemical potential in a magnetic insulator', Science, 14 July 2017, science.sciencemag.org/content/357/6347/195

Battery-less sensors

We know RFID from bank cards and travel cards, which communicate over short distances with payment terminals or ticket readers. WISENT is making the next generations of RFID: computational RFIDs (CRFIDS), which are in effect small battery-less computers that can be programmed remotely.

The ultrashort film in which Dr Przemysław Pawełczak (Faculty of Electrical Engineering, Mathematics and Computer Science, EEMCS) announces his finding has been viewed over 65,000 times. He explains that WISP (Wireless Identification and Sensing Platform), an example of a CRFID that takes its energy from radio waves, has now really become wireless. The microcomputer is now also reprogrammed wirelessly thanks to a communication protocol developed by Pawełczak and his colleagues in the Embedded Software department of EEMCS, in collaboration with researchers from the University of Washington in Seattle, USA.
The protocol is called Wisent, referring to 'wireless (re)programming of battery-less sensors.
Pawełczak imagines networks of reprogrammable and wireless sensors wherever and whenever you want. "Imagine the possibilities," he says, concluding his video. A tracking system that follows goods through a warehouse, for example, or students through a school or patients in a hospital? Or a wireless and flexible system of smoke detectors? A large number of WISPs on the wall that communicate with each other via Wisent would make this possible. And no more climbing ladders to replace the batteries. JW

Photo: Sam Rentmeester

Watch the video here:
youtube.com 'TU Delft TV Wisent'

Measuring Groningen ground with fibre-optic cable

Groningen is trembling and shaking. It has been known for years that this is related to gas extraction. But precisely how gas extraction influences ground stresses is not clear. How do the fault lines run and how do ground stresses accumulate?
TU Delft researchers want to gain insight into the seismicity of the ground in Groningen. The standard instruments for this are geophones. By artificially generating a wave, geophones, a type of microphone, can identify the geological structure of the subsurface. But, according to geophysicists Prof Kees Wapenaar and Dr Guy Drijkoningen, this can also be done using fibre-optic cable. As part of a 2.5 million euro Advanced Grant from the European Research Council (ERC), they will lay five to ten kilometres of fibre-optic cable in an area in Groningen.
"The advantage is that we can measure at a much higher resolution," says Drijkoningen. "And it's cheap. A cable costs about one euro per metre. And that cable can easily remain in the ground for twenty years." TvD

Measuring waves

After losing their expensive wave measurement buoy, civil engineer Max Radermacher and his South African colleague Zane Thackeray decided to build a buoy themselves, based on cheap smartphone technology.

During wave measurements in Durban, South Africa, Radermacher and Thackeray lost contact with their conventional buoy. "These buoys are so expensive that it is worth searching for them by helicopter," Radermacher explains. "When buoys float in the open sea, it is hard to monitor them. They can get damaged or be stolen." Thackeray wondered why these buoys are so expensive, while the sensors needed can simply be found in your pocket. Using their knowledge of ocean waves and software, Thackeray and Radermacher developed a buoy that is ten times cheaper than its conventional counterpart.

Years of research and development in the smartphone industry have led to accurate, reliable and usually cheap sensors. Although they are usually used to rotate the phone screen or for navigation, they have also proved suitable for wave data collection. Using the accelerometer and gyroscope in the smartphone, the buoy measures the height, direction and period of waves. "These data are immediately processed and sent to the client in real-time via the internet," says Radermacher. Extensive prototype testing resulted in almost an exact copy of the conventional buoy measurements. "The data turned out to be more accurate than we had imagined," says Radermacher.

'These data are immediately processed and sent to the client in real-time via the internet'

According to Radermacher, the strength of WaveDroid lies in its low costs and quick deployment. Until now, the buoy has been mostly applied close to the coast. Contractors used the measured wave data to monitor the workability of their ships, while coastal engineers needed the data to analyze erosion of beaches. For the first version of the WaveDroid, a 3G connection was required to deliver real-time data. In addition, the batteries only lasted three months, limiting the application to locations close to the coast. And, says Radermacher, close to shore is precisely where the data is needed. "Coastal waves vary greatly from location to location, so buoys are needed specifically close to shore to collect these data. WaveDroid provides an affordable alternative to conventional buoys."

A Dutch dredger decided to test the WaveDroid on one of their projects. Now, two years ahead and a wealth of experience richer, the next milestone is at stake: the introduction of a new version of the WaveDroid. The phone is replaced with self-developed electronics, which opens the door to long battery life, solar and satellite communication. AS

Photos: WaveDroid

View

Dr Przemyslaw Pawlczak, researcher in the embedded software group (EEMCS) anticipates a world full of sensors. Although convenient, they also affect privacy.

"In the future, we will live in a web surrounded by sensors that measure anything you can think of. We are used to sensors in smartphones and thermostats. In future, sensors will also be found in chairs, tables, hallways and microphones, there will be temperature sensors and odour sensors. The technology already exists, but is often still too expensive. Once they become cheap enough, we'll be able to scatter sensors from an aeroplane as 'smart dust'. Such sensors communicate over large distances and harvest energy from radio waves in the air.

The concept of smart dust was developed in the 1990s. It was used for surveillance in uncharted territories during the wars against Iraq and Afghanistan.

We already have wireless sensor nodes, but they are as big as a smartphone. Now the technology has been developed further, the sensors are increasingly smaller. The technology is already smart, but not yet as small as dust. But that will come.

Through a start-up, I am developing autonomous units that take their energy from Wi-Fi signals. We can't yet use these signals to power sensors, but our goal is a battery-free smartphone. That will take another twenty to thirty years. We can however build a sensor that only measures temperature, for example, or only sound, not continuously but every fifteen minutes. The more functionality you add, the more energy is required. Sensors have to be small, smart, reliable, and – preferably – biodegradable. The development of smart dust requires collaboration between people who understand computer science, communication, microelectronics and parallel processing.

The problem is not just the technology, but also privacy. More sensors means more information about an individual. Not everyone wants that. In Germany, for example, a row has broken out in response to a test with facial recognition at train stations. Sensors everywhere also means total monitoring. So is there any room left for surprises and challenges? No, because the state or the company knows all about you right away, they're always monitoring you.

So what can you do to protect yourself? There will have to be sensor-free zones. Perhaps not at the station but, for example, in the woods or at the beach. The dilemma is that people want to be able to be able to use the weather app, so this privacy is lost anyway. You see that now with browser usage. You can disable cookies, but then you don't get any information. There's a conflict between convenience, privacy and information. The more sensors are added, the more difficult it becomes to preserve your privacy." JW

Photo: Sam Rentmeester

‘Energy transition complicated? Do something!’

During the opening of the academic year, the 2017 Delft University Fund Best Professor Award was presented to Paulien Herder, Professor of Engineering Systems Design in Energy. “I’m not afraid of somebody else also taking on our research. In fact, I hope that they do.”

TEXT CONNIE VAN UFFELEN PHOTOS SAM RENTMEESTER

What do you teach your students?
"My main contribution has been to Technology, Policy and Management's design teaching. In recent years, I was responsible for the Energy Systems Design Master's course. We teach students about the design of energy systems and markets. It's important that they understand how the industry works, how you can use electricity to produce fuels, and how you convert gas back into electricity. So that they also understand the chemical side of things. I hope that I've managed to get this across to them".

They are very enthusiastic – one of the reasons that the Curius student association put you forward was because your lectures often receive positive feedback. How do you do it?
"I am myself when I teach my students, and I always try to convey my enthusiasm for certain parts of the course. There are also parts about which I say: it's a bit dull, but we will get through it together. I don't mince my words. I always try to show something of myself as a person".

How do you do that?
"It's not something that I incorporate into the course itself, it's more for in the breaks. I say that I went to the gym, or that I will be a little late because I have to take my child to school. Then they see that I lead a normal life. I also tell them if I go to a gig. I like sharing a little of what I get up to".

Did any professors serve as role models for you?
"One of my promoters once said to me: "You shouldn't hide your light under a bushel". You should show what you can do, and selflessly share your knowledge with others. I hope that I'm always collaboration oriented. And I'm not afraid of somebody else also taking on our research. In fact, I hope they do. I like people who try to make the cake bigger. But to identify a single professor to whom I attribute my every action? No. My promotors, Johan Grievink and Margot Weijnen, laid solid foundations for systems thinking and multidisciplinary collaboration. That has profoundly influenced what I've done in the rest of my 20 years here".

You are a member of the national Top Team for Energy. What is your mission within that team?
"There are four people in that Top Team, and I represent the knowledge institutions. My impressive, if somewhat overblown title is 'Captain of Sciences'. My role is to facilitate the participation of knowledge institutions in energy transition. I see it as my mission to make the cake bigger there as well, and not to get sucked into lots of little, fun projects. I'm currently racing around the country, trying to launch a national programme. My portfolio also covers systems integration, social innovation and digitisation of the energy sector. I'm also responsible for the human capital agenda".

What does that agenda cover?
"Encouraging intermediate vocational (MBO), higher professional (HBO) and pre-university (WO) institutions to educate the right, well-trained personnel for the future. With HBO schools, we set up platforms that allow us to ensure that teachers at HBO and WO schools are also retrained and learn a range of new technologies. I once visited the Duurzaamheidsfabriek (Sustainability Factory) in Dordrecht, an MBO college that is working hard teaching primarily male students – female student numbers are, unfortunately, lagging behind – to use the latest technologies, such as new heating installations. The installation sector still has plenty to learn about heat pumps, so schools like this help the fitters of the future to understand what they are. That makes me happy".

'With a bit of luck, our students will solve it all for us'

Last year, Statistics Netherlands (CBS) reported that within the EU, only France is further away than the Netherlands from achieving the objective of 14% sustainable energy by 2020. What do you think of that?
"That's terrible, and embarrassing. It pushes me to intensify efforts in collaboration with the Top Sector and the universities. If I talk to colleagues from universities in other European countries, it strikes me that they say, "The Netherlands, our role model!". Then I say, "Have you checked the figures recently? You'll see that we are not really up to much". Some people are surprised. They identify the Netherlands with sustainability. I thought that we led the way in this field for a long time. Or in any case, in talking about the issue".

All words and no action. Is that the problem?
"Yes. Nowadays, there is greater necessity, thankfully. Just get stuck in, without getting bogged down in detailed analyses of whether it will

CV

Paulien Herder (1971) studied Chemical Technology at TU Delft and was appointed Professor of Engineering Systems Design in Energy in 2009. Her primary focus is on the transition to sustainable energy provision. She was appointed as Chair of the Delft Energy Initiative in 2013, and in 2014, she became a member of the national Top Team for Energy, which is committed to stimulating energy transition. Herder is the only European researcher to be on the Board of the CESUN network: the Council of Engineering Systems Universities. She was the first woman to be awarded the Best Professor Award, which comprises a prize of 15,000 euros and an airplane ticket for a sabbatical. Herder is married with three children.

result in exactly what you hoped. It sometimes helps just to do something".

Where did it all go wrong?

"If I had the answer to that... I think that a lack of urgency is one of the problems. In our country, the industry is yet to feel the effects of the CO_2 problem. If you want to emit CO_2, you have to pay for it, but the price is very low. Another issue that could be affecting the Netherlands is that it's home to an enormous industrial sector, but not all of it is in Dutch hands. That makes negotiations on measures for energy transition all the more complex. Thirdly, the Dutch energy system itself is very complex and entangled. The chemistry is dependent on electricity, on heat – in short, on everything together. And then you can end up with the waiting game effect: who starts? If you pull this string, what happens? It's almost a sort of paralysis. Nobody dares to start, because nobody can oversee the entire problem".

Why are other countries in a better position?

"It sometimes comes down to political will. Of course, we all know about Germany, where lots of solar energy has been introduced with 'feed-in' rates. Those are amounts set by the government, for which people who generated their own solar energy could 'feed' it back into the grid. This allows you to recoup your investment. The policy has been criticised, as the government heavily supported it using public funds. At the time, the political considerations in the Netherlands were different".

What now?

"We say: place a spot on the horizon. Like: in 20 years' time, we want to be able to produce sustainable fuels for a cost price of x euros. Or: in x number of years, we want to remove gas from residential areas in the Netherlands. Simply establish an ambitious mission and base a major programme on it, working with other knowledge institutions and companies. At least then something is happening. Because if nothing happens, nobody moves. It could be that it is too complex and people think "Help, I'm not doing anything". But I would rather have: Energy transition complicated? Do something!"

An objective had already been established. Early this year, a report by Maros Sefcovic – EU Commissioner for Energy – stated that the Netherlands invests too little in sustainable energy and as a result, will not achieve its national target. Do you agree?

"There is little space in the Netherlands. The government can plan onshore wind energy, but with our appeal procedures, it all takes a long time. And the widespread introduction of solar energy in rural areas, like in Germany? I'd be delighted if someone could show us where. A major issue for us is spatial planning. It sounds like an excuse for us not achieving the target, but these are real issues. The move towards offshore wind farms, for which the cost price is dropping, appears to be a good way of achieving the necessary percentages of renewable energy".

We have space outside of the Randstad, don't we?

"Less than you may think. We also have to consider agriculture, we want to keep our cows, and we need space for recreation. The same issue applies to the North Sea, where we're planning offshore wind energy. You have to consider fishing, recreation, shipping. A range of different interests, also political. These interests clash, but you can't just introduce sustainable energy from a single perspective and say: we're now claiming the North Sea. That's not how it works".

Tricky considerations...

"Yes, but we're educating our students to deal with them. With a bit of luck, they will solve it all for us. (Laughs) They see the energy system as a cohesive system. What does the introduction of solar energy mean for the existing gas and coal-fired power stations? How does this technology impact other technology? What can the government do with regulations? It's this way of thinking that we teach to our students, and that's what's required to get through this transition". <<

TEXT: JOS WASSINK PHOTOS: SAM RENTMEESTER

Metal foam helps to reduce wind turbine noise

A porous metal structure fitted to the tips of the blades can help to reduce the noise produced by wind turbines. PhD candidate Alejandro Rubio Carpio demonstrated his discovery at the Inter.Noise conference in Hong Kong last summer.

Rubio Carpio used industrial strenght metal foam with pores of 0.45 mm, 0.6 mm and 0.8 mm.

At the conference, Rubio Carpio (Aerospace Engineering) was literally able to 'show noise' by using a model designed to make sound visible. The model comprises 64 microphones mounted in a spiral form on a metal grid. The device was constructed by Christaan Vlemmix as a graduation project. Reconstruction software uses the phase differences from the various microphones to calculate the position of the source of the noise on a two-dimensional map. The greater the distance between the microphones, the more accurately the location can be pinpointed. In this case, the resolution for a grid measuring two by two metres is approximately one millimetre. Rubio Carpio's design has been set up in the vertical wind tunnel of the Faculty of Aerospace Engineering. Special foam structures absorb any reflection of noise, like in an anechoic chamber. A powerful airflow blasts past a 40-cm wide section of a wind turbine blade at 70 to 140 km per hour.

The metal grid with 64 microphones analyses the noise at a distance of two metres. The result is a two-dimensional map showing the sound pressure levels in deci-

bels (dB) in a colour code. The highest sound pressure level (61 dB) comes from the centre of the blade, swiftly dropping to 55 dB over a distance of a few decimetres. The filters are set up for the bandwidth of a third of an octave around 1,600 Hertz.

GERMAN FOAM

The concept that metal foam might help to dampen the noise caused by wind turbine blades originates from the German research institute for aerospace engineering, DLR. This is the first piece of systematic research into materials with different densities, in which the airflow comes from different angles.
The preliminary results presented by Rubio Carpio in Hong Kong show

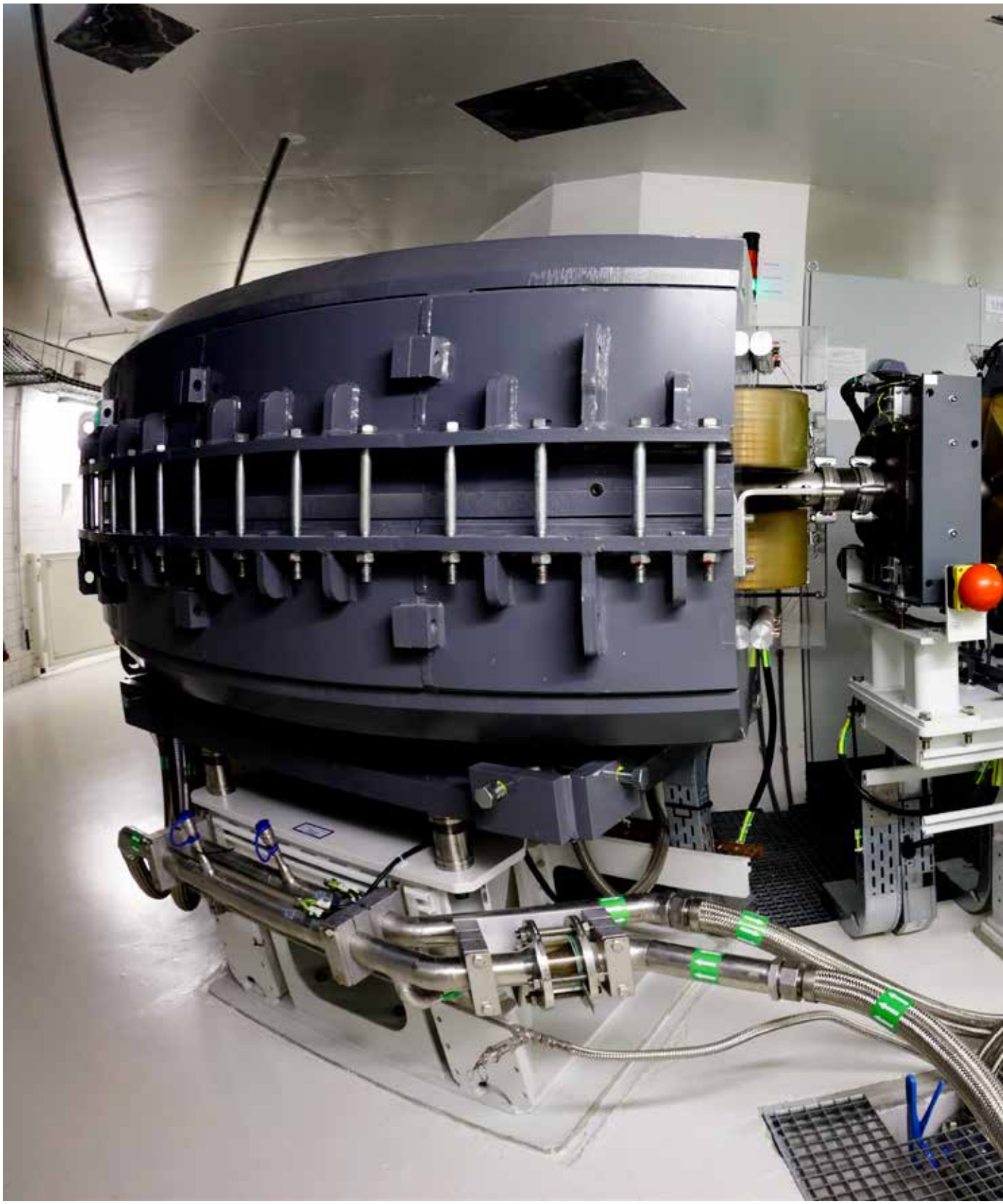
In the best-case scenario, there will be a 75% drop in noise

that in a best-case scenario, the sound pressure level across the frequency band would drop by five to six decibels. Three decibels is equal to half the noise level, so in total, this represents a 75% drop in noise.
The researcher also notes that the silencing effect is dependent on the angle of the airflow. If the airflow comes in at a wider angle, the reduction of lower frequency noise will be less strong, while the reduction of higher frequency noise is enhanced. These differences are greater when more porous versions of the metal foam are used.
For the purposes of his research, Rubio Carpio used industrial strength metal foam with pores of 0.45 mm, 0.6 mm and 0.8 mm. For his follow-up research (he still needs to complete three years of PhD research with Professor Sybrand van der Zwaag), Rubio Carpio plans to measure the effect of non-homogeneous metal foam, by making it denser on the solid part of the blade than on the tips, for example. When he finishes his research, he aims to produce an optimum topology of metal foam providing optimum noise reduction in specific conditions.
Metal foam is not currently being used to reduce the noise caused by wind turbines, but the aerospace structures and materials research group expects it to be introduced in another five to ten years. <<

Alejandro Rubio Carpio's design has been set up in the vertical wind tunnel, where special foam structures help to prevent noise from being reflected.

Alejandro Rubio Carpio, Roberto Merino Martinez, Francesco Avallone, Daniele Ragni, Mirjam Snellen, Sybrand van der Zwaag, Broadband trailing edge noise reduction using permeable metal foams, Conference paper Inter.Noise, August 2017

TEXT: TOMAS VAN DIJK PHOTO'S: SAM RENTMEESTER



Measuring and regulating in the proton clinic

Before HollandPTC (Holland Proton Therapy Centre) officially opens early next year, Delft Outlook was shown around. “We need to demonstrate that protons are the best, according to the rules.”

"You cannot simply drill a hole and pull a cable through here," quips clinical physicist Nienke Holtzer. She is not exaggerating. We are zigzagging through a maze of hallways with 3-metre-thick concrete walls, making our way to the heart of the proton clinic.
We walk through the catacombs of HollandPTC. At a solid pace, Holtzer leads us to the cyclotron. She is carrying a sensor that records how much ionising radiation we encounter.
All of that concrete – six metres in total, due to the winding layout of the corridors – is designed to protect the outside world from radiation from the particle accelerator, which spits out protons at two thirds of the speed of light. Well, it does when it's turned on. It is now at rest – not a common occurrence and the ideal time to show journalists around.
The superconductive cyclotron looms up at the end of the corridor. A giant: the size of a tank and twice as heavy. To get the 90-tonne particle accelerator into place, one of Europe's largest cranes was erected on the building site last year, on campus behind the Reactor Institute Delft.
In the distance, experts tinker with the tube emerging from the cyclotron. There is a sense of urgency, the clinic opens its doors in a few months' time. The tube is surrounded by electromagnets. The magnets collect the protons and shepherd them to the treatment rooms.


The superconductive cyclotron is the size of a tank and twice as heavy.

HollandPTC, founded by Erasmus MC, the Leiden University Medical Centre and TU Delft, will be the first proton clinic in the Netherlands. In addition to Delft, Groningen and Maastricht will also get their own proton therapy centres.
The outpatient centre will also facilitate scientific research into the effectiveness of the therapy, imaging and how materials behave in proton bundles.

Ideas at the coffee machine

For Dr Dennis Schaart, Head of the new Medical Physics & Technology research section (AP) and linked to HollandPTC, the opening cannot come soon enough. He is TU Delft's 'proton quartermaster'.
"I have been working in medical physics for nearly 20 years now," says Schaart. "The potential is in the details. Having a clinic on campus is new for us, and added to that, this clinic is for highly technical treatments. We will soon have a physical location where doctors and physicians can work together. Ideas are born at the coffee machine that would not see the light of day behind desks."
Schaart is convinced of the added value of proton therapy. "That is purely down to the inherent physical logic. With the Bragg peak."
Time for a brief explanation. Photons release a large amount of their energy as soon as they are beamed into the body. That means that the area in front of the tumour is exposed to a heavy dose. But in contrast, with protons, a limited amount of energy is released directly under the skin. The release increases exponentially towards a sharp peak, the Bragg peak, named after the man who discovered it – Henry William Bragg. By varying the amount of energy in the bundle, the depth of the peak can be altered, thereby tailoring the energy release to the tumour.

Less harmful for children

Outside of the Netherlands, proton therapy is primarily used on patients with tumours in tissue that is especially vulnerable to radiation, such as the brain and around the eyes. Protons are also said to be less harmful for children. They have lots of proliferating cells that are additionally sensitive to radiation.
However, there is still no definitive proof that protons are better than photons. This will only be available once years have been spent treating thousands of patients in accordance with strict protocols that are identical at numerous clinics.
"We need to demonstrate this added value according to the rules. We will

therefore be working closely with the other proton clinics in the Netherlands," says Schaart. "What's more, one of TU Delft's roles is to further increase this added value. There is potential for improvement in areas such as imaging. We are researching 4D imaging, so including time. We want to be able to see the tumours and the Bragg peak of the protons during radiation. Measuring and regulating: two of our fortes at TU Delft."
A green light is illuminated close to the cyclotron. Surprisingly enough, 'Area Insecured' is the text next to the light. "Don't worry," says Holtzer. "That means that the area is no longer secured, because people are here. So the cyclotron cannot be started."
The tube coming out of the cyclotron makes a sharp left turn after a couple of metres. To the right, there is a wall covered in a thick layer of baryte. The protons that cannot take the bend crash into this wall.
"We have to purify the proton beam," explains Holtzer. "It is a 'dirty' bundle comprised of particles travelling at different speeds. The bend in the tube ensures that only the particles with the desired speed remain."
Back outside, the radiation sensor indicates 1 µSv, comparable to the amount of radiation you would encounter in the fresh air.


Nienke Holtzer

Six metres of concrete is designed to protect the outside world from radiation from the particle accelerator, which spits out protons at two thirds of the speed of light

PHANTOM TESTING

There are exciting times ahead for Holtzer and her colleagues. "This is the first time that I will experience the entire process from the beginning; configuring the equipment and drafting the protocols," says Holtzer. "We have recruited several international experts with previous experience of protons. And we have completed training at proton clinics in Baltimore in the US, and in Trento in Italy. Their equipment is just like ours."
That being said, clinical physicist Petra Trnkova – one of the international experts, emphasises that it is not plug and play. Until recently, she worked on proton therapy at the Paul Scherrer Institute in Switzerland.
"We need to properly calibrate and test the machines," says Trnkova. "We use phantoms for this – objects that simulate patient tissue."
In the first year, the doctors in Delft will primarily treat patients with head and neck tumours. "We expect proton therapy to offer added value to a specific group of patients with tumours in this area," says Holtzer.
Majella de Spaey, communications consultant at HollandPTC, nods in agreement. "We do not want to create expectations that are too high. People phone us to ask if they can be put on a waiting list. But for many types of cancer, we cannot yet say whether proton therapy is more effective than with photons."
The tour continues towards one of the three treatment rooms. This area is also closed off from the outside world by six metres of concrete – two three-metre-thick walls. Attractive wood panelling conceals the concrete, and the light is soft and pleasant – decorative touches that continue into the treatment room itself.
De Spaey believes that design is important. "We think that patients will be quite taken aback when they come here for the first time. Especially once the laboratory technicians leave the room and the patient is left alone for their proton therapy."
Robot arm from the car industry
In the middle of the room is a robot arm, originally from the car industry. An examination table will be fixed to the arm, onto which the patient will be secured. The arm will then be able to move the patient in two directions: firstly into the CT scanner to visualise the tumour again, and then under the proton bundle.
The proton bundle is produced by a so-called gantry, a machine with a diameter of nine metres. This circular colossus can rotate 360 degrees around the patient. It uses magnets to focus the protons on the tumour with the greatest possible accuracy.
Patients do not see much of the machine, only a tip protrudes into the treatment room. "Some finishing touches are still to arrive from BMW," says De Spaey. BMW, the car manufacturer? "Yes, they helped design the space."
Holtzer opens a door next to the treatment table. We arrive in the back of the space with the towering gantry. "In Baltimore, the doctors show this machine to the patients," says Holtzer. "It gives them the feeling that they are in good hands. Perhaps we will do the same here." <<

IN PERSON

Bojk Berghuis, who was awarded a PhD last year by the Nynke Dekker Lab (Kavli Institute of Nanoscience), will spend the next 24 months working in the Department of Bioengineering at Stanford University (USA), trying to identify microbial genomes using microfluidic chips. Microbial genomes provide a wealth of medically and biotechnologically relevant information. He was awarded a Rubicon grant for his research.

The European Research Council has awarded a total funding of € 1.5 million to four TU Delft scientists. **Wilson Smith** is studying the conversion and storage of solar energy using materials and chemical substances that are abundantly available on Earth. **Lidewij Laan** will examine how adaptive mutations in yeast cells boost their fitness, to provide more insight into the evolution of organisms. **Monique van der Veen**'s project focuses on designing ferro-electric materials. Last but not least, **Manuel Mazo** will try to reduce the cost of implementing and maintaining so-called cyber-physical systems. These are digital systems used to control complex physical processes, such as chemical reactors or power networks.

Anka Mulder will leave the Executive Board of TU Delft on January 1, 2018. She is appointed chairman of the Executive Board at Saxion University. As a result, Saxion will then be the only university in the Netherlands with a female only college. Mulder was Vice President of Education and Operations at Delft University since April 2013 and before that Director of Education & Student Affairs for nine years.

COLUMN

Sensor? Watch out!

Killing someone by hacking their pacemaker. When I first came across the concept in the television series 'Homeland', I thought it was fairly far-fetched.

That was until, on a recent summer evening, I happened upon the website of the FDA – an American federal health care agency. They advised patients with certain pacemakers to make an appointment at their hospital to update the software in their implants. Why? The devices had suffered a security breach, allowing hackers to remotely drain the battery, or make the patient's heartbeat go haywire.

This affected nearly 500,000 pacemakers in the US. People in the Netherlands are also fitted with pacemakers from the brand in question – St Jude Medical, later renamed Abbott.

There were no known reports of hackers abusing the breach, but for people with a pacemaker, news like this must feel like they have a large on/off switch on their chests, which anyone with the inclination can press whenever they like.

I fully understand that it can be very useful if medical devices are able to communicate with the internet, smartphones and other ICT. It makes it easier for doctors and patients to analyse performance and adjust the configuration where necessary.

However, considering that it is impossible to completely protect any system against hackers, I think it would be good for manufacturers and users to ask themselves:
is an internet connection really a worthwhile addition, in light of the risks?

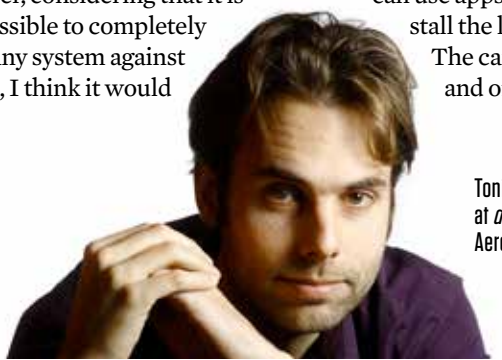
In recent years, the 'Internet of Things' has been in vogue in ICT circles: connect everything to everything, and everything can communicate with everything. Using a solar panel only to generate energy? What a waste! Add a Wi-Fi connection to the converter so that you can use your smartphone to get live updates on how much electricity the panels at home are generating, from your office.

Sounds good, it is cheap, so why not? Well, because – as two of my colleagues at de Volkskrant newspaper discovered last summer – these solar panels can also be hacked. In their research article, they outline how hackers could attack poorly protected solar panels en masse, potentially putting the electricity supply of entire cities at risk.

With this in mind, I am becoming increasingly concerned about the technological advances in cars. Everything electric, onboard computers wirelessly connected with the entire world: that is where it is heading.

I recently read a review of the Tesla Model 3, a car designed to bring e-mobility to the automotive masses. Tesla top man Elon Musk views the car as a kind of iPhone on wheels; you can use apps and updates to install the latest gimmicks.

The car of your dreams, and of hackers' dreams.



Tonie Mudde is the Head of Scientific News at *de Volkskrant* newspaper. He studied Aerospace Engineering at TU Delft.

After Delft

Aiming to work in management, Douwe Lycklama studied Business Administration at Nijenrode for a year before deciding it was a subject you could spend your whole life learning.

Photo: Sam Rentmeester

He switched to Electrical Engineering at TU Delft, spending seven years in product marketing at Philips ("consumer electronics innovation; there was definitely a link"). After trying this and that, he finally became a manager. "Don't be afraid to avoid doing a highly technical degree programme," is Lycklama's advice. "With a technical qualification, the world is your oyster. But the link between your qualification and what you do in later life is not as strong as you might think."

He works like a Trojan, although he's keen to emphasise that it doesn't feel like that. His Innopay company is a consultancy in the field of digital transactions. Payments, digital identity and the growing importance of data are "his thing," says Lycklama. "I decide where it's heading." Innopay carries out strategic research, for example, and product development and implementation projects for financial institutions, government and web stores. Since it was founded in 2002, the company has developed into a market leader in the Netherlands and an international player with branches in Amsterdam, Frankfurt, Berlin and soon in Stockholm. The company employs over forty people, and is still growing. Fact: in 2004, Innopay helped to develop iDEAL.

"Companies are increasingly dependent on digital transactions these days, but many of them are not fully aware. Legislation on data is being tightened, which affects customer perception. We have had to broaden our field of expertise. We support the public transport sector, for example, with mobile payment transactions. We're heading for a world in which people are more conscious of the information they are willing to provide

> Companies are increasingly dependent on digital transactions but many are not fully aware

on the internet. The world is at our feet. At present, we're working on iSHARE for the logistics sector: simplifying the way data are shared between the numerous parties involved in international goods and payment traffic. We're helping 'The Netherlands PLC' to progress".

"I was an average student," says Lycklama. "I passed what I needed to pass, but did a lot outside uni. I wrote for the the University newspaper Delta, for example, and organised a study trip to Korea and Japan in 1987 for students and professors in the Electrical Engineering Association. This group gave rise to my first real company: Kojac. It was a consultancy agency, and it's survived to this day. It was set up as a company to pass on; you had to find someone to take it over after you graduated. It's now a job agency for student programmers."

"Being an entrepreneur means recognising opportunities and seizing them when you can," is Lycklama's vision. "Fifteen years from now, I'll still be helping to design the transactional future; most likely we'll be a few steps further by then. We're publishing our first book about this next year." JB

Is the end of the combustion engine in sight?

Following in Tesla's tracks, an increasing number of car manufacturers are focusing on electric driving. The first electric airplane was even announced recently. Is it really the end of the road for the combustion engine?

It looks nifty, the Wright One: the electric airplane that was presented (on paper) earlier this year. With 150 seats, it is intended as a rival to the Boeing 737. It is set to hit the market in ten years' time. But how realistic is it to expect that an environmentally friendly alternative for the jet engine will actually be developed within that time frame?
Alexis Bohlin, researcher in the Flight Performance and Propulsion research group at the Faculty of Aerospace Engineering prefers not to waste too many words on the subject. The energy capacity per kilogramme of kerosene is still 60 times that of the best battery, and that does not counterbalance the greater efficiency of the electric engine. An electric airplane would simply be too heavy.
"That doesn't mean we are not doing our utmost to make flight more environmentally friendly", emphasises Bohlin. "After all, we expect air traffic to continue to grow, and the aviation sector will have to take responsibility".

FEMTOSECOND

Bohlin was recently awarded a Vidi grant for research that is ultimately intended to facilitate the creation of efficient combustion engines for reliable biofuels. His area of expertise, optical spectroscopy, plays a role in both fields. "In order to make the combustion process more efficient, you need to understand it in detail", he explains. "The process takes place extremely quickly and at very high temperatures. To track the process without interrupting it, you need sturdy, high-speed lasers". We recently purchased a laser with a pulse frequency of a femtosecond. We are now constructing measuring equipment around it. We will also have to develop the analysis methods ourselves, as we are moving into completely uncharted territory".
The measuring equipment will ultimately precisely gauge how the temperature is distributed in the combustion chamber. The more balanced the distribution, the better: high peaks in temperature are responsible for the production of nitrogen oxides. Bohlin's colleagues are working on new concepts for an engine: so-called 'distributed auto-ignition', in which fuel and oxygen are supplied to the combustion chamber at the correct temperature, so that they spontaneously combust. That results in less high peaks.
When developing an engine like this, it naturally helps if the quality of the fuel itself is consistent. If it is not, you cannot be sure whether the variations you are measuring are down to the kerosene or the design of the engine. But to truly make aviation green, the kerose-

The first electric airplane is set to hit the market in ten year's time. But how realistic is it to expect that an environmentally friendly alternative for the jet engine will be developed within that time frame?

ne will have to make way for biodiesel. And the quality of this biodiesel needs to be consistent.

BIOREACTOR

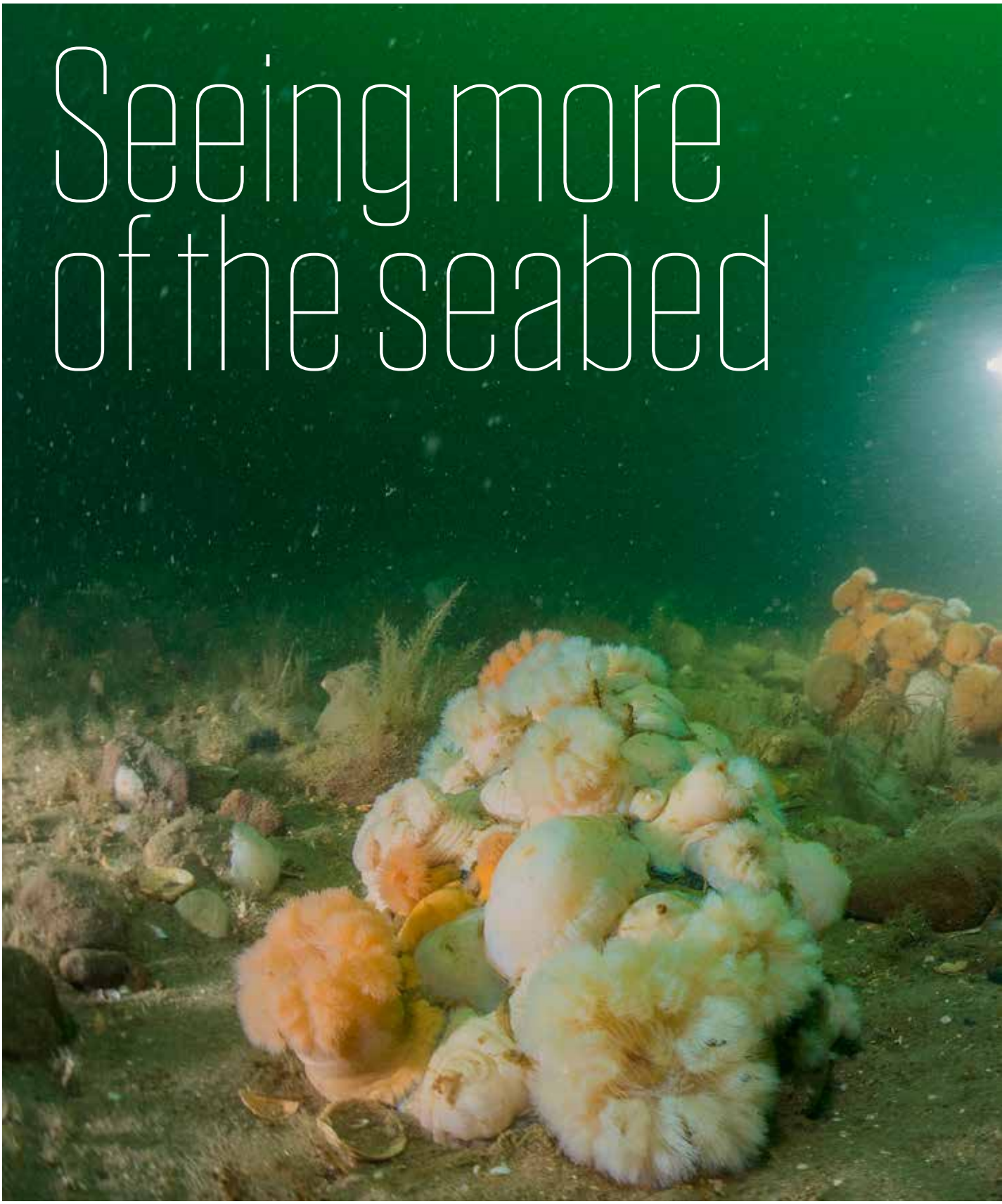
"You can also apply spectroscopy in the production of biofuels", explains Bohlin. "Being able to closely examine which molecules are made by which bacteria under which conditions allows you to produce fuel of a more consistent quality. From an analytical perspective, this is a lot more complicated. The gas in the combustion chamber is comprised of a limited number of different molecules. That results in clear peaks in the spectrum. In the moist environment of a bioreactor, the image is more diffused".
For this branch of his research, which has already resulted in a patent, Bohlin works closely with the bioengineers at the university. The research into better biofuels and airplane engines has something else in common: a significant part of both areas concerns discovery based science. The conditions in the fuel chamber and reactor are so complex that you cannot work out what

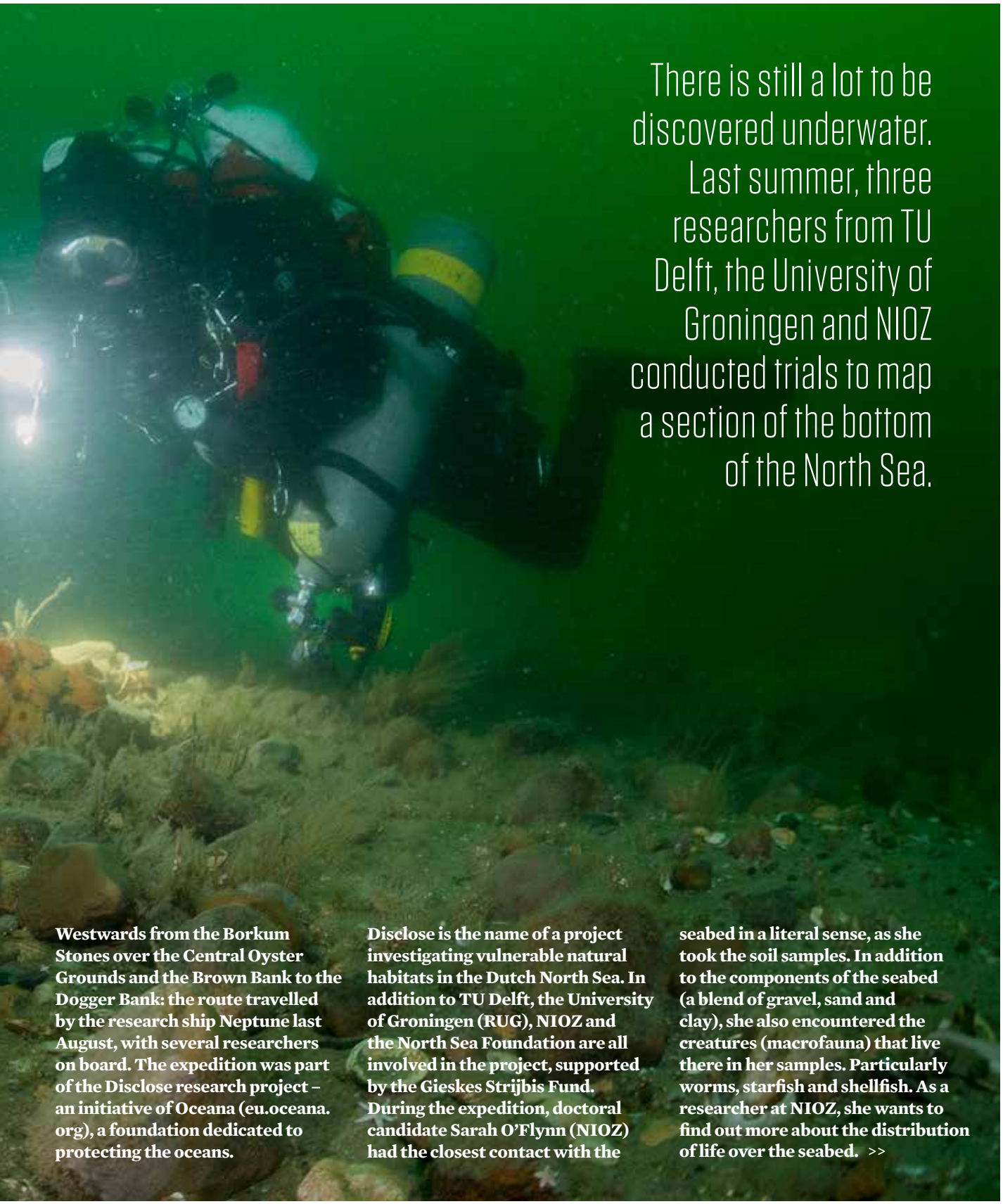
> To truly make aviation green, the kerosine will have to make way for biodiesel

will happen in advance. It is a matter of systematically examining the possibilities, studying the results and focusing on the most promising lines of research. That is why detailed analysis methods are vital.
It is currently primarily still fundamental research. Mastering the femto-laser, gaining insight into how the laser and matter interact, refining the data analysis, getting to grips with the molecules. However, the focus remains firmly on the ultimate goal: controlling the production of biofuels that are perfect for use in a new generation of combustion engines. The funds from the Vidi grant will enable Bohlin to expand his research. He has complete confidence.
So, we can forget about electric planes? Well, perhaps for 50 or 100 years, conjectures Bohlin. Wright appears to be taking this into account, as the ambitious manufacturer (largely staffed by former NASA personnel) is also considering a hybrid plane for if the development of the battery technology fails to meet the mark. If all goes well, Wright will only be concentrating on short-haul flights for the now. Even those optimistic about the electric future assume that long-haul flights will remain the domain of the combustion engine. <<

TEXT: JOS WASSINK PHOTOS: **OCEANA**

Seeing more of the seabed



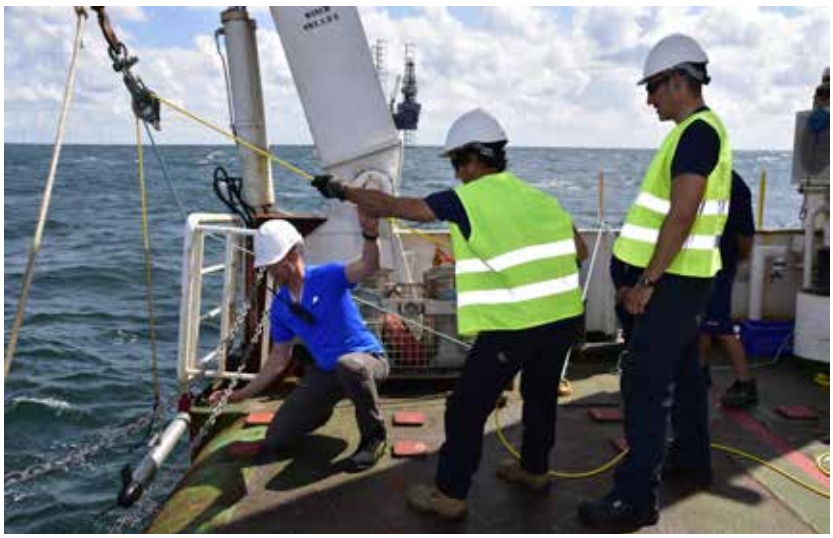


There is still a lot to be discovered underwater. Last summer, three researchers from TU Delft, the University of Groningen and NIOZ conducted trials to map a section of the bottom of the North Sea.

Westwards from the Borkum Stones over the Central Oyster Grounds and the Brown Bank to the Dogger Bank: the route travelled by the research ship Neptune last August, with several researchers on board. The expedition was part of the Disclose research project – an initiative of Oceana (eu.oceana.org), a foundation dedicated to protecting the oceans.

Disclose is the name of a project investigating vulnerable natural habitats in the Dutch North Sea. In addition to TU Delft, the University of Groningen (RUG), NIOZ and the North Sea Foundation are all involved in the project, supported by the Gieskes Strijbis Fund. During the expedition, doctoral candidate Sarah O'Flynn (NIOZ) had the closest contact with the seabed in a literal sense, as she took the soil samples. In addition to the components of the seabed (a blend of gravel, sand and clay), she also encountered the creatures (macrofauna) that live there in her samples. Particularly worms, starfish and shellfish. As a researcher at NIOZ, she wants to find out more about the distribution of life over the seabed. >>

Karin van der Reijden (RUG) prepares the 'tow camera' for submersion. (© OCEANA/Juan Cuetos)



Leo Koop (in blue) and the crew lower the side scan sonar into the water. (© OCEANA/Carlos Minguell)

Sarah O'Flynn (NIOZ) explains results of the sediment profile camera to the crew and researchers. (© OCEANA/Juan Cuetos)

Why is a certain species found at a certain place, and not elsewhere? Karin van der Reijden, doctoral candidate at the RUG, is researching the distribution of life on the seabed. For her research, she uses photos and video recordings taken by a specially designed 'tow camera'. This camera is dragged behind the ship, and floats a metre above the seabed. On the Dogger Bank, she saw sand, shell fragments and lots of flatfish. Around a shipwreck, the Oceana team used a robot submarine to film various strains of seaweed and soft coral, which was providing refuge to cod.

SONAR DATA

The contribution from TU Delft comes in the form of Leo Koop, a doctoral candidate with a Dutch name, but who comes from Belize (Central America). Koop is part of Prof. Dick Simons' Acoustics group at the Faculty of

Policy makers can use this information to plan fishing and shipping routes

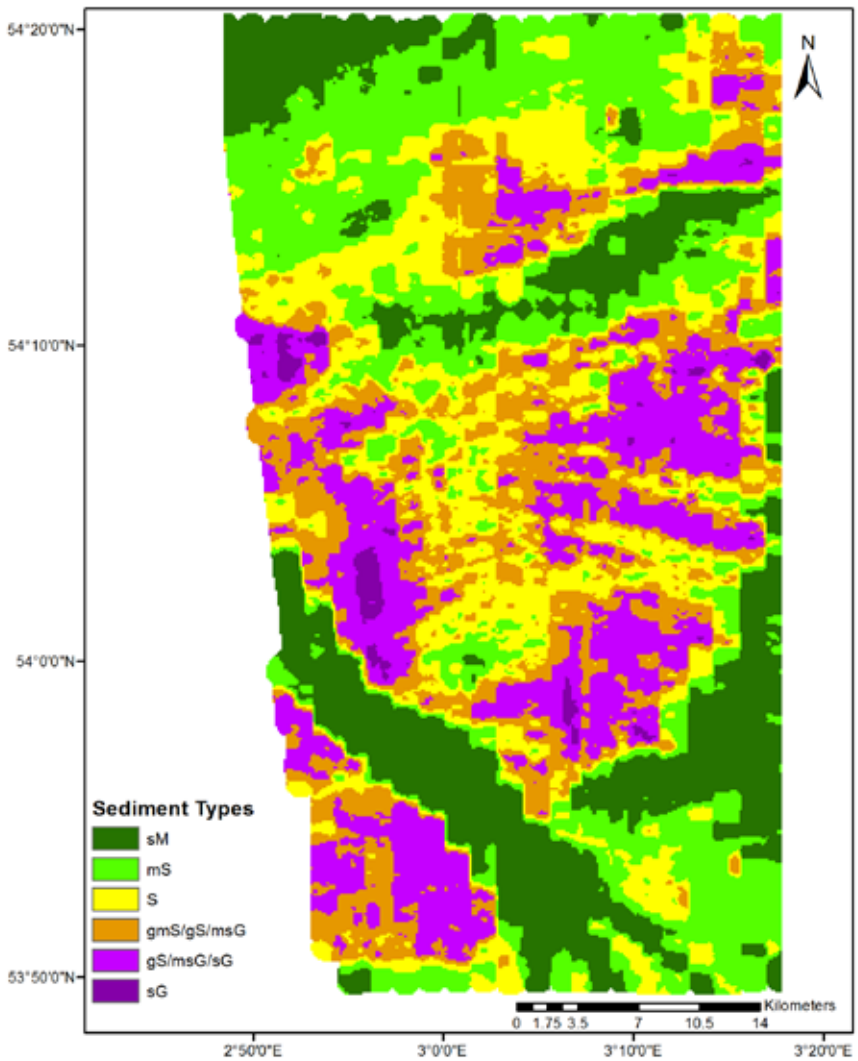
Aerospace Engineering. During this project, he used two techniques to collect 400 gigabytes of sonar data. The multibeam echo sounder is a device about a metre in length that is attached to the keel of a ship and transmits a 'ping' up to 50 times per second, gathering the echoes from the seabed. The sonar scans 100-metre-wide strips, perpendicular to the course of the ship. The delay in the signal provides information about the distance or depth, while the strength of the reflected signal provides information about the composition of the seabed. Reflection is greater with hard pebbles than with a layer of mud.
He also used a side scan sonar, which is dragged behind the ship at between 5

and 15 metres above the seabed. Koop explains a dilemma he faces: 'The amount of detail is improved nearer the seabed, but there is also a greater risk of collision'.
The sonar under the ship is linked to GPS and adds precise location data to the sonar measurements. The exact location of the side scan sonar is not known, but this is compensated for by more detailed information due to it being closer to the seabed.

VIDEO

Koop thinks that analysing the sonar data will take months. This will be followed by another, more adventurous, project: the researchers plan to link sonar, video and seabed samples. Koop explains: 'Seabed samples offer the most detailed information about the seabed, about its composition and the life forms found in it. Video covers a larger surface area, but offers less detail. And sonar is observation of an even larger area, with even less detail'.
The hope is to use the sonar to identify sections of the seabed where video images and samples have already indicated biological activity. And that is also in line with the objectives of the DISCLOSE project, namely to identify vulnerable sections of the seabed. Policymakers can use this information to plan fishing and shipping routes, and to determine the location of offshore wind farms and oil and gas extraction sites in the North Sea – apparently one of the most intensively used bodies of water in the world. <<

Leo Koop checks the configuration of the multibeam echo sounder onboard the Neptune. (© OCEANA/Carlos Minguell)



One of the intermediary results of the expedition is the most detailed seabed map of a 25 to 30km-wide strip of the Klaver Bank. The colours indicate which mixture of sand (s), mud (m) and gravel (g) is on the surface. (Image: Leo Koop/TU Delft)

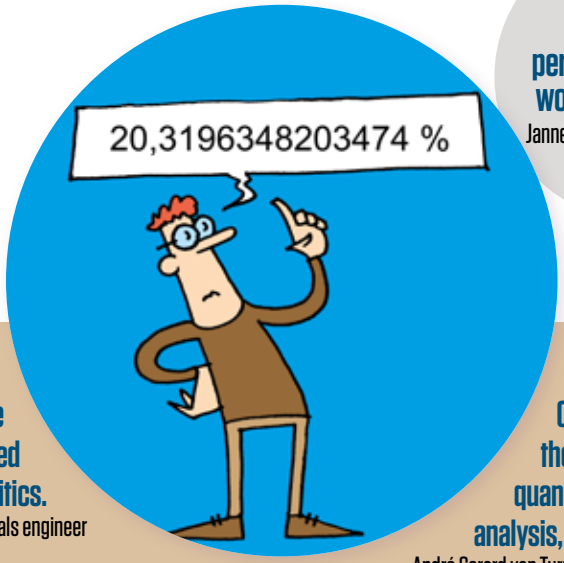
HORA EST

‘The government should not punish all owners of classic cars. Only a small proportion of these owners use them to travel long distances’

Yashar Araghi, systems policy engineer

“Old cars pollute the environment more than their modern equivalents, which is why policymakers are arguing in favour of banning classic cars from cities. This is unfair. For my PhD research, I explored how 16,000 classic car owners in 15 EU countries used their vehicles. I split the population into various user groups. One of these groups used their car nearly three times more than average, representing 8 per cent of the owner population. 92 per cent of the owners only drive their car on special occasions. It is unfair to punish them for the actions of the other 8 per cent.”

The optimum percentage of perfectionists in the world is about 20%.
Janneke van der Stok-Nienhuis, materials engineer



Society imposes an unfair pressure on the higher educated to be engaged in politics.
Janneke van der Stok-Nienhuis, materials engineer

Computational power is not the main limiting factor of quantitative, statistical data analysis, data management is.
André Gerard van Turnhout, civil engineer

Cheap sensors are not cheap.
Ruijun Deng, mechanical engineer

Let’s make wind great again.
Carlos Arce León, aerospace engineer

Humans are too resourceful for their intelligence.
Gerben Bas, management engineer

Solar cell technologies will not save the planet, but they might save humanity.
Dimitrios Deligiannis, electrotechnical engineer

It is easier to teach very young children basic affordances than robots.
Chang Wang, robotics engineer

Improvisation is a learnable skill.
Jakob Hammhuber, physics engineer

Combat aircraft selection should not be based on multi-criteria analysis but on war gaming.
Herman Johan Koolstra, aerospace engineering

THE FIRM

A real IDE product. That's how Jos Ramselaar and Jurrit Hollands see their bike. Spaac intends to make electric bikes hip. The leather saddle and motor were inspired by 1900s motorcycles.

The Spaac office is located at an industrial estate in The Hague. There are bikes of all colours, and even one with a side-car. The walls are hung with photos of motorcycles and the first Spaac bike frames they ever made. Bike repair man meets hipster: two Macs are sitting on the table churning out data, coffee comes from an espresso machine and the seating area features vintage chairs.

Ramselaar and Hollands met in 2005 at the student windsurfing club Plankenkoorts. After graduating, Ramselaar took a job at a mobility design agency. "I thought about how I could do things differently. Electric bikes were a whole new category in the bike world back then. Jurrit and I both thought along the same lines. We agreed to work on our concept together one day a week. We made designs on the computer and entered business plan competitions. We gradually started to get things off the ground."

"We milled and welded our own frame from structural steel," says Hollands, pointing to a frame on the wall. "Then we sprayed it white. We just used an aerosol. Looking for a factory willing to produce small numbers - thirty frames - we ended up in the Czech Republic. It's awesome when someone hands you the manufactured product of something you designed yourself!"

Photo: Sam Rentmeester

Name:	Jos Ramselaar and Jurrit Hollands
Degree programme:	Industrial Design Engineering
Company:	Spaac Motorized Bicycles
Product:	(electric) bicycles
Mission:	To get everyone onto a Spaac
Turnover:	"We've only just started, so quite modest."
In five years' time:	To have a few thousand bikes on the road, in the Netherlands and abroad.

So what's so interesting about bikes? "I think all modes of transport are interesting, normal and fun," says Ramselaar. "Nobody is happy having to drive through The Hague by car. You're much better off cycling, preferably on a fast, electric bike. We want to dispel the 'old fogey' image. The bikes have a nifty motor, and you can whiz through the streets. You feel like superman accelerating away."

The mid-drive motor provides the pedal power. Turning the key in the ignition switches on the motor and the lights. The bike has just two gears, located on the hub, which are changed automatically. "We wanted to keep things as simple as possible," says Hollands. "When you have lots of gears, you're always trying to find the right one. You don't have to think about this if the gears are automatic. The bike can do up to 27 kilometres per hour. There are no buttons, switches or a display; you just turn the key and you're off."

The two have big ambitions. "We want to go international! We're thinking about expanding to cities like Copenhagen, Berlin, Hamburg." "Yes, or Sydney, San Francisco... There are lots of hills there and people could use a motor." RVT

ALUMNI NEWS

Alumni Activities

18-19 October
IDE Master classes in New Product Marketing

23 October
4TU alumni event at Dutch Design Week in Eindhoven

28 October
Leeghwater alumni event in Delft

22-23 November
IDE Master classes in Thing Centered Design

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You too can support TU Delft talent by donating to the Delft University Fund:
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Dutch Engineers Alumni Network in Barcelona

On 7 September last, Marc Zink, CEO of Spain's most successful start-up Subaste de Ocio, gave a presentation in Barcelona about his company to alumni from the four Dutch universities of technology. This start-up event of the Dutch Engineers Alumni Network group was rounded off with drinks and a networking opportunity.

The purpose of this group is to serve as an engagement platform for graduates of the four technical universities of the Netherlands, and is jointly administrated by the TU Delft, TU/e, Wageningen University and University of Twente Alumni Offices. Our hope is that this will be a valuable networking resource for alumni, and we encourage members to use the group for sharing both achievements and information as well as tapping into the expertise of each other. This network therefore represents a significant source of skills, contacts, and advice!

Life long learning

This autumn heralds the start of another extensive range of massive open online courses (MOOCs). MOOCs are the easiest way of updating your knowledge on a wide range of subjects (including technical subjects).

- 17 October: Forensic Engineering: Learning from Failures
- 17 October: Industrial Biotechnology
- 24 October: Globally Distributed Software Engineering
- 14 November: Solar Energy: Photovoltaic Energy Conversion
- 14 November: Quantum Cryptograpgy
- 22 November: Models In Architecture – Design through Physical & Digital Models
- 28 November: Solar Energy: Photovoltaic (PV) Systems

Paulien Herder receives Best Professor Award

From the UFD

On 4 September, Professor Paulien Herder was voted Best Professor at TU Delft 2017. The Professor of Engineering Systems Design in Energy was presented with the award by the Delft University Fund (UfD).

Each year, the UfD gives this award to a professor who has excelled in both teaching and research, and who serves as an inspiration to both students and PhD candidates. Paulien Herder was nominated by the Dean as well as by Curius study association, a number of current and former doctoral candidates, former MSc students, the industry, and various management boards.

Social impact

Hans Wamelink, Dean of TPM speaking about the nomination: 'Paulien has colossal social impact, and further improving energy transition is a key issue that affects all of us and that will have a major impact on future generations. We clearly cannot let the fact that we have an academic in our midst who makes an extremely valuable contribution to this key global issue – and who takes an approach that unites, motivates and inspires – pass by unnoticed. Paulien is also truly representative of a generation of scientists who care little for disciplinary boundaries and who possess the intellectual powers needed to transcend these boundaries. It is patently clear to me that in Paulien, we have a Professor of exceptional stature.'
Read more about Paulien Herder in an in-depth interview on page 18.

Read more about Paulien Herder in an in-depth interview on page 18.

The aim of the Delft University Fund is to lend financial support to TU Delft in its ambition to be a global player in the field of education, research and talent development. It does so by maintaining close ties between the University and alumni, companies and philanthropists.

You too can support TU Delft talent by sending a donation to the Delft University Fund. See tudelft.nl/universiteitsfonds for more information.

Portable prototype

Alberto Gancedo has just started with his Master-degree in Electrical Engineering.
He has an extraordinary cool 'student job'. With help from EEMCS alumni and the TU Delft University Fund he is able to further develop a portable prototype to detect babies' unusual brain activity, directly after birth which he developed himself when he was still a Bachelor-student.
Alberto: "It is a monitoring device to measure baby's brain activity in a simple way, to easily detect malfunctions. Since a baby is fragile and can't lay still, a standard cap with electrodes and lots of wires is not an option for a (premature) baby, so my prototype uses only few electrodes to overcome this issue and cause the least amount of harm possible. Its aim is to be small, portable, and cheap. Although it takes a lot of work, I might be able to do some live measurements with my prototype in a hospital by the end of this class year."

tudelft.nl/ewi/actueel/humans-of-eemcs/alberto-gancedo

The lab of...

Cleanroom Aerospace Engineering

Mehmet Sevket Uludag is currently working on a pocket qube satellite which is called Delfi-PQ. Purpose of this satellite is to miniaturize the subsystems and to show their capabilities. “It is important to work in cleanroom because, we should not be sending any particles to space and we would like to protect the satellite from unwanted particles which might cause bigger problems for the satellite and the space”, he says.

PHOTO: SAM RENTMEESTER