DELFT OUTLOOK
NO. 4 | DEC 2014 | YEAR 31
TU Delft

290X5X9.5 METRES
LARGEST WAVE CHANNEL IN EUROPE

MARK VAN LOOSDRECHT
'I want to move on to the next development'

150 YEARS OF MECHANICAL ENGINEERING
Pioneers of the industry

THEME
Shortage

Coverphoto: Entire computers are being shredded and sorted by size for recycling purposes by Professor Yang (see page 12). Some fragments are still just big enough to recognise. Smaller parts are unrecognisable, they just look like grey powder. (Photo: Sam Rentmeester)

REDACTIONEEL
Frank Nuijens

Shortage

In a 2013 report, the Dutch Language Union and the Council for the Dutch Language and Literature expressed serious concern about the 'declining usage of Dutch as a language of instruction'. They fear that this will 'come at the cost of academic language skills in Dutch'. TU Delft is not discouraged. At present, 16% of the student population is foreign. In its *Roadmap to 2020*, however, the university is aiming for an intake of 40% of its Master's students and 10% of its Bachelor's students from abroad. To achieve this goal will require more English in the curriculum. The Master's programmes are already being taught in English, and the Executive Board hopes that the Bachelor's programmes will follow in three or four years. Only time will tell whether this will lead to a shortage of Dutch at TU Delft. In this issue of *Delft Outlook*, we report on shortages in other areas, including raw materials, sanitation, women and classrooms, as well as on how TU Delft is searching for solutions. We wish you an abundant 2015.

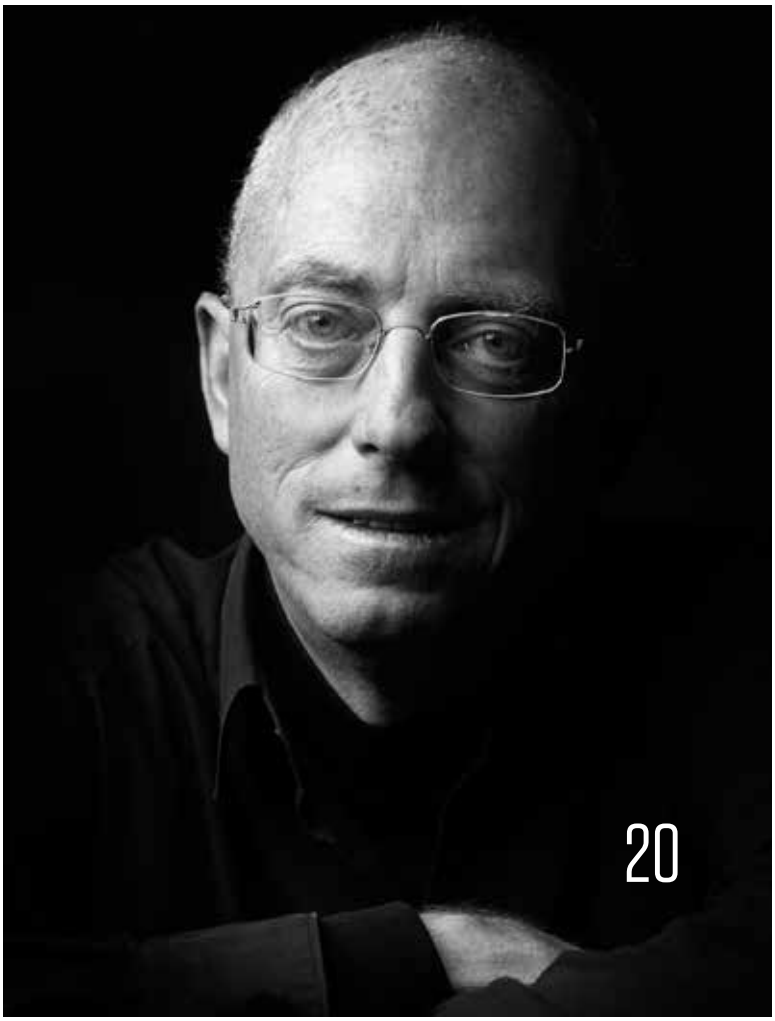
Frank Nuijens,
Editor-in-Chief

page 07
Theme Shortage

PHOTO: SAM RENTMEESTER

04

COLOPHON
Cover photo Sam Rentmeester
Editorial staff Frank Nuijens (editor-in-chief), Dorine van Gorp, Katja Wijnands (managing editors), Saskia Bonger, Tomas van Dijk, Sam Rentmeester (image editor), Connie van Uffelen, Jos Wassink
T +31 (0) 15 2784848,
E-mail delftoutlook@tudelft.nl
Contributing writers Auke Herrema, Jorinde Benner, Remco de Boer,
Design Jelle Hoogendam
Typesetting Saskia de Been
Printing Quantes Grafimedia
Subscriptions
delftoutlook@tudelft.nl



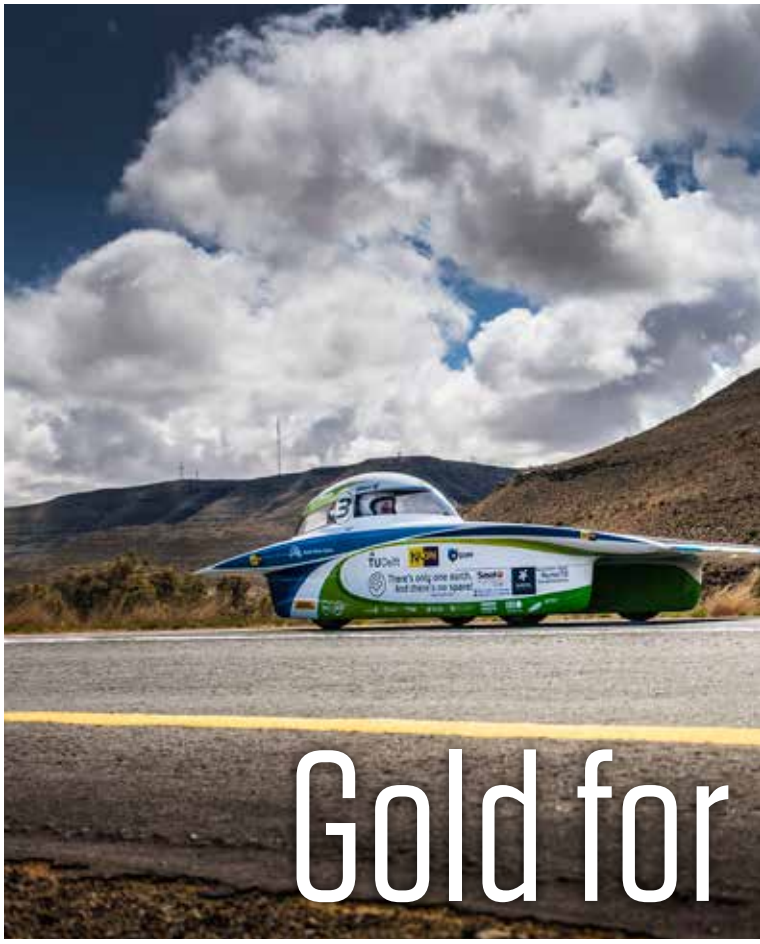
DELFT IN BRIEF

PHOTO: TU DELFT

PHOTO: DELMIC

Life under the magnifying glass

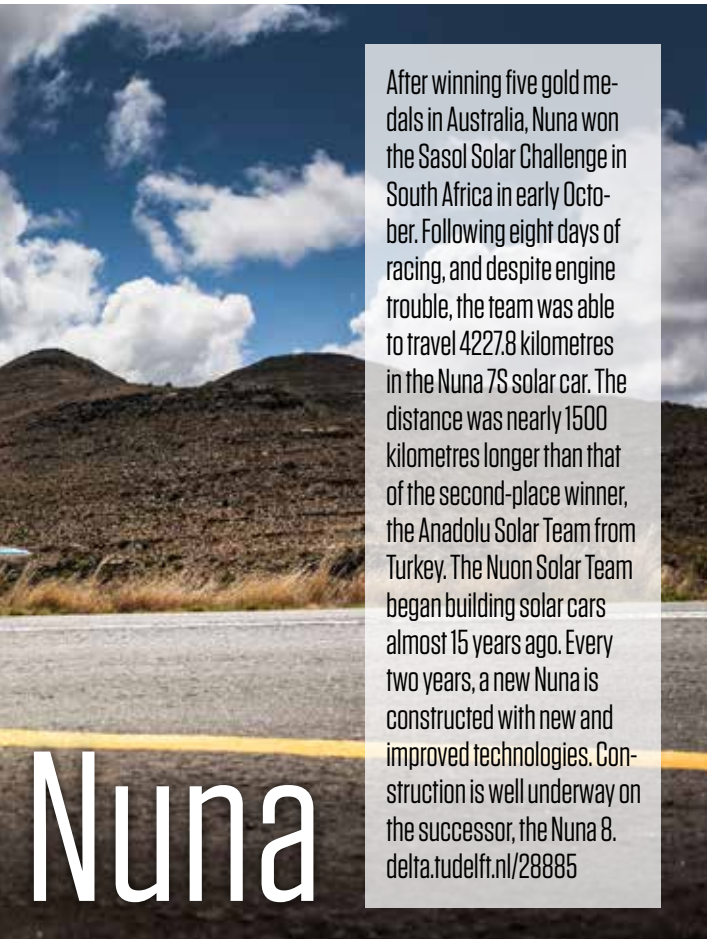
A smart combination of an optical and a electron microscope can follow individual molecules in their course through a living cell. Named Delmic, the combination microscope is an optical microscope in the vacuum chamber of an electron microscope. Both microscopes view the same object – one from above, and one from below. In her dissertation, researcher Dr Nalan Liv demonstrates how the optical microscope follows a molecule labelled with quantum dots on its way through a cell. At the same time, she uses the electron microscope to take snapshots of the organelles encountered by the molecule. In this way, the Delmic reveals elementary life processes.
delta.tudelft.nl/28870



Gold for

Flying ambulance

Alec Momont, a graduating student of IDE, devised an ambulance drone that could substantially increase the chances of survival of those suffering cardiac arrest. The unmanned mini-aircraft has medical equipment on board, such as a defibrillator, and it can communicate with emergency-services operators.
The drone can travel at a speed of 100 kilometres per hour, enabling it to reach a victim in one minute within a twelve-square-kilometre area. Although it is currently illegal to operate unmanned aerial vehicles, Momont predicts that his idea could be realised within five years. The drone is expected to cost €15,000.



Nuna

After winning five gold medals in Australia, Nuna won the Sasol Solar Challenge in South Africa in early October. Following eight days of racing, and despite engine trouble, the team was able to travel 4227.8 kilometres in the Nuna 7S solar car. The distance was nearly 1500 kilometres longer than that of the second-place winner, the Anadolu Solar Team from Turkey. The Nuon Solar Team began building solar cars almost 15 years ago. Every two years, a new Nuna is constructed with new and improved technologies. Construction is well underway on the successor, the Nuna 8.
delta.tudelft.nl/28885

PHOTO: HANS PETER VAN VELTHOVEN

PHOTO: SAM RENTMEESTER

Chemical companies negligent

Two thirds of the chemical companies investigated do not take safety regulations very seriously. They are either unaware, or they deliberately violate the rules. This statistic does not surprise Dr Marieke Kluin. 'Studies from the United States and Denmark report similar results', observes the doctoral candidate. She conducted research at TPM on options for encouraging companies to improve their adherence to the prescriptions. Kluin is convinced that openness about accidents and pressure from the local environment are likely to be more effective than the formal inspections.
delta.tudelft.nl/29059

Dangerous automatic pilot

Pilots Alexander in 't Veld and Hans Mulder discovered a software error during a simulation of a Ryan Air flight using the Cessna Citation, the aeroplane of TU Delft and the LNR. Further research by the AE researcher ir. Michiel Schuurman and his colleague in the Dutch Safety Board, Kas Beumkes, revealed that the error had led to dangerous situations on at least four other flights of various airlines. In October, Schuurman and Beumkes received the Award of Excellence for Best Paper during the annual seminar of the International Society of Air Safety Investigators (ISASI) in Adelaide.
http://tinyurl.com/qb2zyq6

Launch cancelled

On the last of three launch days in Spain, the rocket motor stalled, forcing the DARE student rocket team to abandon their attempt at a new record. With the Stratos II rocket, which they had designed and built themselves, the TU Delft team aimed to set the record for amateur rockets at a height of 50 kilometres. Unfortunately, the rocket failed to leave the ground. During the last opportunity to launch the rocket, the nitrous-oxide supply valve froze, thus impeding the ignition of the permanent fuel and causing the launch to fail. The students are now preparing for a new launch opportunity next summer.
delta.tudelft.nl/28882

Ozone layer

In September the World Meteorological Organization (WMO) announced that the ozone layer is recovering. Prof Pieternel Levelt, a remote-sensing expert in the CEG faculty and the Royal Dutch Meteorological Institute (KNMI) contributed to this conclusion. Levelt is the head of OMI, the Ozone Monitoring Instrument, which is on board the NASA space agency's EOS-Aura satellite. It has been measuring the composition of the atmosphere for 10 years. The measurements have revealed a causal relationship between the decrease in CFCs in the atmosphere and the recovery of the ozone layer. Although the OMI was designed to last for five years, it is still flying after a decade. There is enough fuel to make measurements until 2023, but a successor is already being developed and is scheduled to be launched in 2016.

Calling your uterus

FOTO: SAM RENTMEESTER

The inability to become pregnant can cause a great deal of stress – hassles with clinical ovulation tests and planned intercourse. For her graduation project, industrial designer Cora Man devised a solution for the problem of calendar sex: the Cycle-Observation-Ring-Application for vaginal use. She called her solution CORA, adding the word 'With' to create a sense of friendly intimacy. The oval 'With CORA' device is inserted around the cervix after menstruation, and it communicates with the user's mobile phone by Bluetooth, providing constant readings of the user's body temperature. 'If it is 0.4 degrees higher than normal, the user is ovulating and knows that it's time for action', explains Man. Or not, of course, as the ovulation meter can also be used for the opposite purpose – avoiding intercourse on fertile days.

delta.tudelft.nl/29010

Camera frame

A tripod is obviously nice for making stable video images. Lugging it around, however, is not for the industrial designer and film maker ir. Hakim Sugito. A camera on a tripod can also be clumsy if you suddenly wish to move along with your subject. For his graduation project, Sugito devised a self-stabilising frame on which the camera can be mounted. The ingenious system of gyroscopes and accelerometers ensures stability. With his invention, the Waltz, Sugito hopes to give more freedom to camera operators.

delta.tudelft.nl/28955

PHOTO: SAM RENTMEESTER

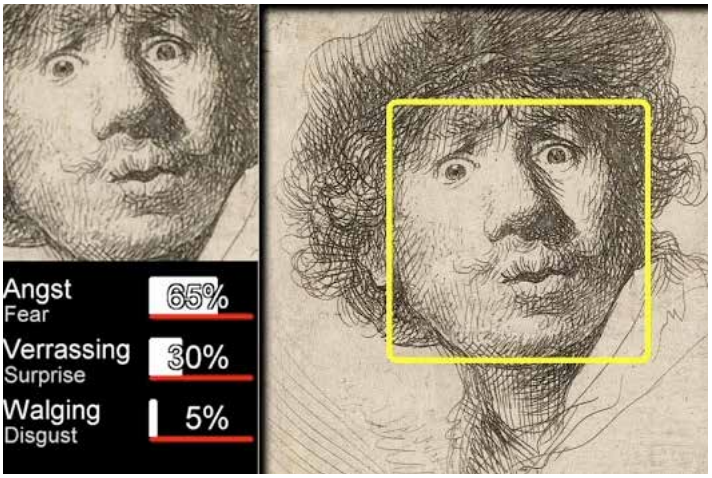


PHOTO: FRANS HALS MUSEUM

Emotions

In the art of the Golden Age, almost nothing was more important than the ability to depict human emotions convincingly. For the exhibition 'Emotions – Painted feelings in the Golden Age' in the Frans Hals Museum, Hamdi Dibeklioğlu of the Pattern Recognition and Bioinformatics research group (EEMC) developed software that can analyse facial expressions. The software interprets the faces on paintings in terms of basic emotions such as happiness, sadness, fear, anger, surprise, repulsion and contempt. The exhibition runs until 15 February 2015.

delta.tudelft.nl/28985

THEME
shortage

PHOTO: PATRICK DI FRUSCIA, VISUALS UNLIMITED / SCIENCE PHOTO LIBRARY

TEXT: JOS WASSINK
PHOTO: SAM RENTMEESTER

Shortage is a European problem

Rising prices for raw materials are slowing down the European economy, according to Peter Rem, Professor of Resources and Recycling. He demonstrates how we can extract more of our raw materials from waste.

Inashco manufactures devices that process hundreds of tons of ash per hour.

"We are addicted to metals, and the ore supplies are finite', says Prof. Peter Rem (CEG Faculty). 'A shortage of raw materials is going to emerge, starting in Europe. Europe was the first to begin industrial development, and it has almost no raw materials of its own remaining. European imports of energy and materials amount to €500 billion per year. This is 4% of the European economy. It had been 2%, but the prices of raw materials exploded between 2005 and 2008. We need to switch to the use of raw materials from recycling before another price increase of this magnitude occurs. The entire industrial sector will eventually need to shift, but Europe is facing the greatest urgency'.

Innovations in recycling are sorely needed. In the 1960s, the extraction of metals from waste was seen as a type of mining, and some of the same techniques were used. The results were disappointing: 40 years later, only 4% of all raw materials came from recycling. Nobody had realised that recycling, in contrast to mining, would yield an array of metals suitable for re-use only in their pure form. Moreover, economically interesting metals in waste are often in very small particles, making them difficult to extract. Separate collection and improved separation techniques are now allowing Germany to obtain 15% of its raw materials from recycling. Rem predicts that, in 15 to 20 years, we will need to recycle at least half of our metals. He is developing the technology for doing this.

Metals from ash

In 2007, the TU Delft alumnus Jaap Vandehoek approached Rem. On assignment from the metal supplier Fondel, he was searching for metal-recycling technologies. After touring Europe, his search led him back to his own faculty, where Rem and his group had recently developed a 'neat technology with great potential'. This technology made it possible to extract nearly all metals out of the ash from waste incinerators – something that had not been possible before. The ash is a sticky, burnt-out mass containing tiny small metal particles: a curtain hook, a tack, a shred of copper wire and many pellets no larger than a few millimetres. It is all stuck together with wet ash. For this reason, the

fine metal particles cannot be extracted with magnets or eddy currents.
Now, seven years later, the separation technology is being used on an industrial scale. The Inashco *(Incinerator Ash Company)* firm, which was established with patents from TU Delft and investments from Fondel, manufactures devices that process hundreds of tons of the ash per hour. A river of ash flows from a conveyor belt to a rapidly turning turbine vane wheel. Blows from the wheel knock adherent ash away from the metal particles and shoot the material into a metal tube measuring 25 metres in length. While the lighter particles start whirling downward after only a few metres, the higher density of the heavy particles cause the

'You can see the entire periodic table passing by'

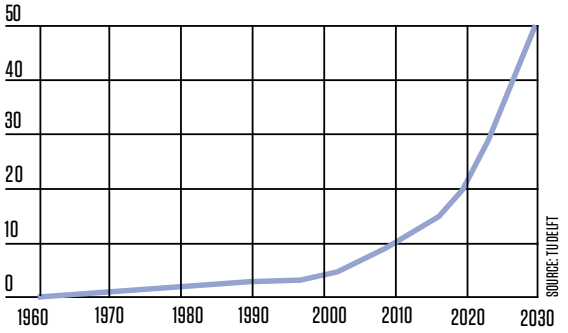
heavier particles – including the majority of the metal – to fly further. The result is two separate streams, one of which now allows the use of eddy currents to extract the metal particles from the heavier portion. The majority (96%) of the input ultimately remains as a fine, metal-free mineral fraction that can be processed into curbs and paving tiles. The remaining 4% forms a concentrated stream, about half of which consists of non-ferrous metals. In this way, the Advanced Dry Recovery (ADR) unit produces an enriched stream of metals. 'It contains aluminium, copper, zinc, lead, gold, silver, platinum and palladium', explains Inashco director Arno La Haye. 'You can see the entire periodic table passing by.'

Another device operates in the refinement process to separate the remaining minerals from the metals and to separate the metals into the lighter aluminium and the other, heavier metals. Inashco supplies the two mixtures as raw materials for the metal industry.
Seven years ago, the company consisted of only one man. It now processes 2.5 million tons of ash per year, with a turnover of €50 million. It employs 130 people in locations in the Netherlands, Germany, Finland, Singapore and the USA. In two years, when all of the installations that have been contracted are operational, the company will be processing 4.3 tons of ash per year, amounting to 17% of all global production.

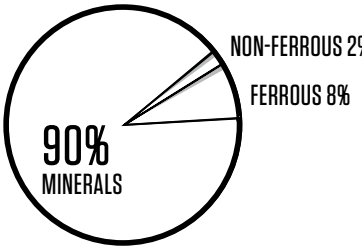
Sensors

Meanwhile at TU Delft, Rem's group is working to develop new separation technologies. Using magnetic fluids, the researchers are already able to separate various metals into five different densities. Special sensors are offering prospects as well. Infrared 'light' can sometimes reveal differences between apparently identical metals.
'We can achieve that 50% recycling', states Rem. 'Doing so, however, will require considerable effort to apply the principles of physics in the market'. Rem is convinced that his research deserves greater investment. It is a frequently heard argument, but Rem can back it up with a good story: 'Research should not focus on whatever is hot right now, but on the problems that will be playing a role in 5–10 years. One of these problems is Europe's dependence on imported raw materials'.

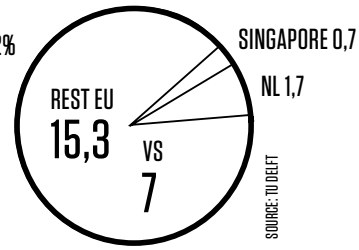
RAW MATERIAL FROM RECYCLING (%)
INCLUDING PROJECTION



COMPOSITION BOTTOM ASH (%)



ORIGIN BOTTOM ASH (MILLIONS OF TONS/YEAR)



Weather stations water research

In many areas in Africa, the weather is erratic. Rainfall is irregular, and there are long periods of drought. A network of tens of thousands of low-budget weather stations is expected to provide greater certainty to Africans with regard to weather and water, thereby increasing agricultural yield.

Professor of Water Management Nick van de Giesen (CEG) is collaborating on this with several American colleagues. Their dream is to have thousands of working weather units throughout Africa by 2018, most of them managed by schools. The project was launched in Kenya in the summer of 2013, with the Trans-African Hydro-Meteorological Observatory. At this facility, African students used inexpensive electronics to construct cheap weather stations. In March, Giesen will go to Stanford for five months of uninterrupted work on the African project.

Reinventing the toilet

A toilet that requires no water, electricity or sewer – this is needed in a world of refugee camps and poverty. Researchers at TU Delft have found a solution.

A toilet cistern contains around ten litres of water, and people tend to flush around three times per day, on average. If all 7 billion people on earth were to do this, the result would be a serious water shortage. According to the World Health Organisation (WHO), 2.6 billion people worldwide have no access to a toilet. Each year, this results in 200 million tons of raw human waste lying or floating around. The WHO also estimates that 1.4 million children die every year due to contamination from contact with faeces. This is why the United Nations decided in 2011 to reduce the number of people without a toilet by half. The Bill & Melinda Gates Foundation made 42 million dollars available for the development of a toilet that could process faeces and urine without electricity, water or a sewerage system. This lead to the 'Reinventing the Toilet Challenge', in which a team from TU Delft is also participating: eight researchers from the Process & Energy department (Faculty of 3mE)and five from the Faculty of IDE (Design for Sustainability department).
The team's solution consists of a toilet that separates urine and faeces from flush water, along with a toilet building and a technical plant that dries and gasifies the waste and converts it into electricity. According to the project manager Jan Carel Diehl (IDE), the most outstanding feature of the entry from TU Delft is its ability to be customised to the end-user. Other universities tend not to look beyond the technology itself.

The design

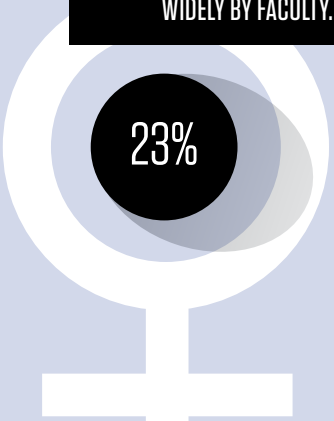
The toilet is a perfect example of user-oriented design. It was preceded by tests and countless discussions. *Ir*. Anne Jansen and her colleagues put the people from India at their ease and asked them about their experiences and preferences. Which hand do you use to rinse your anus? And do you prefer to use a bottle, a hose or a bidet? Supported by the experience of 'toilet professor' Dr *ir*. Johan Molenbroek, the current design was developed with a wide opening between the feet, a button for flushing (with half a litre of water) and a handle operating a hose to rinse the anus and bowl (always with the left hand) with another litre of water.
An ingenious dual-flap system separates the faeces and urine from the flush water. The excrement and urine drop down when someone activates the flap by pressing the flush. A special handle for the flush water moves a separate flap for the toilet opening that diverts the water into a sedimentation tank.
As much as 80% of this flush water is recycled. It is estimated that 500 litres of water are lost and 2000 litres purified in a sedimentation tank, sand filter and UV disinfection unit on the roof. After treatment, the water is good enough for washing hands, but not for drinking. JW

io.tudelft.nl/reinventthetoilet

SHORTAGE OF WOMEN

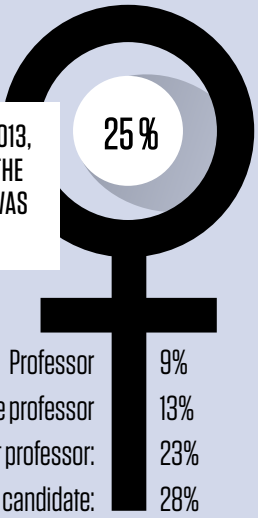
A glass ceiling and a lack of interest amongst women with regard to technical degree programmes – this combination continues to limit the number of women at TU Delft. The intake of first-year students reveals no major changes thus far. (the reference date for all figures is December 2013)

23% OF THE STUDENT POPULATION IS FEMALE. THE PERCENTAGES VARY WIDELY BY FACULTY.



A+BE	43%
IDE	40%
TPM	27%
AS	25%
CEG	22%
EEMCS	13%
3ME	11%
AE	10%

AS OF DECEMBER 2013, EXACTLY 25 % OF THE ACADEMIC STAFF WAS FEMALE.



Professor	9%
Associate professor	13%
Assistant professor:	23%
PhD candidate:	28%

Rare earth elements

You have to come very close to see the type of screenings that Prof. YongXiang Yang (3mE) is shaking back and forth in a plastic bottle. If you look carefully, you can see fragments of copper wire, green motherboard pellets and transistor particles. As the recycling expert can tell you, neodymium is also amongst the pulverised computer particles.

Yang's job is to extract this rare silver-coloured earth element. It has been processed into the magnet of the hard-disk drive. The magnets in windmills and electric automobiles also contain this element.

In addition to the computer powder, Yang has hundreds of hard-drive magnets lying around in his laboratory. All of the materials are delivered to him by a Spanish recycling company.

Although neodymium is a scarce substance, this material is not yet being recycled from PCs. There is no industrial method for doing so. Yang has several ideas for how it could be done. In 2013, he received two EU grants to conduct research here, in collaboration with several European partners. The team, which also includes four TU Delft doctoral candidates, is investigating two methods.

In both cases, the magnets must first be demagnetised and converted into a powder. This can be done by heating the hard disks to 450–500 °C. 'The powder that is created in this way can be extracted from the casings by shaking them hard in a rotating drum', explains Yang. 'We can also obtain the magnet powder by exposing the magnets to high concentrations of hydrogen', the professor continues. 'The neodymium then forms a powdery metal hydride and expands considerably'.

The powder, with iron and the black metalloid boron in addition to neodymium, is then purified through an electrolytic reaction and a long series of treatments with solvents. 'The techniques appear to be very promising, although we do not yet know how efficient these processes would be on an industrial scale. The study will continue until 2016.'

The researchers are simultaneously testing comparable methods of extracting rare earth metals out of waste (tailings) from an iron mine in Sweden. (WD)

Used up

At the current rate of the usage of these non-renewable resources, these products will soon have been disappeared from the face of our planet.

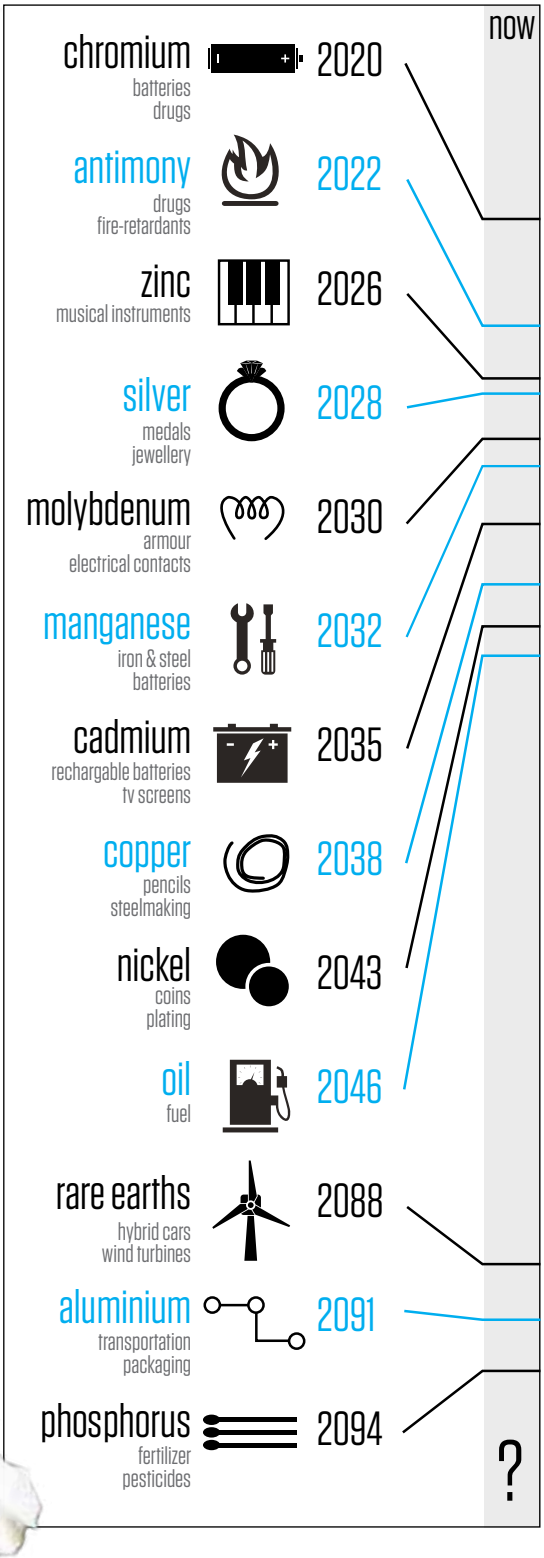


PHOTO: LANCELMAAT

Online touching

People are increasingly communicating through computers, tablets and smartphones. One element that is lacking in all of these screens is actual proximity. The artist and TU Delft doctoral candidate Karen Lancel hopes to use online touching to change this.

'Artists design experiences.' Frances Brazier stated this in a 2011 interview with Delta. The knowledge generated by these experiences is crucial for designers of participation systems, said the systems engineering professor. Designing experiences is exactly what Karen Lancel is doing in her doctoral programme in Professor Brazier's group. Using internationally presented performance-art projects with such titles as E.E.G. Kiss, Saving Face, StalkShow and Tele_Trust, she is searching for the connection between looking at a screen and actually touching the other person.

Lancel and her husband, the artist Hermen Maat, are designing 'social laboratories'. 'Our work is about communication, for which we are making increasing use of machines - computers, tablets, and smartphones. How do I experience you and me if I meet you through a screen? There is no reciprocity, no form of reflecting each other's behaviour, as happens in the physical world. Such reflection is needed for understanding and trust. How do you trust your own observations of the other person via a screen? And how can you make designs that deal with this? We are investigating this'.

This work is aimed at the introduction of forms of online touching that can provide a sense of trust and togetherness. 'We want to make a sensitive social space through the screen. One way we are doing this is through the rituals we have designed for touching and sensor technology.

The most recent project, E.E.G. Kiss, is one example. People are able to kiss each other using EEG headsets. Their kisses were converted into two graphs using the data from their brain activity. Lancel is looking for ways of assigning meaning to these data. 'Neurological research into social reciprocal experiences is a new field. Can I convert the data into an experience, and how would that work? The University of Vienna's Digital Synesthesia Group has asked us to convert the kiss data into sheet music. This will be presented in Vienna, Shanghai, Hong Kong and New York in 2015 and 2016.'

'We want to make a sensitive social space through the screen'

Lancel was moved by the reactions that some people had to the E.E.G. Kiss system. 'One woman said to me: "Those data are a portrait of my intimate relationship with my husband." Incidentally, the graphs all look very different; they are unique. And they don't say anything about the state of your relationship.'

Lancel observes that her doctoral research is helping her to establish a position for herself within the realm of scientific research, and it is teaching her how to work according to a scientific method. 'At TU Delft, I am able to add intuition and experience as part of a design method. When it comes to development based on experience and designing for experience, my knowledge is ahead of the game.' SB

lancelmaat.nl

In 2008, it was world news: hospitals were struggling with a shortage of radio-isotopes, requiring patients to wait longer for cancer research.

Radio-isotopes in RID

The isotope technetium-99m is manufactured in only a few reactors in the world. Three of these manufacturers, including the most prominent source in Europe – the reactor in Petten – had temporarily halted deliveries due to maintenance work. If such a situation were to arise again, TU Delft would be able to help. Since 2011, a minor adaptation has allowed the Reactor Institute Delft to produce radio-isotopes as well.
The 2008 disaster shifted TU Delft's research on the production of radio-isotopes into high gear, as recounted by the RID researcher Prof. Bert Wolterbeek. 'The key substance, technetium-99m, is produced by splitting highly enriched uranium', he explains. 'One of the products that is produced is radioactive molybdenum-99, the source material for technetium-99m. The molybdenum that manufacturers supply to hospitals is bound into rods. A hospital can 'harvest' the technetium-99m isotope from one rod for a week, as the molybdenum-99 slowly decays into technetium-99m on site. The more molybdenum we can bind into such a rod, the better. We are collaborating with an American company to develop optimisation techniques for this purpose.'
The RID is also investigating the production of alternative radio-isotopes.

'A hospital can "harvest" the technetium-99m isotope from one rod for a week'

In collaboration with Utrecht University and Erasmus University Rotterdam, the RID is developing methods of producing holmium-166 and lutetium-177, which are used in the treatment of various types of tumours in internal organs. It is also developing techniques for producing molybdenum-99 from non-radioactive molybdenum-98, without requiring the fission of enriched uranium. TvD

Imminent food shortage

In the United States, one out of every three corn plants ends in a bio-ethanol plant. Further increases in this share could lead to undesirable competition with food production – unless only non-edible plant waste is converted into bio-ethanol. Professor of Biotechnology Jack Pronk (Applied Sciences) is working on this, in collaboration with the chemical firm DSM. Last September, DSM and an American partner opened their first plant in the USA in which fuel is produced from corn leaves and stalks – the 'second-generation bio-ethanol'.
The champagne flowed freely, in Delft as well. 'We had a live feed with the party in Iowa', recounts Pronk. 'It was one of the highlights of my career. It is fantastic to see the contributions that our research has made to this achievement.'
Pronk is referring to the yeast cells that his research group has been adapting genetically through years of research, such that they are now able to break down nearly all of the sugars in plant waste. Ordinarily, yeasts convert only sugars that have six carbon atoms (e.g. glucose) into ethanol. The production of second-generation bio-fuels also requires the ability to convert sugars with five carbon atoms, particularly xylose and arabinose.
Ten years ago, Pronk and Prof. Hans van Dijken took the first major step in this direction. A mould that colleagues in Nijmegen detected in elephant manure was found to contain a special gene that would become the key to the conversion of xylose. The TU Delft scientists introduced this gene into the DNA of their yeast cells. Since that time, they have been improving this 'xylose yeast' through further genetic modifications and natural selection. TvD

Not enough water

With more than 100 million tons of freight passing up and down each year, more water transport takes place on the Rhine than anywhere else in the world. Drier summers caused by climate change are likely to complicate matters, however, cautions Cornelis Dorsser (CEG).

Rijkswaterstaat (Directorate of General Water Management) has commissioned Dorsser, a naval architect and transport economist, to outline scenarios with projections into 2100. 'In the second half of this century, the river is likely to be too shallow to allow shipping for months at a time', predicts Dorsser. 'Two areas along the Rhine give cause for particular concern; Lobith in the Netherlands and Kaub in Germany. In Kaub, the depth is likely to fall below 1.40 metres on a regular basis. At this depth, shipping would no longer be profitable. Alternatively, the ships would have to be shallower. This would also be problematic, however, given that shallow ships are relatively heavy'.

Another option would be to adapt the river. Dorsser: 'Although it may sound crazy now, in the long term, it might be necessary to canalise the entire Rhine. This would be in diametric opposition to the principles of "Room for the River" and "building with nature", which are currently so popular.

Dorsser's colleague, Dr Kees Sloff, who works for both TU Delft and Deltares, also sees a number of challenges for the shipping industry. 'The river will be affected by more and more shallow areas. At some point dredging will no longer work. In the future, we will even have to replenish (add sand to the river bed) in order to prevent it sinking too far'.

According to Sloof, shipping companies will need to sail much smarter and closer to each other. 'They will have to navigate around the shallow points. For this, constant and precise monitoring of the river's depth will be required. This would be possible, if all ships were to take depth measurements and forward them to a central point on shore. We are currently working on the Smart waterways project, in which we are researching how we can use this up-to-date depth information to direct ships from land'.

Artificial gas

It is not so difficult to generate sustainable energy, but you do have to be able to store it for dark days.

Energy storage comes in all shapes and sizes. Condensers are convenient for peak storage, but they are exhausted within a few seconds. The same applies to flywheels. Water storage in reservoir lakes and pressurised gas storage in underground reservoirs can provide a buffer of several hours of energy use. Batteries and accumulators can even store energy for weeks. According to Professor of Energy Technology Bendiks Jan Boersma (Faculty of 3mE), however, chemistry is needed in order to store larger quantities of energy for longer periods 'In the future, we will generate large amounts of inexpensive wind and solar energy, but fluctuations in production will mean energy storage is required. We will have to produce our own fuel. I think that methane is the best option, given the existing infrastructure'. Electricity can be used to generate hydrogen, which can be combined with CO_2 to produce methane, which must be diluted with nitrogen to make it compatible with the natural gas in the Netherlands. 'The processes are known. The problem now is to use them efficiently and for large quantities', observes Boersma. The production of synthetic gas is a good solution, as long as fossil fuels with CO_2 emissions can also be used. 'Although carbon dioxide is currently a social problem, the concentration is so low that we can't extract it from the atmosphere'. We could thus face a shortage of CO_2. Who would have ever thought that would happen? JW

Photo: Hans Stakelbeek

Lectures in the Aula Building, the Army Museum, Theater de Veste and the Pathé cinema – TU Delft will stop at nothing to accommodate the increasing number of students. In the former Army Museum, two lecture halls have been created for a total of 300 students. Intensive efforts are being made to develop long-term solutions. Plans call for the construction of a new Learning Centre, and several renovations have been scheduled.

2030

Shortages of raw materials are forcing producers to develop new business models, in order that they can make a profit on articles that last longer or that can be re-used. Associate professor Conny Bakker predicts a future in which we lease, borrow, share, repair and reconstruct.

Bugaboo sells baby strollers that are sturdy, hip and expensive. Buyers can use them for a while, possibly re-selling them later. What happens to them then? Do they end up in an attic, or on the scrapheap? The company does not know. It is therefore conducting a test: parents can lease a stroller for their child, exchanging it a year later for a step-up model, which can be returned once the child no longer needs it. After completely refurbishing the returned strollers, Bugaboo can lease them again. In this way, the company is able to reuse its source materials, and consumers will pay less.

An associate professor in the Faculty of Industrial Design Engineering, Dr Conny Bakker uses this and other examples to explain the functioning of a circular economy. Seeing is believing, Bakker explains, particularly for companies.

To demonstrate how they can turn a profit on products that last longer or that can be reused, she has set up a comparison of several business models. These models allow companies to turn a profit on high-quality products (which can be enhanced with extra features) or on parts and service. They could also lease their products. Alternatively, instead of products, they could sell functionalities. 'Light instead of lamps' is a commonly cited example.

Companies are not the only one who need to change their thinking, argues Bakker. Her students, the designers of the future, are also linear thinkers. 'Designers devote considerable thought to how their products are used, but not to what will or should happen to these products afterwards. This is based on the "box-moving" model of making and selling inexpensive products.

But the life of a product continues beyond this. If companies do not capitalise on this themselves, the growing number of "gap exploiters" will do it for them. Leapp is one example of this. This online shop offers used and refurbished iPads, iPhones and other Apple articles. Bakker: 'It's not new, it's not second-hand, but something in between'. It's used, but with a new screen, a new battery, a clean memory, a relatively low price and a 12-month warranty. 'Once consumers understand what it is, they will soon become accustomed to such services'.

This is good, as some raw materials will run out in the future, or they will be inaccessible due to geopolitical developments. 'We will probably become a bit poorer', predicts Bakker. She does not see this as a bad thing. The recession has led people to use things longer. 'It's not that I want a recession, but I don't want explosive growth. Just give me a steady state economy. In such an economy, repairing and preserving products is commonplace, and companies and designers are able to cope with it. We can alter clothing, patch shoes and reupholster sofas. Companies can profit from this, as well as from rentals, leasing and, if all else fails, recycling'. SB

In Person

Ir. Nynke Tromp
INDUSTRIAL DESIGN ENGINEERING

Her research is of international and social importance, her research approach is original and she completed her PhD cum laude. The assistant professor of Design Aesthetics more than meets all the conditions, and she therefore won this year's Dewis Award. The network for women scientists in Delft, Dewis, presents the award each year to a highly talented woman doctoral candidate.

Prof. Teunis Klapwijk
KAVLI INSTITUTE

For his achievements in his field, the nano-scientist received a Humboldt Research Award from the German Humboldt Stiftung. This foundation promotes academic collaboration between excellent scientists in Germany and abroad. As the winner of the prize, Klapwijk has been invited to participate in a scientific project for one year at a German research institute of his choice.

Prof ir. Leo Kouwenhoven
APPLIED SCIENCES

The Dutch government has awarded National Icon status to Kouwenhoven's field, quantum technology. According to the professor, technology has progressed to the point that 'the question is no longer whether we can build a quantum computer, but when'.

Prof ir. Tim van der Hagen
APPLIED PHYSICS

The Professor of Reactor Physics and the dean of the AS Faculty has been given a four-year appointment as member of the Advisory Council for Science, Technology and Innovation (AWTI), which advises the Dutch government and parliament on policy in the areas of scientific research, technological development and innovation. Van der Hagen is responsible for the Energy portfolio.

Viva and Opzij

The TU Delft alumni Jantien Herfst and Mei Ling Tan (both from TPM) have won the Viva400 Award in the category of fashion. In 2012, the two graduates established House of Einstein, a clothing formula for men who do not like to shop. In two years, the rapidly growing start-up has expanded to more than 1000 customers and profits in the thousands. House of Einstein offers boxes containing hand-selected outfits. Following a Skype interview with the customer, a personal Outfitter starts to work. Jantien and Ling began the company immediately after completing their studies at TU Delft. Their mission is to become a fashion-tech company that combines the latest technology with personal service.

According to the monthly magazine *Opzij*, Anka Mulder, Executive Board vice-president for Education, is one of the most powerful women in the field of education and science. In last month's issue, the feminist monthly magazine presented a list of 100 powerful women in all areas of society, including sports, justice, public administration, politics, media, charitable organisations, culture, business and health care. Mulder was listed in fifth place for the category of education and science. In first place was Louise Gunning of the Amsterdam University of Applied Sciences and the University of Amsterdam.

HORA EST

‘Long-term plans only serve to create an illusion of control over our lives’

Bart Bolsterlee, bio-mechanical engineer

‘It is only human to want control over what happens in our lives. This is why many people make long-range plans. Nevertheless, the influence of unexpected and unpredictable events is so great that it is impossible to make long-term predictions with a useful level of precision. Ten years ago, could you have predicted your current situation in life? At any rate, I would not have been able to, and I’m glad. Many people continue to make detailed plans for the long term anyway. In my opinion, all this does is to create an illusion of control. If we are able to accept and cope with the fact that we are living in a world in which uncertain factors play a major role in our day-to-day existence, long-term plans are unnecessary. Planning for the long term can even have negative effects, as it can blind us to valuable opportunities that arise along the way’. TU/e

Simplicity offers elegance and beauty to all things, including scientific theories.

Anamaria Soare, mechanical engineer

Raising a child is easier than writing a PhD thesis.

Pavel Babál, electrotechnical engineer

Every generalising proposition is false.

Jacopo Antonello mechanical engineer

Social media shortens the communication distance between people but enlarge the distance between their hearts.

Yihui Wang, mechanical engineer

Morality is defined by people and therefore people are good in general.

Andrew Nelson, computer engineer

For a successful career path, what you study is not as important as who your mentor is.

Tamara Djukic, civil engineer

Solutions are obtained more quickly when a problem is called a challenge.

Arjan Meskers, mechanical engineer

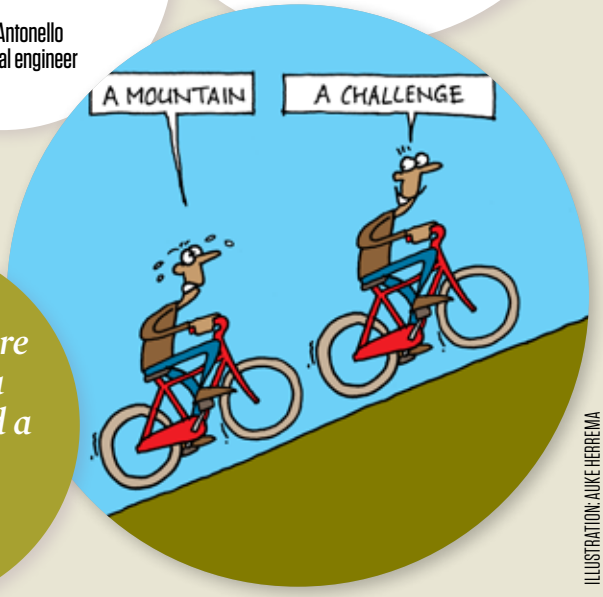


ILLUSTRATION: AUKE HERREMA

‘Don’t build your whole career on a single success’

In the future, we will flush our toilets with seawater and the sewage system will become a source of raw materials. This is according to Spinoza prize-winner and water purification expert Professor Mark van Loosdrecht.

TEXT TOMAS VAN DIJK PHOTOS SAM RENTMEESTER

A slightly futuristic dwelling – not dissimilar to those on many a University of Technology campus – collects urine and faeces separately. The faeces are sent to a fermentation unit and the resulting methane can be used to heat the house. Flushing away excrement is a complete waste and the same can be said of course of clean water. Although it may seem that our sewage system needs updating, nothing could be further from the truth, according to Mark van Loosdrecht. "If I had to completely redesign the Dutch sewage system, I would make it exactly as it is now", he says, when asked. The professor in environmental biotechnology and water purification in the Faculty of Applied Sciences is not one for hypes or pretentiousness. His down-to-earth attitude has been richly rewarded. This summer, he was awarded the Spinoza Prize, the highest science award in the Netherlands, for his ground-breaking research into the ecology of micro-organisms in sewage water. Mark is the mastermind behind two new water-purification techniques: Nereda technology, which enables water-purifying bacteria to grow in rapidly-settling granules and Anammox technology, which is used to convert damaging ammonia and nitrite into harmless nitrogen gas and water.
After his sobering response to the first question in the interview, a brief silence ensues.

You really wouldn't change anything about the sewage system?

"On that front, our business is in order, so to speak. We have been free of cholera and typhoid since the late 19th century. Of course, there are some ways it could be optimised. In the future, for example, we will use seawater to flush our toilets and produce raw materials from sewage water. But the basic theme remains the same. Water flows into the city, it takes all of the waste with it and is collected and processed outside the city. Exactly the way the Babylonians devised it, 3,000 years ago."

Use seawater to flush the toilet?

"Yes. In Hong Kong, it's already quite normal. Most mega-cities are located on the coast. If there is a shortage of fresh water, it is an obvious strategy to flush the toilet using seawater. Salt water also opens up new opportunities for water purification."

You have now been given EUR 2.5 million. How do you plan to use the money?

"We know virtually nothing about 99% of all bacteria. We don't know how they respond to changes in the environment, such as the availability of nutrients. Bacteria use change for a competitive advantage. For example, some can store fats in order to see off competitors during periods when nutrient levels are low. I am convinced that this kind of knowledge about ecology will enable us to produce raw materials from sewage water: bio-plastics, for example. Since the oil crisis in 1973, scientists have been attempting to make these from sugar. But nobody ever asked themselves what the significance of a particular substance was for micro-organisms and how they can be encouraged to produce it."

You studied environmental technology in Wageningen. Would biology not have been a better choice?

"I was interested in biology, but was not impressed by the degree programme. Biologists are like stamp collectors: they want to label and categorise everything. The biology programme involves learning a lot of names and facts. I don't have a very good memory. The environmental technology programme in Wageningen included a lot of chemistry and physics, which suited me much better. If you understand the principles of these subjects, you can extrapolate the rest."

What fascinates you so much about micro-organisms?

"They form complex living communities. How does that life fit together? They are puzzles. We know very little about bacteria, but we do know that if we change the conditions in a certain way, it will result in a creature that makes granules or bio-plastics. In the water purification system, there are billions of bacteria. They divide on an hourly basis, so after just a few days, they can be completely different."

You turn the switches...

"Yes, and evolution takes its course."

How did you end up in water purification?

"After my doctoral research in Wageningen, on the subject of the transport of bacteria through the ground, Sef Heijnen (professor of biotechnology at Applied Sciences, Ed.) asked me if I wanted to work here. I was simply in search of a job. I started by looking for work in industry and had

CV

Mark van Loosdrecht (1959) won one of the three NWO Spinoza prizes this summer. He studied environmental technology in Wageningen and was awarded his doctorate there in 1988. He was then offered a research position at TU Delft. He studies and influences the properties of bacteria in water purification systems. Last year, he was awarded the Simon Stevin Master Prize 2013 (worth EUR 500,000) by the STW Technology Foundation for the development of two new water purification technologies using micro-organisms: the anammox and granular sludge technologies (Nereda). Only two other researchers have previously won both this and the Spinoza prize. There's no shortage of prizes. In 2012, Van Loosdrecht was awarded the prestigious Lee Kuan Yew Water Prize in Singapore.

already had two interviews at DSM. They were in the process of evaluating things, which was taking quite a while. Then I opted for TU Delft. The job at DSM was about the physical chemistry of baking bread." And he adds with a laugh: "That is another fascinating subject."

Why the laugh?

"Because it sounds so traditional, baking bread, but its not an easy task to get the bubbles just right. It just shows that a job in water purification wasn't my particular ambition in life. If I had been offered work at Wageningen with a focus on water purification, I wouldn't have taken it. The group there has a tendency to focus on applied research. I prefer to research the basics and then see how they can be applied. Application is not my primary objective."

Is that why you work in a university and not in industry?

"On balance, the university is an enjoyable employer. I can focus on things that I consider important. Making raw materials from waste will be our next area of focus. A company will never take the first steps. Around the year 2000, when we started with Nereda, companies would not have been interested in ideas about sludge granules. Back then everyone was obsessed with membrane bioreactors, which were seen as the future. It was a real hype. At the university, you can happily ignore hypes."

Nereda is your baby.

"It feels like that, yes."

Are you following Nereda, for example, to Brazil? Twelve Nereda plants are currently being built there.

"No, I'm not going to Brazil. Technology can often be held back because inventors cling to their inventions too much. It is better to leave things to the market. As an inventor, you are not always the right person to bring the technology to the people. The technology has been passed on to the engineering firm DHV. If I really had wanted to become involved, I would have had to join the company.
"That is how things are supposed to work at TU Delft. You mustn't spend too long putting things into practice and you shouldn't build your whole career on a single success. I think I could easily have set another 10 doctoral candidates to work on Nereda technology. But I want to move onto the next development.

You now want to focus on alginate, a type of gel used in the pharmaceutical and food industry.

"The bacteria in the granules produce alginate, something we only discovered years after the technology had been developed. Alginate is an expensive material that is currently extracted from brown algae. In the past, people thought that the bacteria that make this material simply excreted it. That made it difficult to establish an industrial production process using bacteria, because you cannot stir a gel. However, with Nereda it emerged that the material is actually in granules. If all water purification in Utrecht were to switch to Nereda, enough alginate would be produced to meet 5% of global demand."

'At the university, you can happily ignore hypes'

You are not a great believer in the separated collection of urine and faeces. Is that because it cannot be effectively combined with Nereda?

"Reclaiming raw materials is a scale-dependent process. To that extent, it is the reason why I think we should not introduce segregated collection locally. Besides that, collecting urine and faeces separately requires a lot of material.
In the Third World, I do see a future for decentralised toilets, because large-scale sanitation is difficult to get off the ground. Governments prefer to invest in military hardware than install a sewer. High-ranking politicians should rally behind sanitation projects. When the Dutch king goes on a working visit, that is the kind of project he looks at. Your average president doesn't officiate at the opening of a village toilet."

Are you a workaholic?

"Of course. Workaholics come in two varieties. One type does it for the career prospects. That's not what motivates me. I want to find out how things work. At TU Delft, there is actually no higher position than that of professor. Professors are the face of the university.
I may be a workaholic, but I go on holiday for two months every year. I have absolutely no problem with being cut off from the outside world. I go to the Himalayas, the Andes or the Alps, to the mountains and the panoramic views."

Industrial pioneers

With their knowledge of metallurgy, mechanics and thermodynamics, mechanical engineers had to give shape to the industrial revolution in the Netherlands 150 years ago. This revolution only slowly gathered momentum, however, especially in comparison with England.

TEXT: JOS WASSINK PHOTOS: SAM RENTMEESTER ILLUSTRATION: STEPHAN TIMMERS

In England, half of the energy was produced by steam engines in 1830; this wasn't the case in the Netherlands until fifty years later. After that, however, the industry experienced a rapid development - gas plants, water towers, small power plants, port facilities, railways and sewage systems were constructed around cities. Large steam installations were operated at sugar factories in West Brabant, dairies in the north and food industries in the cities of western Holland. Electricity companies grew rapidly and started constructing electricity networks in cities, which eventually expanded to cover the entire country. The production of electricity was also the domain of mechanical engineers back then.

Those engineers were trained at the Polytechnic School in Delft - the predecessor of TU Delft. It had been founded in 1842 as the Royal Academy to train civil engineers, and another programme was created in 1864, 150 years ago, to train mechanical engineers to be industrial pioneers.

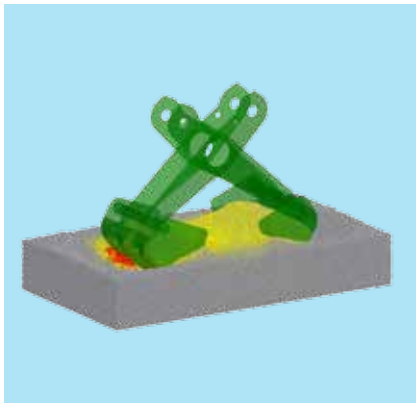
The new mechanical engineering study programme was shaped by the efforts of *ir.* Adrien Huet. After graduating as a civil engineer five years previously, Huet went on educational trips to England, which was more industrially developed. Once he had returned to the Netherlands, the polemical Huet, who was a teacher at the Polytechnic School, fervently called for more practical experience and experiments in the engineering programme, and for more theoretical education in the vocational schools. As a result of what he had seen in England, he strove to transform the school culture into a workplace culture. As a lecturer, he was given the task of changing the existing education in mechanical engineering and the knowledge of tools. His initial accomplishments - eight students in two small classrooms on Westvest - were modest, to say the least.

As an outspoken educational reformer, Huet was not very popular among the other professors and was not appointed a full professor until 1896. When he died three years later at the age of 63, his loyal former students took the initiative to erect a monumental bench in Delft as a memorial to him. That semicircular bench is still standing there today.

1864 Adrien Huet | 1868 typewriter | 1878 two-stroke engine | 1885 car | 1896 first flight | 1908 vacuum cleaner

Modern turbine converts steam into electricity by means of motion. (Photo: Wikimedia/Siemens)

Thin-walled systems can fail spectacularly. (Photo: Jos Wassink



Virtual Nemag grab (photo: Stef Lommen)

From steam to electricity

Prof. Bendiks Jan Boersma of the Energy Technology department regards the transition from steam to electric power as the most important breakthrough. "One hundred and fifty years ago, everything ran on steam. There were steamships and steam locomotives, and even pile drivers were powered by steam until 1920. All factories had a central steam engine and motion transmission occurred by means of leather belts. Between 1930 and 1940, however, steam made way for electric power. In some cases steam engines were replaced by diesel and petrol engines. Electricity is now the most important means of generating power and energy."

The most important challenge is the transition to a sustainable energy supply. "There are many ideas about this and I'm sure the result will eventually be a combination of all of these ideas. You will be able to generate lot of cheap electricity from wind and the sun, but you will need to store the energy due to fluctuating production. We have to produce our own fuel and, given the existing infrastructure, I think that methane is the best choice for this."

Koiter's cabinet

"You can say 'Delft' and 'mechanics' anywhere in the world, and the response will usually be: 'Oh, Koiter!'", says Prof. Fred van Keulen of the Precision and Microsystems Engineering department. Koiter published his PhD thesis (On the Stability of Elastic Equilibrium) soon after the end of the Second World War. The thesis was discovered and translated in the United States a decade later. It has been the standard for the stability of thin-walled systems such as submarines, aircraft, silos, rockets and microsystems ever since. Prof. Warner Koiter created the mathematical framework to describe that in a satisfactory way. A cabinet in the hallway is filled with his certificates and awards.

There are plenty of challenges for micro and nano engineering. "There must be a good description of materials at the nano level, nano phenomena must be translated to the macroscopic world and there is no shortage of tools for creating nanostructures. In short, there is plenty of work to do."

Intelligent and sustainable

"A bit obvious" is what Prof. Gabriel Lodewijks (maritime and transport technology) thinks of his own answer. But if you consider what led to the most significant change and the greatest innovations, it would have to be information and communications technology (ICT). "As a designing tool, the computer has made new things possible. Hydrodynamics allows us to determine the behaviour of a ship in the design phase. We can also create virtual prototypes of grabs, for example, in order to observe how well they perform. Furthermore, communications protocols made the development of automated guided vehicles possible, like the ones used in container handling.

Lodewijks considers good stewardship to be the biggest challenge: "Everything we are currently developing is aimed at ensuring a sustainable future. For example, transporting containers in the harbour with autonomous electric ships instead of over roads. Or reducing the energy consumption of bulk transport by means of conveyor belts. We have already almost reduced that by half." >>

Zinc is becoming scarce. (Photo: Wikimedia)

Computers are good control devices. (Photo: Wikipedia)

A robotic hand that can pick fruits.
(Photo: Lacquey, Food Handling Solutions, Delft)

Materials do not grow on trees

"The greatest breakthrough is the existence of the subject of Materials Science," says Prof. Jilt Sietsma of the Materials Science and Engineering department. "In the fifties, people started to realise that materials do not grow on trees and that scientific research is required to understand and improve the properties of materials. A medieval blacksmith would place a red-hot sword in water in order to temper it. We now understand how that works, and we can make the material structures visible and control them." The research initially focused on metals and later expanded to include plastics, ceramics and semiconductors.

The challenge for the future lies in sustainability, as hackneyed as that might sound. Materials are becoming scarce. Take zinc, for example. Zinc is indispensable for corrosion protection in cars and for tempering rubber tyres. In fifteen years, however, zinc will be depleted. In fact, many other raw materials will be depleted too. Recovery techniques and alternative materials are developed using materials science.

A circus of negotiations

"The advent of the computer is the most significant change in our field in that period", says Prof. Hans Hellendoorn, Departmental Director of the Measurement and Control Technology department. The first control systems were mechanical. After the Second World War, electric control devices with resistors, condensers and coils for proportional, calculating and differential controls were developed. All those controls have now been incorporated in the computer and we can network with hundreds of control devices that communicate with each another. This is the case with traffic lights and signs above motorways, but also with the regulation of water levels. Control technology has become an automated circus of negotiations."

"Controlling light is new for us. Take, for example, a movable mirror in a telescope that compensates for atmospheric fluctuations in real time, or a chip machine that compensates for the heat generated by the laser. We have to get used to the non-deterministic behaviour of photons, which behave according to the laws of probability, and that is a challenge."

Nature as a model

"In biomechanics, we want to use our knowledge of nature to develop new mechanical principles", says Prof. Jenny Dankelman, head of the department of Biomechanical Engineering. Developing walking robots, for example, requires a better understanding of how humans walk, while the tentacles of a squid can be used as a model for surgical tools.

"We are currently trying to understand the stinger of a wasp, which can be up to ten centimetres in length and one tenth of a millimetre thick. And yet it doesn't bend. Not even when it penetrates stiff materials. Once we understand why this is the case, we will be able to create extremely thin and controllable needles."

How can we ensure that humans remain in control of mechanical systems? Take, for example, a reinforcing exoskeleton for patients that have difficulty walking. How can you ensure that people can still continue to literally feel what they are doing? According to Dankelman, the challenge lies in finding an optimal interaction between human beings and technical systems.

After Delft

Seeing and grasping opportunities, while making a difference for people and the planet: this characterises the career of Laetitia Smits van Oyen (54). Thirty years after completing her studies in architecture, she has returned to TU Delft as a member of the Supervisory Board.

Laetitia Smits van Oyen had already made a turnaround at her graduation. Although she had been fascinated by architecture from the start, she did not think that the world would be interested in her designs. It was the 1980s, and a new phenomenon was emerging: the computer. 'I didn't know anything about it, but I saw opportunities and did my graduation project on a computer programme for designing low-cost public housing. It was very new at the time'.

After De Telegraaf wrote an article about it, Kraan Bouwcomputing asked her to come and work on software for the construction industry. After a year, she continued in a subsidiary of Volmac. 'Talking to companies about how they could apply automation and the problems that they had encountered. At that time, everybody was buying computers, but nobody knew what for.

Smits van Oyen observed the lack of a link between hardware suppliers and accountants, and thus entered this gap in the market with a customer. Their solution consisted of secondment. Synergy Consultants grew to 150 employees, after which they sold the company to Getronics.

The time was ripe to relocate to live with her husband in Curaçao. Together with the owner of the Sea Aquarium, she established the Curaçao Dolphin Academy, where visitors could swim with dolphins and learn about protecting this species. The Smithsonian Institute was conducting research on the ocean floor there.

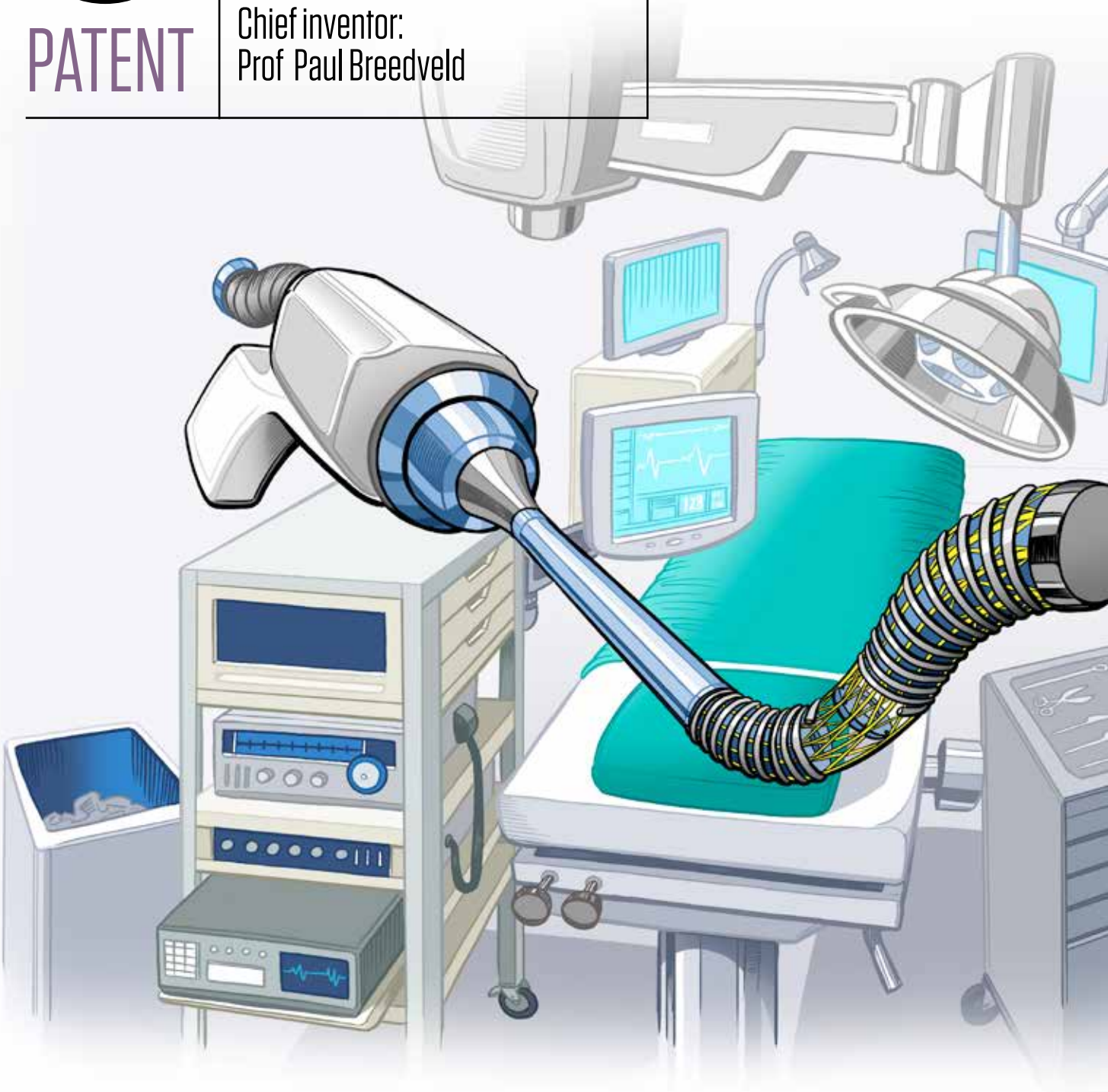
Once back in the Netherlands, Smits van Oyen completed a global executive MBA, which Rotterdam was offering in partnership with universities in Mexico, Brazil, the United States and Hong Kong. 'It showed me how the world works. I learned the importance of the people–planet–profit triangle. It brought her to the board of the African Parks Foundation and the Stichting Urgenda, which aims for sustainable enterprise. In the latter organisation, she noticed that the Netherlands was losing its position as a leader in water management due to public administrators' lack of knowledge. To remedy this, she ran for a seat in the municipal council. Much to her dismay, she noticed that 'the political system was more concerned with service to the party and short-term gain than it was with competencies'. She now prefers to invest her energy (and money) in such institutions as the Alexander Monro breast-cancer hospital in Bilthoven. Her role on the TU Delft Supervisory Board will allow her to use all of her entrepreneurial qualities. 'Looking at opportunities, collaborating and assessing risks (e.g. for the proton clinic in Delft). The cycle is complete'. BVU

R

PATENT

Helix Flex, a super-flexible medical instrument

Chief inventor:
Prof Paul Breedveld



'Helix Flex could make many new surgical techniques possible in the future', states Prof Paul Breedveld, of the Bio-mechanical Engineering department in the 3mE faculty. A perfect working prototype of the super-flexible instrument has been constructed. During an operation (particularly keyhole surgery), the snake-like motions of Helix Flex will make it possible to reach deeper into the body to access areas surrounded by 'delicate anatomy' (e.g. the brain). The instrument is able to rotate and move in various directions. 'It can be controlled by the head, as well as by the part behind the head. This allows it to follow a precise anatomic path'. In this way, surgeons will be able to reach parts of tumours that would be impossible to remove with the current, rigid instruments.

It is all made possible by the special structure of the controllable helix cables in the instrument, which are based on the tentacles of a squid. The device was invented in collaboration between TU Delft, the AMC and the BioRobotics Institute in Pisa, with financing from STW. Surgeons can place a wide range of accessories on the tip of the instrument, including hooks, scissors and cameras. 'The latter application is particularly useful, as the flexibility of the Helix Flex makes it possible to see around objects in the body'.

Breedveld's group is still working on an application that will allow the Helix Flex to be as rigid as it is flexible. 'This would allow us to do things such as affix a tiny pair of scissors very firmly and then apply considerable force'. JB

Unnatural selection

Next year, Minister of Infrastructure Schultz van Haegen will be meeting with the leading automobile manufacturers to discuss the standardisation of self-driving cars. She would like the Netherlands to play a leading role in the technology that will ensure that autonomous vehicles can find their way around without problems. Although her mission is admirable, there are certain aspects to it that are as touching as they are hopelessly idealistic. 'It would be a shame for us to develop various technologies for self-guided cars, only to find that they are ultimately incompatible', she stated recently in *Het Financieele Dagblad*. The minister would like to avoid having different brands and systems in different countries. She is not alone in this; the Rathenau Institute is in complete agreement, for example. The researchers have distinguished two lines in the field of self-driving: cars that work together and the independent robot car developed by Google. Rathenau has a clear preference for the cooperative approach, and feels strongly that that is what the government should focus on. This is the gist of their recent report entitled 'Tame the robot car'. Translation: 'Tame Google'. The underlying assumption is that governments are capable of doing so is, at best, naive. Technologies are not led by policies agreed on by politicians. Some will pass quickly into oblivion, while others meet their demise only after a long and noisy decline. In the end, they always become obsolete. The Netherlands has a problem with this Darwinist aspect of innovation. We are a country of consensus, both literally and figuratively. As a country of merchants and regulators, we believe we will find our way together and we are not comfortable with tech entrepreneurs who enter the fray and forge ahead on their own. 'Invention is messy and unpredictable', stated Google director Eric Schmidt, two weeks before Schultz van Haegen revealed her mission. In a speech in Berlin, he outlined precisely how his company regards innovation, technology and the fragile nature of its own existence. 'History has proven that size and past success are no guarantee for the future. Great companies can be surpassed swiftly. Many of you are skeptical. I get that. You look at Google, Apple, Facebook, and Amazon and say there's no way competitors can beat them. I'm less certain'. Such ongoing scepticism is the first lesson in today's technological jungle. There's no time to seek consensus on what the standard should be. Just produce *kick-ass stuff* that will become the standard simply because it's the best. 'Great inventors (...) keep working furiously to create something even better. It's part love, part necessity. Because if they don't reinvent their ideas time and again, someone else will – rendering their life's work irrelevant, or worse still, extinct'.

Schmidt's speech is entitled The New Gründergeist. Could someone please send a link to the Rathenau Institute and the Ministry?

Dr Remco de Boer is a technology & science communication specialist

Delft Outlook online

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THE FIRM

Three TU Delft students, one dream. When Robbert van Geldrop in 2004 and two fellow students of Systems Engineering, Policy Analysis & Management wrote their first business plan for a company that would offer back-up services in the cloud, he was convinced that it could become a modest success. Reality proved better than expected.

‘We predicted annual profits between 300,000 and 400,000. We were young and ambitious, and we thought that this would be feasible’. Ten years later, Robbert van Geldrop, one of the founders of the YesDelft-startup BackUpAgent, looks back with a smile. The company was one of the first worldwide cloud backup suppliers in the market. Current profits amount to between two and three million dollars per year – ‘we never state the exact amount’. ‘We established a serious company that, as of the takeover date, was protecting data for more than 50,000 companies around the world, in addition to free users’.

With a nose for business, he was thus able to sell his first company at the age of 34. The American industry counterpart Acronis, a worldwide supplier in the area of back-up services, repairs and file allocation, saw potential in the activities of the TU Delft alumni. Aiming to become the leader in the commercial market, what could be better than to bring the star players in this area into the company? The takeover was completed last September. Van Geldrop and his partner Roland Sars, who studied aerospace engineering for two years (the third partner left in 2012), will remain on board for the next 18 months. The office will remain open, and the old name will be maintained for the time being. After this period, BackUpAgent is expected to be fully integrated into Acronis with regard to services and name, and supplemented with services for broken PCs. Not too bad for a company that only entered the market in 2009. Van Geldrop: ‘It was actually a bit earlier; we brought out our first product in 2006. We were collaborating with Surfnet and other partners, and we had recruited Paul van Keep, one of the founders of Exact, as an investor, but it was not yet mature. In 2009, we had everything worked out in our business model. Until that point, we had been accustomed to having software companies pay a one-time licence fee for our services, which we would then develop. By changing that to monthly billing for the software that we would deliver, we ensured a constant flow of income. The only problem was that this eliminated our buffer for the next three years (as companies were paying large sums in advance) in one fell swoop’.

PHOTO: SAM RENTMEESTER

This temporarily resulted in a 30% drop in profits. ‘We had to let some people go, but we always kept our eyes on the big picture. It proved relatively easy to bring in big players, like international telecom operators’. The secret to our success? ‘No consultancy services, no projects – just one product, which can be sold hundreds of times. A good business plan should fit on the back of a beer mat’.

And now? ‘The sky’s the limit’, laughs Van Geldrop. He is not afraid of getting bored after the coming two years. ‘Moreover, we knew from the start that we would be selling the company. It just came sooner than we had expected. Things worked out well for Android when it was taken over by Google; I’m sure if I do my best in the next two years, my baby will survive’. JB

Name:	Robbert van Geldrop (34)
Degree programme:	Systems Engineering, Policy Analysis & Management
Company:	BackUpAgent
Established:	2005
Product:	cloud back-up services and software
Profits:	2–3 million dollars per year
Mission:	‘To compete with with other commercial back-up services in the cloud’.
In 5 years:	‘... BackUpAgent will have been fully incorporated into its American industry counterpart Acronis. Maybe I will be on the board, or even start a new company’.

Raging water

At TU Delft neighbour Deltares, the Ballast construction company is putting the finishing touches on the world's largest wave channel. Last month, a group of science journalists were invited to take a peek.

TEXT JOS WASSINK PHOTOS HANS STAKELBEEK

No, there is no water in the 300-metre-long Delta channel, which is a pity for those hoping for a tsunami-like demonstration. Later on the empty tank turns out to be an advantage, as it allows us to get a much better idea of the size of the facility and the technology behind it. Visitors in the bottom of the channel make selfies in a site that will soon be covered by 9.5 metres of water. How cool is that?

WAVE MACHINE

'Pick a pair of boots'. Substantive Project Manager Rob de Jong takes 10 visitors to the channel and ensures that they are outfitted according to Ballast's specifications. A short time later, the procession, kitted out in roomy boots, orange vests and yellow helmets, stomps its way through the halls of Deltares on the Rotterdamseweg – the site of the independent knowledge institution on water, subsoil and infrastructure. Once outside, the group follows De Jong to a white tent on the far left end of the concrete Delta channel. Having been instructed to proceed with care, they descend the steel ladder cautiously to just above the machine that will soon be causing the waves, which smells of oil and paint. At one end of the footbridge are pressurised tanks with thick hoses connected to four horizontal cylinders.

Gleaming piston rods appear on the other side of the black cylinders, each mounted on the corner of a high bulkhead. From the bridge, visitors see a network of hoses, tubes and valves, which will soon control the cylinders. The four cylinders must be perfectly synchronised in order to hold the channel straight. This is no small job, as there will soon be around seven metres of water on the other side of the bulkhead. With a maximum speed of two metres per second, over a maximum length of seven metres, the bulkhead will set this mass of water in motion.

> The new Delta channel can generate 85% of the waves on the Dutch coast at actual size

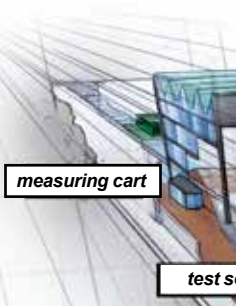
The static counter-pressure will be supplied by pressurised nitrogen; the dynamic pressure will come from a 1.9 megawatt hydraulic installation. 'We will save energy by building up the pressure gradually', explains De Jong, 'and then using valves to transfer it to the cylinders. Because this will bring so much air into motion on this side, it will be impossible to close off the machine chamber. We will have to cover it with a sort of carport, so the air can escape. To absorb the blows, this part of the channel is outfitted with a 1.80-metre thick concrete floor, which will restrict the movement of the tank to one millimetre'.

Sealing is another area of concern: how can we keep it dry in here, with such a volume of raging water on the other side of the bulkhead? The exact solution is a trade secret of the American firm MTS, but it has something to do with inflated Teflon cushions gliding along the steel walls. The corners at the bottom are always the most difficult. They also cause the most leakage in the current channel in the Noordoostpolder. That is why in the new Delta channel they have a more rounded shape.

LONGER AND DEEPER

Even in this current age of enormous calculation capacity and advanced calculation models, practical tests are still needed, if only to validate the calculation models. This is one of the channel's functions. The Deltares ecologist Minder de Vries mentions several others for testing at actual size: extreme conditions, the behaviour of clay, peat and sand mixtures (which cannot be calculated), the behaviour of natural materials (e.g. grass, willow and shellfish beds). These cannot be tested on a smaller scale.

Therefore, when it was time to replace >>



the Delta channel at Marknesse (constructed in 1980), Deltares decided to expand the new channel and house it closer to the other laboratories. The Head of the Department of Hydraulic Engineering Structures, Dr Marcel van Gent, calculates that the new Delta channel will be able to generate 85% of the waves on the Dutch coast at actual size (this was 60% for the existing channel). This refers to a 'significant wave height' (crest-trough) of 2.2 metres, with a maximum wave height of 4.5 metres. Even higher waves, which are becoming increasingly rare, can reach the monstrous height of nine metres. These 15% outliers must thus be tested on a scale of 1:2. Although this is customary - water engineers know how to recalculate the experimental levels of mass, force, pressure and other factors to produce the actual values - it is undesirable, particularly for natural materials.

The size and the length of the channel have been scaled up in order to test soft sea walls. The popular principle of 'building with nature' requires testing of natural materials (e.g. willow and shellfish beds), accompanied slightly ascending gradients, which translate into greater length for the channel.

Ninehundred piles were needed for the foundation

The decision to place the channel close by in the soft soil of Delft required 900 piles for the foundation, including tension piles to prevent the tank from drifting. In addition, 22 thousand cubic metres of concrete were poured, combined with 1.850 tons of reinforcement. The total costs of construction were around 25 million euro.

LARGE AND EXPENSIVE

Van Gent emphasises the relationships between the research facilities on the Deltares site. The channel is suitable for research on two-dimensional sections. The basins in the nearby hall are suitable for 3D research, albeit on a smaller scale. In the Delta basin (50m x 50m, 1m deep), waves crash back and forth through a scale model of the port of Costa Rica. The goal is to learn how best to protect the reclaimed land. In addition to the port, therefore, the ocean floor was also modelled.

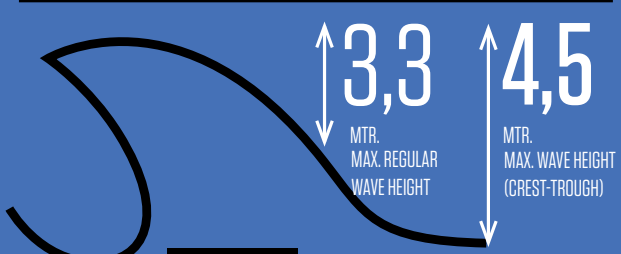
In the nearby Pacific basin, a model of the new IJmuiden sea lock is being constructed. In this model, measurements of salt and fresh water are expected to identify the forces operating on the lock doors and on the seagoing vessels to be contained within the lock. They have also been modelled on a scale of 1:30. Through RWS, Deltares

DIMENSIONS

LENGTH	290 MTR.
BREADTH	5 MTR.
DEPTH	9,5 MTR.

WAVE GENERATOR

STROKE	7 MTR.
MAX. SPEED	2 M/S
HYDRAULIC CAPACITY	1,9 MW
MAXIMUM PRESSURE	300 BAR
EXTINGUISHES REBOUNDING WAVES	



WAVE PROPERTIES

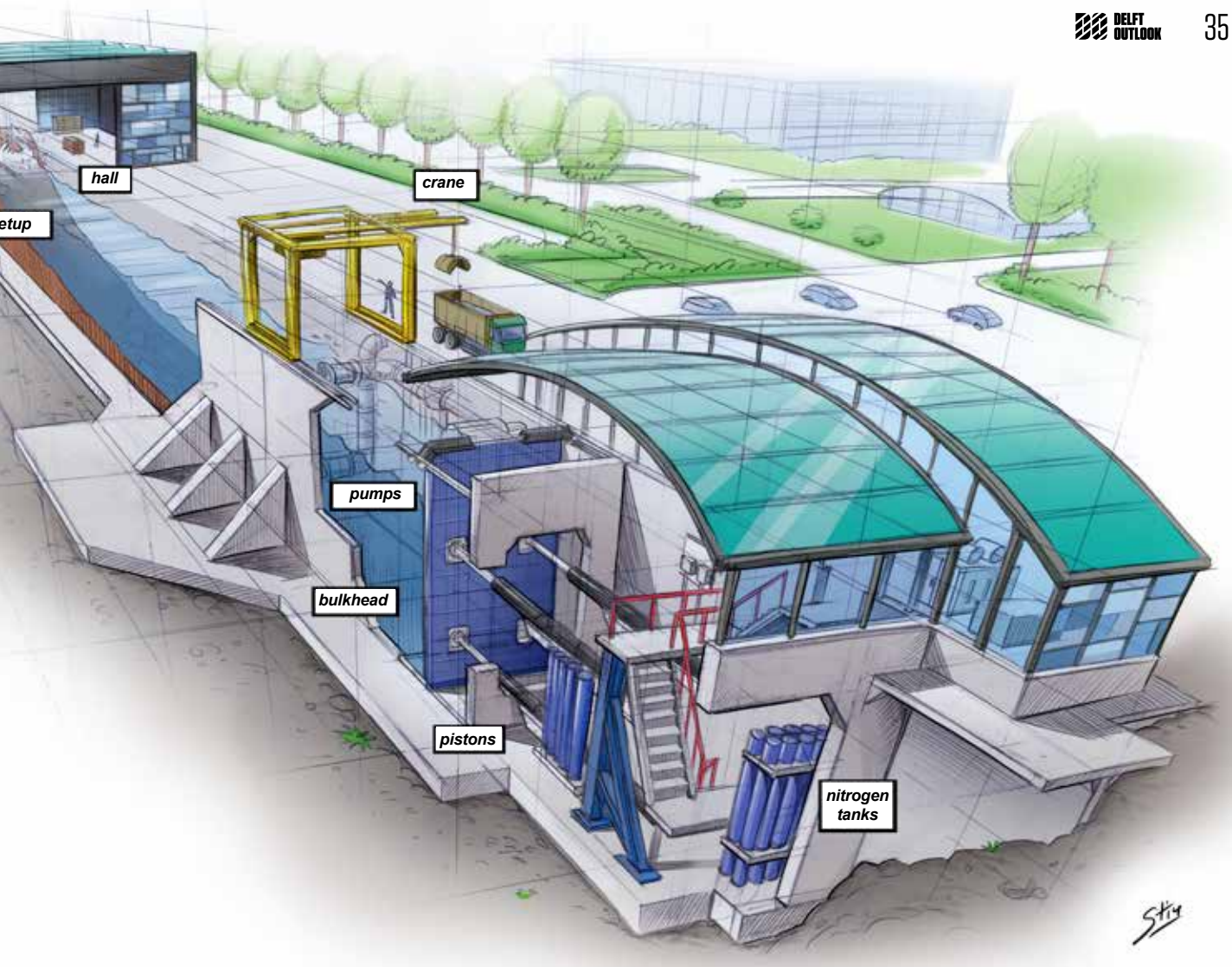
WAVE PERIOD / 1 - 20 SEC.

ADDITIONAL INFORMATION

3 PUMPS
350 LITRES/SEC
FOR SIMULATION OF TIDES AND RISING WATER (MAX 2.4 METRES PER HOUR).

2
CRANES ON THE CHANNEL, EACH WITH LIFT CAPACITY OF 12.5 TONS

TOWING/MEASUREMENT VEHICLE 1 M/S AND MAX. 1 TON TOWING CAPACITY



will deliver the results of the tests conducted here between November and January to the contractor combinations bidding on this project, which is valued at €850 million.
With a 40% share, the government remains the knowledge institution's largest client. Projects also come from provincial and municipal governments, as well as from water boards and engineering firms, and Deltares receives 30% of its proceeds from foreign clients.
As an example of the types of experiments that will be conducted in the new channel, the ecologist De Vries mentions a test that he had previously conducted in the Delta channel at Marknesse. This involved sods being removed from a dike and placed in the wave channel in order to test its wave resistance. With eight weeks for construction and dismantling and one or two weeks of measurements, these were large, expensive experiments (costing €1–1.5 million). However, as De Vries cheerfully points out, it can make a big difference if the results indicate that the dike does not need to be reinforced or that it is resistant to overflow (water flowing over the dike).

ON DRY LAND

Project Manager De Jong guides the group over a concrete track to the other side of the channel. This track is strong enough to bear the weight of lorries carrying sand and stones, as those are required to create the set-up for the experiments. Under the track, 9.2 thousand cubic metres of drinking water is stored in a basin, to be pumped into the nearby channel for testing. Upon arriving at a scaffolding stairway at the testing building, De Jong says, 'One or two people can go down to the bottom'. A few moments later, everyone is down there. The measurements will take place in this shallow part. The part behind it, which ends in a wall of stacked stone blocks, is designed to allow the waves to play out. The visitors photograph themselves and each other. A nice thing to have for later, as soon everything will be under water. <<

View a test at the old Delta channel in Marknesse: youtu.be/t_p32yrLfcw

Alumni World

Young Alumni Career Week

In March 2015, the Young Alumni Career Week will be held for the third time. Alumni graduating within the past five years can take various workshops in order to shape their careers.
If you are wondering whether your job really is right for you, the workshop 'Stay or Go' might be helpful. You might decide that you should structure your work differently (see the workshop 'Job Crafting') or that you should find another job (see the workshop 'Networking' or 'How to apply for the job').
If you are considering starting your own company, you might find the workshop 'Mind your own business' useful.
The activity calendar contains additional information. Alumni with no more than five years of work experience will be invited by email.
The workshops are offered by the TU Delft Career Centre from 18:00 until 21:00, including snacks and drinks. The cost is €35 per workshop. You can register through alumniportal.tudelft.nl . Each workshop can accommodate up to 10 alumni.

Help a student, become a mentor

Since 18 November, a five-month pilot study has been running in the Faculty of EEMCS, in which alumni can become mentors to current Master's students. In doing so, alumni can make an important contribution to students' career orientation by sharing their knowledge, experience and networks with a new generation of students. This is very useful for students, as it allows them to consider their careers in a different manner and to talk with people who have experience in this area. By enhancing their preparation for their working lives, it could even help them complete their studies with greater success. Mentoring students is also good for alumni. It allows them to offer true assistance to students, in addition to building a network of young talent, gaining inspiration from this new generation and learning about issues that are important amongst students. If you are an alumnus EEMCS and would like to contribute to the career orientation of a student, sign up to be a mentor via: dwillo.nl/EEMCS_TUD

Alumni Activities

9 January
New Year's reception for mathematics and computer science alumni
Faculty of EEMCS

16 January
BK9500 event for graduating students: Generation '95 -'00 Architecture
Berlage rooms in the Architecture building

3 March
Young Alumni Career week
workshop 'Stay or Go'

4 March
Young Alumni Career week
workshop 'Mind your own business'

17 March
Young Alumni Career week
workshop 'Stay or Go'

24 March
Young Alumni Career week
workshop 'Job Crafting'

25 March
Young Alumni Career week
workshop 'Networks for your career'

26 March
Young Alumni Career week
workshop 'How to apply to land the job'

University fund

Best graduating student and best teacher

Alexandru Iosup from the Faculty of EEMCS has been named the best teacher at TU Delft. Ir. Jörn Zimmerling was selected as the best graduating student. The prizes are awarded each year by the University Fund and Royal HaskoningDHV. Gamification

Alexandru Iosup has a unique way of teaching. 'He knows that each student is different', note students and the jury. Iosup devised a method for bringing out the best in all students: the gamification of courses. This means that students can choose their own paths through the course.
The best teacher is chosen based on nominations from the study associations of all faculties. A jury consisting of students, the previous year's winner and the Rector Magnificus determines which of these eight is the best teacher at TU Delft. Dr Alexandru Iosup studied computer science at the University of Bucharest (2004) and obtained a doctorate at TU Delft in 2009. Since then, he has been a researcher and assistant professor in the Parallel and Distributed Systems group.

Final mark of 10

The best graduating student was ir. Jörn Zimmerling (EEMCS). He graduated cum laude, and with a final mark of 10 in electrical engineering. Zimmerling focused on the modelling of new optical nano-structures (e.g. nano-lasers) and on the solution of the associated equations, with which computers can calculate the course of light. These types of calculations are usually highly complex, often requiring designers to wait a whole day for the results. Zimmerling was able to introduce 'Krylov sub-space techniques' in this area, demonstrating that the techniques could increase the speed of calculations by a factor of 50. According to the prize winner, this is particularly advantageous for the extra coffee breaks that they offer scientists. Zimmerling will continue his career as a doctoral candidate at TU Delft.
If you would also like to support talented individuals like Alexandru and Jörn, become a 'Friend of TU Delft' at universiteitsfonds.tudelft.nl.

University fund

Good Friends Dinner

The Good Friends Dinner, organised by the University Fund on 6 November, began with a surprise: the quantum technology research of Leo Kouwenhoven was awarded icon status. This was shown live through a link with television show *De Wereld Draait Door*. The dinner was held in the Modelling Hall of the Faculty of Architecture and the Built Environment. The President of the University Fund, Michael Wisbrun, spoke on the future of the University Fund and its collaboration with TU Delft: Connect with Excellence. Rector Karel Luyben discussed several striking studies, and Eric Meijer, Professor of Software Engineering and an entrepreneur in Silicon Valley, presented his inspiring vision on the role of 'givers' in research and education. Finally, Tim Jonathan, of the Pret-à-Lôger student team, told about their prize-winning project for making existing terraced houses in the Netherlands energy neutral and sustainable for the future.
The dinner was attended by nearly 100 alumni who are extremely valuable to TU Delft. If you would like to attend next year's dinner, you can sign up now to be a Friend of TU Delft at **universiteitsfonds.tudelft.nl.**

Dutch engineers USA tour 2014

Engineering new boundaries

The highest concentration of technological alumni outside the Netherlands can be found in the United States: nearly 3100 alumni of TU Delft, Twente University and TU Eindhoven are living and working there. This is a good reason for the three universities to join forces and visit these alumni, in order to create connections and establish Alumni Chapters.

In November, the alumni relations managers visited the five cities with the most alumni (Boston, New York, Seattle, San Francisco and Houston). The theme of the tour was 'Engineering new boundaries'. It represents the large number of fields in which our alumni are trained and employed, in addition to reflecting the renowned innovative character of the three universities of technology.
All of the sessions consisted of lectures, with plenty of time for networking and catching up. Old acquaintances found each other, and new relationships were formed.
In addition to five evening events, there was a lunch-time meeting in the home offices of Microsoft in Seattle and a 'Dutch' breakfast at the Google complex in San Francisco. Both companies employ many alumni.
The following step will be to engage volunteers to establish joint Alumni Chapters. This initiative has full support from Delft, Twente and Eindhoven. 'The atmosphere at all of the events was fantastic. We felt more than welcome, and we made a good start for establishing independent chapters', noted Joe Laufer (Twente) and Anouk Dijkstal (TU Delft). 'Our alumni in the USA are working for the most interesting companies and universities, including Harvard, Stanford, Rice, the United Nations and NASA. This is truly something to be proud of!'
A special LinkedIn group has been set up for alumni in the USA.
For more information, please contact: LinkedIn Dutch engineers alumni in USA

Boston

More than 30 alumni met for two lectures in the Cambridge Innovation Centre in Boston. Andries van der Meer, who works at the Wyss Institute (Harvard), told about his research in the area of engineering the human body (body-on-a-chip). It is the ultimate encounter between biology and engineering. Next, Casper Harteveld spoke on serious gaming or, more specifically, Gamengineer. He demonstrated that this topic has become a fully mature discipline.

New York

In New York as well, more than 30 alumni were present in the Netherlands Club. Speaker Wolfgang Pfaff (PhD researcher at Yale University) gave a lecture on quantum physics – a topic that has regularly brought TU Delft into the news recently.

Seattle

The session in Seattle was of a different nature. Marieke Watson of Frog Design gave a lecture on the design process within Frog, after which Guy de Lijster, Urban Planner Transit Architecture for VIA architects, brought us up to date on several projects in the area of transit infrastructure.

San Francisco

In San Francisco, the Dutch character received even more emphasis, as the event was held in the consulate. More than 60 alumni were heartily welcomed by Consul Ard van der Vorst. This was followed by a lecture by Dahlila Szostak, TU/e alumna and user experience researcher at Google.

Houston

The last stop was Houston. In the Houston Club, Myrte van Ree of Subsea7 spoke on offshore engineering. Mark Moll, an assistant professor at Rice University, then brought the 30 participating alumni up to date on matters in the world of robotics.

Facts

5	cities
7	events
21,568	kilometres
209	alumni
7	bags of pepernoten
5	flights and one train journey
209	signatures

CONTACT

Do you have tips, ideas, questions or comments for the alumni office? Send an e-mail to: alumnibureau@tudelft.nl or call +31 (0)15-2789111

ALUMNIPORTAL

Do you want to change (alumni) information, communication preferences or sign up for alumni events? You can do that through the alumni portal www.alumniportal.tudelft.nl

LINKEDIN

Do you want to contact other alumni? Join the 'Delft University of Technology –Alumni LinkedIn' group.

FRIENDS OF UFD FUND:

Become a 'Friend of TU Delft' and support Talent, Technique and TU Delft with your contribution. Bank account IBAN number NL19FVLB0226850471, account name 'stichting UfD', description 'friends'. universiteitsfonds.tudelft.nl

OAPS

Adrianus de Hoop

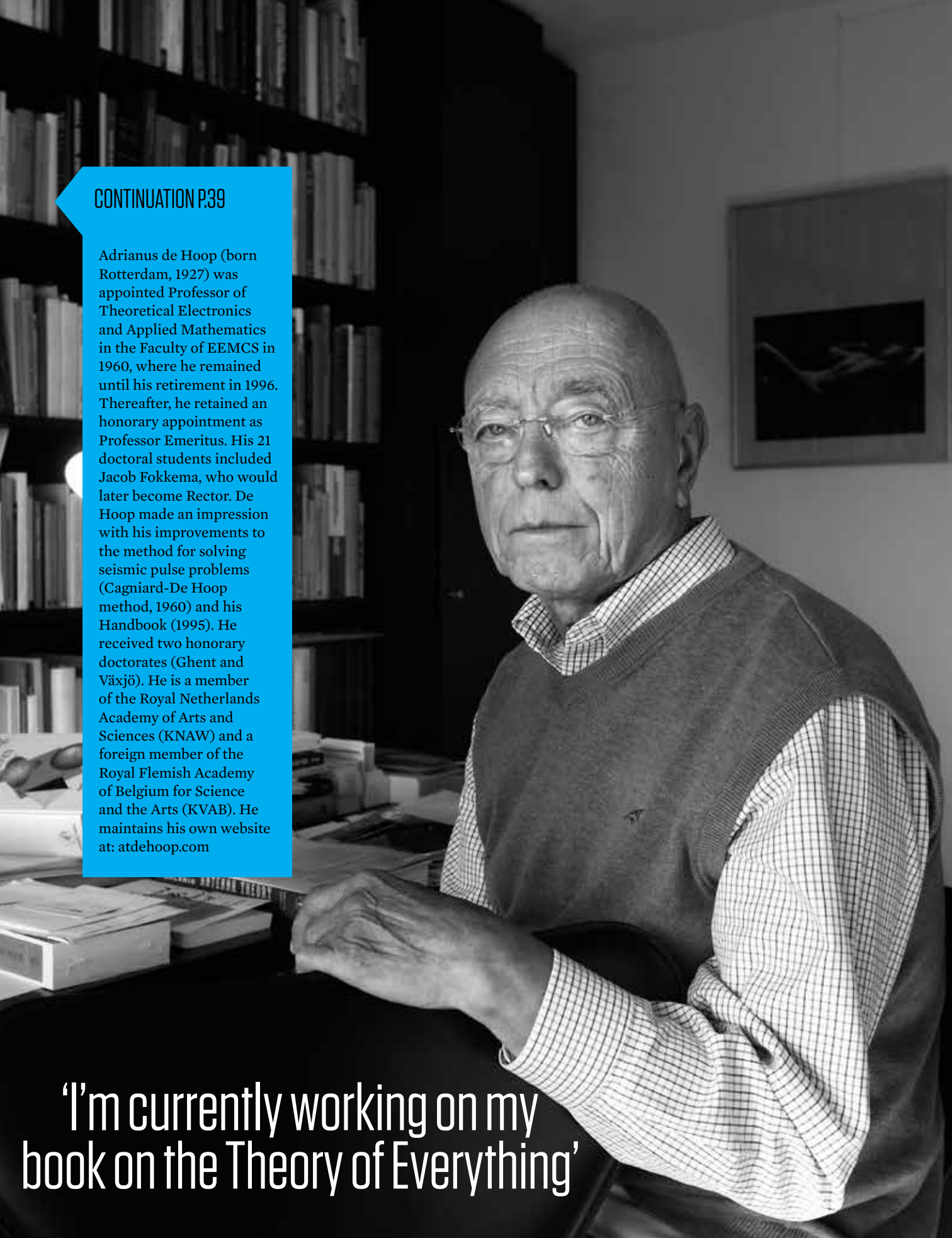
As is the case with all other employees, professors retire when they turn 65. But there are exceptions. This week: mathematical physicist and electrical engineer Prof. ir. Adrianus de Hoop (86).

The interview was held in the garden of Aad de Hoop and his wife Annelies. A pile of papers lay on the table: an article being reviewed by De Hoop for an American journal. It was a tough job that had kept De Hoop busy for weeks. 'If it's rubbish, it goes faster', he laughs.

Until last year, De Hoop cycled every day from Bergschenhoek to the EEMCS building in Delft, where he still has an office. When he retired in 1996, he was no longer required to attend meetings, and he enjoyed having more time for colleagues and his last doctoral students. De Hoop was also a regular in the Schlumberger-Doll American research laboratory. When he asked what they expected of him, the answer was, 'Just sit back and think'. The daily trips to Delft came to an abrupt end with a stroke, which caused him to lose control of the left side of his body. He considers himself fortunate that his mental ability was not affected, so that he can continue to work on articles written by others, as well as on his own scientific work. His field is the triple intersection between mathematics, physics and electronics: from seismic research and acoustics to antennas and beyond. His thoughts have recently been taking him even further. He has returned to the mathematical equations of the Lorentz transformation – a system of equations compiled by Hendrik Antoon Lorentz (Nobel prize winner of 1902) that describes the relationship between the space-time coordinates of two observers moving in relation to each other using electromagnetic waves to exchange information. These equations form the foundation of Einstein's special theory of relativity.

In addition to regarding time as a component of a four-dimensional geometry, as proposed by Einstein, De Hoop sees time as a separate, independent and observer-specific measure of the course of physical phenomena (following Herman Weyl). This arrangement allows space for speculation concerning the relationship with the quantum theory developed by Dirac (Nobel prize winner of 1933). De Hoop regards the article that he recently published on this topic in the journal Wave Motion as a springboard for further research in this direction. For example, he discovered another set of equations with a related structure, which he now thinks could be used to describe gravity. This could clarify the nature of dark matter, which is currently a persistent problem for physicists. Aad de Hoop is far from finished. Inexhaustible and enthusiastic, he is taking on the major questions of contemporary physics. He still wants to understand, solve and explain them. 'I'm currently working on my book on the theory of everything', states De Hoop in all seriousness. 'It will be on the internet'. It might take another few years. JW

PHOTOS: SAM RENTMEESTER



CONTINUATION P.39

Adrianus de Hoop (born Rotterdam, 1927) was appointed Professor of Theoretical Electronics and Applied Mathematics in the Faculty of EEMCS in 1960, where he remained until his retirement in 1996. Thereafter, he retained an honorary appointment as Professor Emeritus. His 21 doctoral students included Jacob Fokkema, who would later become Rector. De Hoop made an impression with his improvements to the method for solving seismic pulse problems (Cagniard-De Hoop method, 1960) and his Handbook (1995). He received two honorary doctorates (Ghent and Växjö). He is a member of the Royal Netherlands Academy of Arts and Sciences (KNAW) and a foreign member of the Royal Flemish Academy of Belgium for Science and the Arts (KVAB). He maintains his own website at: atdehoop.com

‘I’m currently working on my book on the Theory of Everything’