DELFT OUTLOOK
NO. 2 JULY 2019 YEAR 36
TU Delft

## Joop Roodenburg
'We should start producing intelligent structures again'

## PHAGE LIBRARY
Fighting bacterial infections

Home-grown design professors
## Focus on sustainability in design

TU Delft

THEME
# To the moon

Cover:
Taking a photo of the moon together with a piece of a university building requires some planning. Fortunately there are apps that indicate the position of the moon. Just before sunrise the moon is located in the right corner and low above the horizon, and around that time you can also see the contours of buildings. Luckily, at the same time the clouds disappear.
(Photo: Sam Rentmeester)

## Foreword

*Tim van der Hagen*

# Sharing ideas

We like to keep you, our alumni, informed about the latest developments at your alma mater. Not necessarily to show you all the amazing things happening on campus – although we do enjoy doing that, too – but because sharing knowledge and exchanging ideas is so important. Knowledge that you need to keep up with your field, or that can help you progress within your company. Your ideas that we can use to ensure our research matches day-to-day practice. This way, together we form a community of Delft engineers who are striving to create a better society. The occasional meeting is also part of that. It was great being able to welcome so many of you to the TU Delft for Life|Xperience day on 4 June. On that day, the TU Delft Quantum Vision team presented its findings. They looked at the impact the emergence of quantum internet will have on industry and society. Because, to the best of their knowledge, there is a lot we cannot predict when it comes to brand-new technology. That's why it's vital for us to come together and think about these issues now, and we hope you will help us. In the future, too, we will continue to involve you in major issues that affect everyone – from climate change to cyber security. Incidentally, some of our scientists believe this future lies in other galaxies. As such, this issue puts the spotlight on space research in Delft.

*Professor Tim van der Hagen,*
*President Executive Board*

PHOTO: SAM RENTMEESTER

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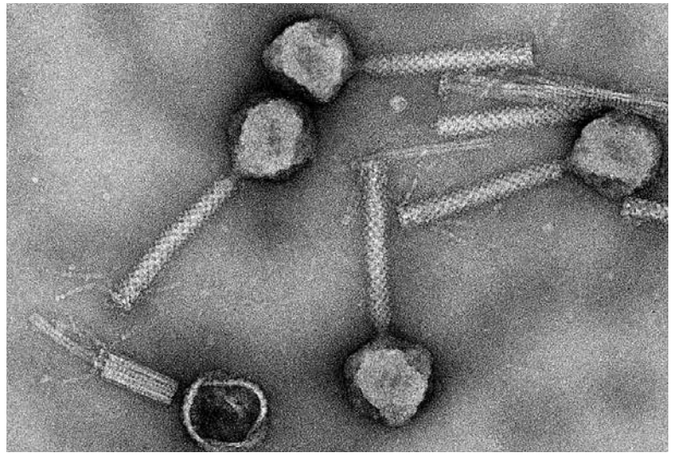


# DELFT IN BRIEF

Photo: Sam Rentmeester

## Tracking surgical instruments

Medical doctor and PhD student Frédérique Meeuwsen worked for two years on a test with Radio Frequency Identification (RFID) tagged surgical instruments. RFID chips can transfer information over a distance. They are on, among other things, bank cards and OV chip card. The chipped instruments were deployed for the first time during an operation at the Reinier de Graaf hospital in Delft. Automatic monitoring of the instruments turned out to be possible. Meeuwsen' co-supervisor dr.ir. John van den Dobbelsteen sees this as a stepping stone to the digital operating room of the future.

Photo: Wikimedia

## Bye bye glaciers

The glaciers in the Alps will lose at least 40 percent of their ice in the next 30 years. Glaciers react with delay to global warming, researcher Harry Zekollari from the Department of Mathematical Geodesy and Positioning (CEG) and Swiss colleagues demonstrated in a study. If the emission of greenhouse gases ends immediately, almost half will still be lost, their models show. If the average temperature on earth rises by 2 degrees compared to the end of the nineteenth century, two thirds of the ice mass will disappear by 2100.

Photo: Panorama Mesdag

## The missing part of the sea

When painting his Panorama in 1881, Hendrik Willem Mesdag does not seem to have immortalized part of the view. Ten degrees of sea are missing in the painting. This is apparent from surveying measurements carried out by students of the TU under the supervision of Professor Ramon Hanssen (CEG). The students carried out the research for the exhibition 'From the highest point: Surveying in Mesdag's time' that can be seen until 22 September in Panorama Mesdag in The Hague. In his Panorama, Mesdag tried to display the Scheveningen view from the Seinpostduin (dune) as precisely as possible. The students were able to find out the exact place where Mesdag stood while painting.

## Beautiful bridges

In his dissertation 'The Art of Bridge Design', the multi-award winning bridge builder Dr Joris Smits (Royal HaskoningDHV and Faculty of ABE) argues for a master builder in bridge construction. Such a design integrator is an architect and engineer in one person. Smits himself studied civil engineering and architecture. The combination of both disciplines makes a bridge not only strong and reliable, but also an aesthetic addition to the environment. Smits mentions 'The Crossing' in Nijmegen as a successful example.

## Climate position paper

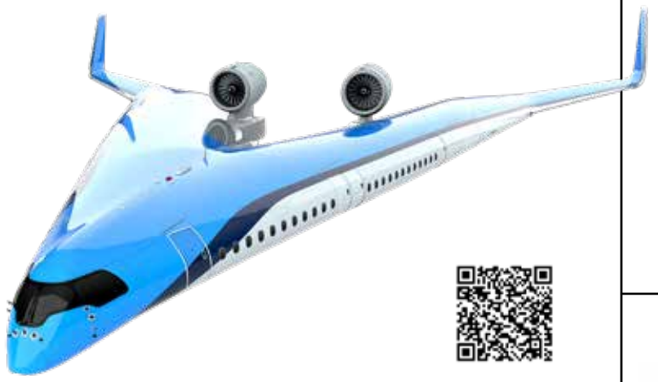
TU Delft recently published a climate position paper. Researchers thought it was time to take action against 'nonsense' on social media and websites. The text was written by about 30 Delft researchers and brought together by professors Professor Herman Russchenberg (CEG), Professor Paulien Herder (3mE) and Professor Andy van den Dobbelsteen (ABE). Rector Magnificus Professor Tim van der Hagen signed the climate position paper on behalf of the Executive Board. 'TU Delft is putting all its innovative capacities into promoting the global transition to non-fossil fuel energy sources and climate adaptation to contend with the warming planet' it says.

## Silicon heart

Heart failure may be better predicted in the future thanks to a transparent silicon imitation heart. Dr. Saša Kenjereš (Applied Sciences) and colleagues from the LUMC, Erasmus MC and the University of Ghent copied a left ventricle with a 3D printer. It is arithmetic average of the hearts of 150 patients at Erasmus MC. The 'tissue' piece is connected to a pump and beats like a real heart. The researchers pump a liquid through it with the same viscosity as blood (a mixture of water and glycerol) and added reflective particles to the liquid which are lit up by a laser. This allows them to map the fluid dynamics in the heart chamber.

## Aircraft without tail

Much work is being done at Aerospace Engineering on a new type of aircraft. The Flying-V tailless aircraft integrates the cabin, hold and fuel tanks in the wing. Such aircraft, also known as blended wings, have often been put forward in recent decades as a more sustainable alternative to traditional passenger aircraft because they are supposed to be lighter and more aerodynamic. But they were never taken into production. The Delft aircraft is designed in such a way that it can easily be manufactured in various sizes. In October the researchers will show a scale model (1 in 20) with a wingspan of 3 meters at Schiphol Airport.



## Earthquakes in Groningen

A parliamentary inquiry into the earthquakes in Groningen is not yet underway. What was TU Delft's role? A reconstruction shows that Delft research was not determined by social urgency, but by the availability of research funding. Until 1990, a link between earthquakes and gas extraction was generally denied. The current dean of CEG, Professor Jan Dirk Jansen responds: "The NAM (Dutch exploration and production company), the KNMI (Netherlands Meteorological Instite), the Ministry of Economic Affairs, the National Mines Inspectorate and also the TU have underestimated the earthquakes. Nobody predicted that it would develop like this." Only after Minister Kamp had started investigations in 2012 did the number of Delft earthquake publications in Groningen increase.


Photo: Milieudefensie

## Indian roots

Photo: holechistorie.nl

Dr Huib Ekkelenkamp delved into the history of surveying and followed the trail back to the Dutch East Indies, where the roots of TU Delft also appear. In his dissertation 'Indonesia on the map', he shows that surveying until 1800 was the only qualified engineering course. The Dutch method was not immediately usable in Indonesia. The mountain landscape with volcanoes, the impenetrable forests and swamps, the climate with heavy rains, the higher humidity and temperature demanded a specific method. Despite this, the Dutch East Indies were largely charted in the period 1850-1950.

## Fall preventer e-bike

Photo: Sam Rentmeester

The TU Delft Bicycle dynamics lab has prototyped a steer-assist electric bike to make riding fall-proof. Professor Arend Schwab, Director of the lab, says that loss of balance at slow speeds often is the problem. This is due to looking over the shoulder, extending your hand or getting on and off. If, through a sensor, the algorithm detects a lean rate above a specific threshold, a smart motor in the front rotates a handlebar and gets the e-bike upright. That seems to go against intuition, says Schwab, but as long as you go faster than 4 kilometers per hour, the steering assistant keeps the bike upright.

# THEME
## To the moon

On July 21 it will be fifty years ago that Neil Armstrong became the first person to set foot on the moon. Following the good example of the InSight Marslander 88 teams of first-year mechanical engineering students built their own 'Marktlander': a Marslander who can take a beating. The assignment was to build an autonomous moving mechanism that can continue moving after a fall from table height, and then deliver a block of 'gold' three meters away. The winning Marktlander placed the block just 5.8 millimeters from the three-meter line.


PHOTO: SAM RENTMEESTER

# Space travel in Delft all started with shifting stars

In the 1970s and 1980s, Delft researchers were involved in the first Astronomical Netherlands Satellite (ANS) and in measuring distances to satellites. Was this prompted by the 1969 moon landing?

TEXT: JOS WASSINK PHOTOS: SAM RENTMEESTER

According to emeritus professors Karel Wakker and Boudewijn Ambrosius, the established order of influential Dutch astronomers considered manned space travel to be a wasteful and pointless activity. At the time, the consensus was that the Netherlands shouldn't dwell on the issue.
Wakker and Ambrosius are two of the instigators of space activities carried out in the current Faculty of Aerospace Engineering. When Apollo 11 landed on the moon, on 20 July 1969, Wakker had graduated two years previously from the then department of Aeronautical Engineering, and Ambrosius was a second-year student there. As a student, he wasn't overly motivated because he wasn't really interested in aircraft constructions or air currents. He came to Delft to study space travel, but it wasn't until later in the degree programme that this subject was covered in Professor Wittenberg's performance theory course.

## INCREASING HEARTBEAT

In the 1960s, guys like Wakker and Ambrosius cut out articles on space travel and wrote to NASA and the Russian Space Agency (the security service even visited the Wakker family asking about their frequent correspondence with Russia).
They studied the starry sky and had a telescope to make their own observations. They both told the story about how they suddenly saw an unknown star moving between the familiar stars. It had to be a satellite. Their hearts began to beat faster. Can you also determine how fast, and therefore how high, that satellite is moving? Can you also calculate when it will return? These kinds of questions inspired the small club that had gathered around Professor Wittenberg in Delft.

## PIONEER

Wakker and Ambrosius speak the name Wittenberg with an amount of respect that borders on awe. To them, Wittenberg is an underestimated pioneer, someone who had good relationships within Dutch space research and Estec (located in Delft until 1969), and who preferred to give others the opportunity to develop rather than step into the limelight himself.
"He wasn't driven by the need for recognition," says Wakker. For example, when Wakker joined Wittenberg as an engineering assistant after his graduation, he gave him the opportunity to work at Estec in Noordwijk one day a week. Wittenberg let his employees devote all their time to what they loved doing: thrust calculations and orbital mechanics. The book *Rocket Propulsion & Space Flight Dynamics*, written by Karel Wakker, Koos Cornelisse and Herman Schöyer, was published in 1979. Orbital mechanics, or how a satellite or a spaceship moves through space, has become a specialty in Delft with researchers participating at an international level. Astrodynamics is the basis for determining the movement of the Earth's crust and global sea level, measuring melting land ice or subsidence caused by gas extraction. How did this all happen?

> Orbital mechanics has become a specialty in Delft with researchers participating at an international level

## ORBITAL CALCULATIONS

One year before the moon landing, Wakker was given a special mission. Wittenberg had connections in the group that wanted to build and launch the first Astronomical Netherlands Satellite (ANS). The purpose of the space telescope was to observe X-ray and ultraviolet radiation. Fokker was responsible for satellite construction, Philips supplied the electronics. Wittenberg put himself forward to do the orbital calculations.
Wakker still remembers the conversation. "Wakker, you're going to do the orbital calculations for the ANS." And there was only one right answer: "Yes, professor." These calculations were carried out in TH Delft's computer centre, first using punched tapes and later with piles of punched cards Wakker handed in at the desk. He would then politely ask when the calculation would be done. "That was usually the next morning." ANS was launched on 29 August 1974 and orbited the earth in an elliptical orbit at an altitude between 266 and 1,176 kilometres. The mission lasted 20 months and was regarded as a success, partly thanks to the discovery of X-ray bursts – which they couldn't have done from the ground due to the atmosphere's ability to absorb X-rays.

## SHOOTING SATELLITES

For a second important mission, the orbital calculations had to be much more accurate. Prof Leen Aardoom of the former Geodesy department wanted to use a laser from Kootwijk, in the Veluwe area, to measure the distance to geodetic satellites. Those satellites were packed with mirrors that would always reflect a light. But you had to know exactly where to aim the laser. For Wakker and Ambrosius it was "a wonderful new problem". Wakker explains: "We combined observations from different stations to predict the trajectory of the satellite as it passed over the station at Kootwijk over a period of several weeks." Ambrosius specialised in computer calculations.

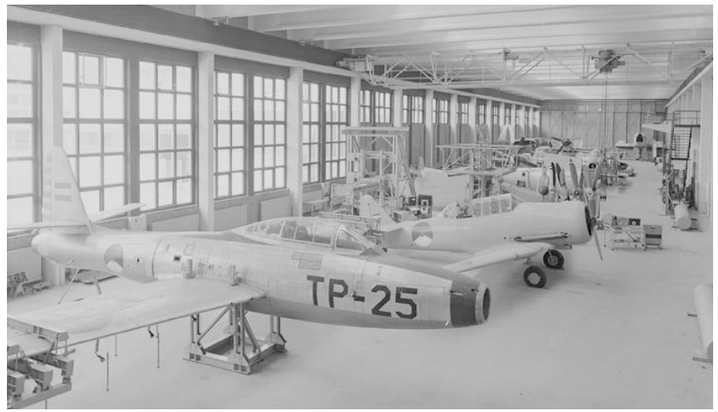
## TRUE BENCHMARKS

At ESA and NASA, orbital calculations from Delft were considered to be true benchmarks. "We were playing in the big leagues," remembers Wakker. "NASA didn't pay us, but they did give us support and data from the international laser station network. We were required to submit reports. It was tough. If you didn't deliver, you'd soon be out the door." Ambrosius looks back: "When you can calculate an orbit to within one decimetre, you can also accurately determine the local sea level. Then it becomes interesting to measure the sea's surface level across the globe. Space travel is not a goal in itself, it's a way to make things possible."

Karel Wakker (left) and Boudewijn Ambrosius.

## BACK TO THE MOON?

Fifty years after the first moon landing, there is increasing talk about going back. Do we Dutch still think that's a wasteful activity? Wakker: "The earth is the cradle of mankind, but one day there will be settlements on the moon and on Mars. Concrete can be made using the water at the poles and moon dust. Various groups are working on that."
Ambrosius sees the moon as an ideal springboard for further destinations. Solar panels can be used to make propellant from the polar ice for space trips to Mars or further afield. Another reason to return is the radio silence on the other side of the moon. For Dutch radio astronomers, made famous by the antenna network Lofar and the first ever 'image' of a black hole (last April), a radio telescope on the other side of the moon would be invaluable. From there, shielded from the noisy Earth, they can listen to the weakest signals from the earliest days of the universe. <<




The old aircraft hall in the building of mechanical and marine engineering at the Mekelweg.

# TU Delft spin-offs in space

Many successful startups have emerged from the Faculty of Aerospace Engineering. From life on Mars to off-the-shelf satellite missions. The 10 that we selected all have one thing in common: space.

## T-Minus Engineering (2011)

+/-10

Founded by four rocket experts, T-Minus Engineering designed rocket products for the European market. In 2014, the company took a sidestep to NASA when it became involved in the InSight project.

## Ursa Minor (2002)

+/-50

Ursa Minor supplies navigational and communications services and was closely involved in the Galileo programme, Europe's biggest space project ever. Among Ursa Minor's products is the Ursa Minor Search and Reference Beacon, civilian satellite navigation systems that have been operational since 2016.

## Spin (2015)

+/-10

Space Products and Innovation (Spin) is currently working on a multi-functional adapter. It supplies a plug-and-play pre-fab kit to build your own satellite. There's a reason that the company's slogan is 'Build a satellite like Lego'.

## S&T (2000)

+/-200

Science & Technology Corporation (S&T) researches and designs measuring and control systems for space travel, science and defence. The company does space monitoring, such as monitoring pipelines. S&T was also closely involved in the building of ESA's Sentinel-3A satellite.

## Mars One (2011)

+/-10

Travelling to Mars and living there permanently seems impossible but Mars One says that living on the red planet is closer than ever. The team, that intends to house the first Earth emigrant in 2031, is involved in unmanned missions to try to build a liveable settlement.

## Isis (2006)

+/-200

Innovative Solutions In Space (Isis) works across the world. It specialises in completing small off-the-shelf satellite missions, including take-off. The company also supports the general development of space travel through training programmes and knowledge sharing.

## GTM Advanced Structures (2004)

+/-50

This company supports the entire aerospace industry by designing and building advanced structures. These could be designing and producing solar panels and antennae for small satellites, and testing materials in space.

## Dawn Aerospace (2016)

+/-10

Dawn Aerospace hopes to be the first company in history to fly twice a day with the same aircraft to space. The aircraft has not yet been built, but the team has already won several world firsts. Such as the first 3D printed pressure vessel ever approved by the European Space Agency.

## Airborne (1995)

+/-150

Airborne supplies affordable space components such as the design and production of composite panels for satellites. The company has offices in the Netherlands, Spain and England.

## Arceon Novel Elements (2017)

+/-6

Arceon Novel Elements developed a versatile advanced ceramic matrix composite (CMC) that can withstand extreme temperature variations. The company has just entered a partnership with the builders of the Lunar Zebro.

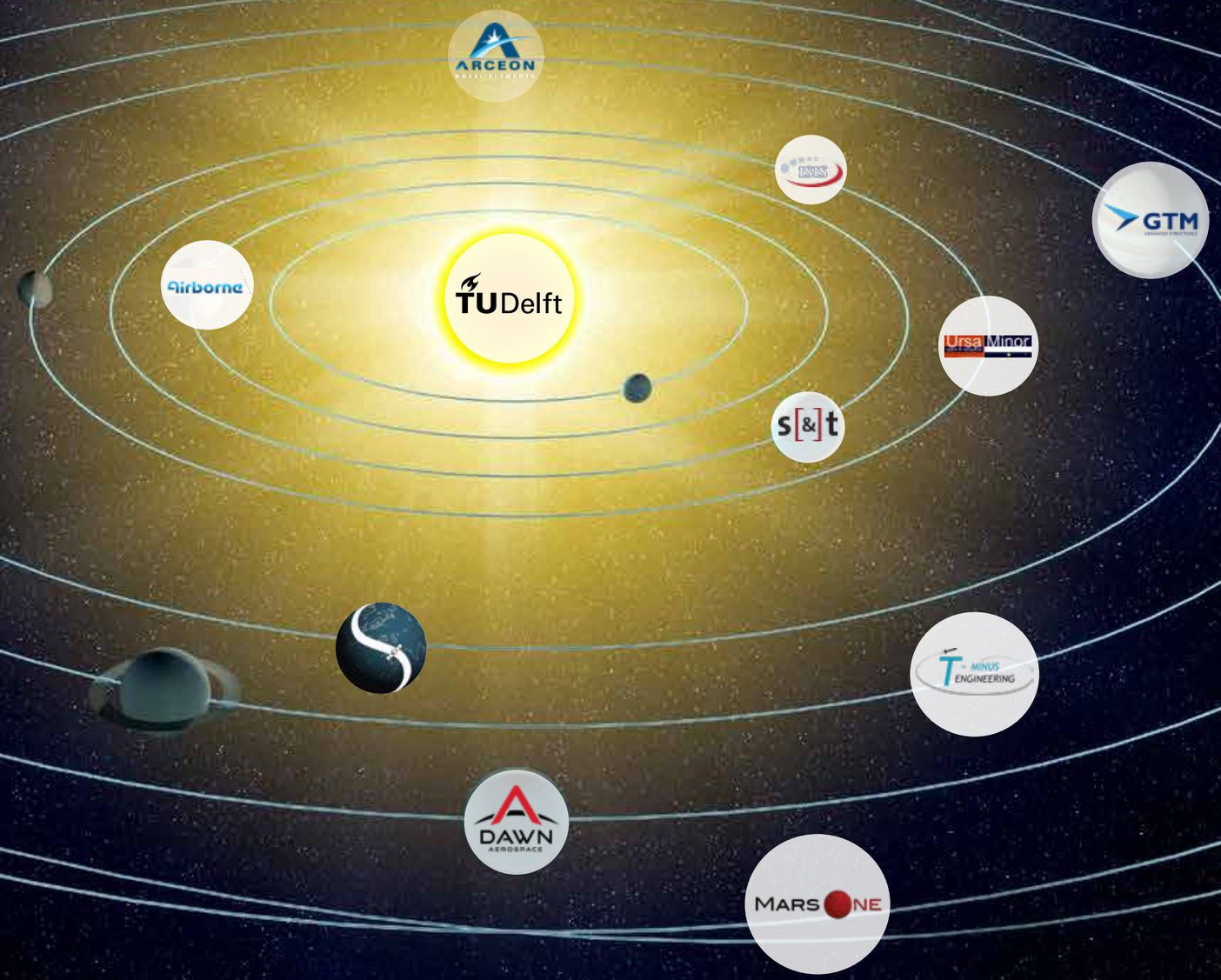



PHOTO: GETTY IMAGES

# This little guy is going to the moon

Led by Dr. Ir Chris Verhoeven and operations manager Maneesh Kumar Verma, TU students developed a robot that travels to the moon in 2022. The robot, named Lunar Zebro, is physically independent thanks to its c-shaped legs and operates in swarms to perform complex tasks. One of those tasks is gathering information on the moon, but the Zebro is also suitable for an expedition to Mars and can assist with rescue operations in difficult areas, such as caves. MvdV

PHOTO: SAM REINTWEESTER



# How we were captivated by the moon landing

Man first set foot on the moon fifty years ago, and yet there are still people today who believe it was faked. In 2003 two TU Delft alumni even wrote a play about it.

The stage play *And what about the flag?* was a response to a documentary claiming that the moon landing was a hoax. Two Delft alumni, urban designer Jan van der Mast and physicist Allard Zoutendijk, wrote it and played the leading roles themselves.
The story: NASA approaches two Dutch scientists, Piet and Henk, to prove that the moon landing did actually happen. They do all kinds of amusing experiments which, of course, fail. Such as creating a

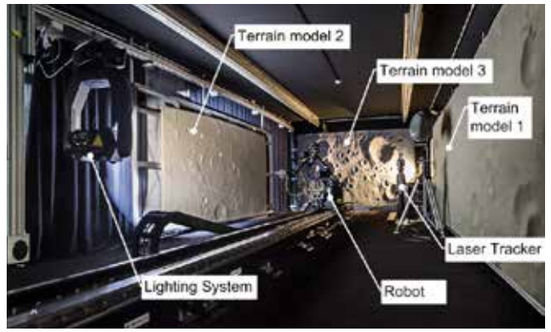
footprint in moon dust. According to conspiracy theorists, this print isn't real: the jet engine of the lunar module would have blown away all the dust.

"We scientists said that this footprint is real, because there is a vacuum on the moon", says Zoutendijk.
The alumni used a bread bin as a dome. "I was supposed to create a vacuum using a VacuVin and a hose," says Zoutendijk. "We dusted a layer of flour on the surface underneath, and I blew on it to show that the flour wouldn't move. Of course that didn't work - it created a huge cloud of flour."
And what about the flag? Surely that couldn't have fluttered in the absence of an atmosphere? Piet used two flags for that part, one of which he had dipped in starch. Van der Mast, as Piet: "Oh no, it's moving. I don't get it. It worked at home. Maybe one of the kids messed with it."
Afterwards, the audience's doubts still lingered – which was the point. Van der Mast and Zoutendijk won a prize for the most innovative play at the festival. CvD

# Landing amidst slopes and stones

The landing of Apollo 11's Lunar Module on the moon was done partly by hand. In the future, spacecraft will have to be able to land autonomously on uncharted territory on a moon or planet. Dr Svenja Woicke developed the software.

The first moon landing is still a thrill to watch. You hear the altitude readings going down: 2,000 feet, 1,600 feet, 540 feet. Meanwhile, the grey moon surface comes closer and closer. It seems the landing computer reached overload during the descent, after which the astronauts had to take over the helm. Luckily they had extensively trained on a jet-powered floating platform for a manual landing.
Later landings, such as the landings on Mars and Venus, were done on selected clean and flat areas.
But, says Woicke in her PhD thesis a flat and spotless terrain isn't very interesting for scientists. The challenge, says Woicke, is to develop an autonomous landing system that strikes a balance between the dreams of planetary scientists and the fears of engineers.
Her landing system consists of two parts. The detection part images the planetary surface with stereo vision. It autonomously detects slopes and obstacles larger than two metres. Woicke tested her robot vision system at the Tron-facility at the German space organisation DLR. Despite the realistic problems with camera noise and hard slant lighting, the system overlooked dangerous obstacles in only 2.5% of the tests.
The second part of the landing system uses the automated obstacle detection to navigate to a safe area. In the tests at Tron, a landing area of 60 by 60 metres is the standard. Woicke's system works much more precisely – it requires only 9 by 6 metres. Besides that, the landing system also overcame nearly all errors in altitude readings.
Woicke's Hazard Relative Navigation will enable a robot to land autonomously on an uncharted moon or planet. A modern-day moon landing would be a lot less nerve racking than it was in 1969. JW



# Travelling among the stars

Humans will inhabit other galaxies, predicts Dr Angelo Vermeulen. We will travel for decades on spaceships that exploit asteroids like parasites. Science fiction? ESA is taking his research seriously.

An asteroid is floating through an immense void. On the surface, we can see a few flashing lights as well as round and hexagonal shapes. In the film that Angelo Vermeulen is showing us, we start to see more and more of these structures. A patchwork of connected modules soon encompasses the entire rock, making the giant object look more like a spaceship than an asteroid. Vermeulen, leader of the TU Delft Starship Team (DSTART) research group, predicts that this type of hybrid colossus will take mankind into space.

### LIFE ON PLANETS AND SPACESHIPS

"In the future, we will live in different constellations in the universe. Not only on planets, but also in spaceships and in space stations scattered throughout various galaxies. This is the deep future."

For his PhD research, Vermeulen is investigating interstellar exploration at the *multi-actor systems* department of the Faculty of Technology, Policy and Management (TPM). He already has a PhD in developmental biology and is not only a researcher but also an artist. He is co-founder of the collective SEAD (Space Ecologies Art and Design), which works on technology-based art projects. With a background like that, Vermeulen is not afraid to leave the beaten track.

"We know little about interstellar space, about the different kinds of particles you can expect there and the types of radiation. For engineers, that's quite a challenge. How can you design a system for a future that you can't properly envisage? Our idea is to build a spaceship that continuously adapts."

> 'Don't start talking to me about something as superficial as *Star Wars*'

In the current design, such a spaceship consists of an asteroid that expands with modules. The rock will provide humans with raw materials. A crucial factor here is the 3D printer to convert mined raw materials into new building components. Boosters can steer the asteroid's trajectory. And so mankind will travel deeper and deeper into space, generation after generation. The system must be completely closed. Everything must be recycled.

### TECHNOLOGICALLY SUBSTANTIATED

Science fiction. Vermeulen is the first to mention this word during our conversation. Yes, he gets that term thrown at him quite a bit – but it doesn't bother him. "I am a huge fan. But it does have to be hard science fiction, which is technologically substantiated. Don't start talking to me about something as superficial as *Star Wars*."

And he is being taken seriously – which is borne out by the fact that he was invited to speak at an ESA conference on interstellar space travel, which was held at ESTEC in Noordwijk last June. In October, he will also be presenting four articles on his research projects at the International Astronautical Congress in Washington DC.

But let's take a step back. Why should we leave our solar system in the first place? "For me, that's a logical next step when you look at human history. We've only had powered flight for a century or so. In the blink of an eye, we have built up emotional and psychological comfort in the atmosphere. And we are also seeing the development of space tourism. We are constantly expanding the human environment."

### ADAPTING ON THE FLY

Interstellar exploration is a totally different ball game compared to space travel as we know it today. Supplies can't be replenished from Earth. A gradual exploration, as in the case of the moon landing 50 years ago, is also not an option. It wasn't until the 11th Apollo mission that man set foot on the moon. All those previous missions served to optimise the system.

On a generation star ship, people have to adapt the spaceship with time. How? That's what Vermeulen is investigating with computer simulations.

"We are looking at how a spaceship develops under different conditions. We are assuming, for example, that a journey will last a hundred years. We take an asteroid with a specific chemical composition as a basis and map out a route through an environment with certain particle densities and radiation that can cause damage. We then determine how long it takes the ship to mine enough aluminium to create a new shield that can withstand unexpected radiation levels. Will the ship make it to the finish line, or will things go pear-shaped halfway through? And what would have happened if the circumstances along the way had been different?"

### MODELLING AN ECOSYSTEM

"We are also modelling the on-board ecosystem. Astronauts need a certain amount of food every day. They produce waste that is broken down by bacteria and converted into crops that in turn provide calories and oxygen."

Vermeulen and his colleagues are using different types of models. "We simulate biology through agent-based modelling. To extract raw materials and to print parts, we will use discrete event simulations, we will capture the impact of the interstellar medium with systems dynamics and we will use evolutionary algorithms for the evolutionary aspects. We are trying to combine these four techniques in one model. It's quite a daunting task."

<<

Photo: Sam Rentmeester, background: EAS 2018 concept rdstart, animation: Joris Putteneers

Dr Angelo Vermeulen: "We are looking at how a spaceship develops under different conditions."

**Surviving in space**
How do living cells react to weightlessness and radiation in space? Dr Ralph Lindeboom (CEG) is investigating that very question. A few years ago, he sent bacteria that could break down urine into space with a Russian mission. The micro-organisms orbited the earth for one and a half months. Upon their return, they were just as alive as before. The study revealed significant findings. According to Lindeboom, the bacteria he studied could be used to recycle water during missions into the remote universe.

**Extra-terrestrial structures**
If we're going to live on another planet or an asteroid, we really need robots that print 3D structures. Software company Dassault has invited the Robotic Building (Architecture) research group, led by Dr Henriette Bier, to participate in a design competition in this area. Bier supervises a group of twelve students who will spend a year studying the best structures to create on Mars, using the raw materials that are available locally and 3D printers. In the summer of 2020, when participants present their designs in Paris, we'll know what these buildings look like.

# The junkyard above your head

Leaving the atmosphere in a rocket is like playing a game of Russian roulette. If you're lucky, you'll make it through all the space debris in once piece, but there's an increasing risk of a fatal collision with a *hypervelocity* impact. Fortunately, we now have a code of conduct.

Every year, space agency ESA publishes an overview of space junk. By the end of 2017 there were 19,894 pieces of debris measuring 10 centimetres or more. Their total weight is 8,135 tons – more than the Eiffel Tower.
A series of incidents demonstrates this is beginning to take its toll. The examples just roll off Ron Noomen's tongue (Aerospace Engineering). In 2009, two satellites collided at 42,000 km/h. An hour later, the Iridium-33 and Kosmos satellites were reduced to two massive clouds of space debris. Collisions on satellites' solar panels are more the rule than the exception, and the Space Shuttle has also been hit – micrometeorites regularly left pits in the cockpit window.
"I think space debris is the number one problem for space technology," says Noomen. Launches, collisions and exploding batteries contribute to an exponentially increasing amount of debris surrounding the earth.
It is quite conceivable that a surge in collisions could create a layer of debris in a low Earth orbit that is virtually impenetrable, resulting in extremely high risks and, in theory, even having major implications for space travel. This worst-case scenario is known as the Kessler syndrome, named after NASA scientist Donald Kessler, who conceived it in 1978.

> 'It's a guideline for decent people'

How long objects continue to orbit the earth depends on their altitude. Up to an altitude of 800 kilometres, the atmosphere will have an effect; satellites and debris will slow down over the course of decades and eventually (largely) burn up in the atmosphere.


PHOTO: ESA

### RULES OF CONDUCT

Space junk has been put on the agenda of the European Union and the United Nations' Office for Outer Space Affairs. For example, rules of conduct stipulate that new satellites must be 'cleaned up' within 25 years after the end of the mission. In practice, this means that when a satellite is down to its last fuel reserves, it is sent to a low orbit, at maybe 200 kilometres, to slow down and burn up. Small satellites such as the cubesats often don't carry a motor, and should therefore only be released at a low altitude to prevent them becoming part of the floating junkyard.
"It's a guideline for decent people," reflects Noomen. "Sanctions aren't dished out to countries that fail to stick to it." He goes on to mention a Chinese stunt from 2007. With the rest of the world looking on in astonishment, the new space power pulverised its own satellite to demonstrate the advanced state of its space technology. But also just because it could. Last spring, India pulled the same stunt.
Nevertheless, Noomen expects the amount of space junk to keep increasing. Until now, it was only possible to detect pieces bigger than 10 centimetres. New technology has reduced this to three, and it makes us painfully aware of the fact that we humans leave our traces everywhere, even hundreds of kilometres above our heads. JW



# Ockels' legacy

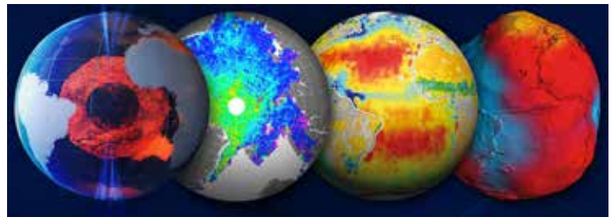
The famous astronaut and Delft professor Wubbo Ockels passed away five years ago. After his 1985 space mission, which made him realise how vulnerable Earth is, he launched many sustainable projects. What's left of that legacy today?

The solar car, solar boat, Superbus and ladder mill – these are just a few of the ideas that Ockels worked on at TU Delft.
Ockels' design for the ladder mill, an energy-generating kite, led to the Airborne Wind Energy network which, through European funding, employs 14 PhD students, as well as to an annual global conference and the start-up Kitepower, which is developing the future generation of wind energy systems.
For years he coached the Nuna team, which, thanks to his efforts, was able to build highly efficient solar panels into their cars. The Solar Boat Team also competed at the very top under his leadership. These student dream-teams are still successful today. The Nuna has won many world titles in Australia and South Africa. And the Solar Boat Team has high ambitions this summer: to be crowned world champions in Monaco – where they will race on the open sea – and to become the fastest solar boat ever to cross the Channel.
Joris Melkert, who worked with Ockels for many years, praises Ockels' positive influence on thinking about sustainability: "He stressed that sustainability means more rather than less if you approach it in a smart way. Ockels' greatest legacy is that he has trained a whole new generation of students who are spreading his knowledge around the world. He was at the forefront of a whole new kind of thinking, a new state of mind." DVG


PHOTO: SAM RENTMEESTER

# The battle for a place in space

TU Delft has provided two of the three proposals that are competing for the tenth Earth Explorer mission by ESA, which is planned for 2027-2028.



One of the proposals (G-CLASS) was submitted by Professor Ramon Hanssen, and the other (STEREOID) by Dr Paco Lopez-Dekker. They both work in the Satellite Radar Lab at the Faculty of Civil Engineering and Geosciences.
"It's a knock-out race," explains Hanssen. "Only one mission will be left standing."
The Earth Explorer missions focus on Earth observation, one of the key objectives of the European Space Agency (ESA). The proposals include measuring movements of the sea surface, glaciers and the Earth's surface, and being better able to forecast the level of precipitation during violent storms.
In the autumn of 2020, it will be announced which two proposals will go on to the next phase. "Then our part will be over," says Hanssen, "and industry will step in. We'll get involved again once the mission has been launched and data are available."

**Mission: G-CLASS**
**Researcher: Prof. Ramon Hanssen (CEG)**
**Purpose:** To continuously monitor a large area in Europe and Africa from a geosynchronous satellite (at an altitude of 36,000 km). Geosynchronous satellites take as long to orbit the Earth as it does for the Earth to rotate on its axis. The satellite emits pulses that reflect on the Earth's surface." This will enable meteorologists to forecast more accurately the level of precipitation in violent storms and how floods will develop. It will also enable landslides to be predicted in real-time.

**Mission: STEREOID**
**Researcher: Dr Paco Lopez-Dekker (CEG)**
**Purpose:** To measure small shifts in the ocean surface, in glaciers and the earth's surface. This will improve our understanding of small-scale ocean circulation patterns, glacial dynamics and their contribution to sea-level rises, and 3D modelling of deformations caused by earthquakes, volcanoes and landslides. STEREOID involves an existing satellite that transmits pulses. Two radar satellites fly in a low orbit (it takes 100 minutes to orbit Earth) in a variable formation in front of or behind existing Sentinel-1 satellites. KW

# 'Look down on Earth as though we were aliens'

There are planets revolving around most stars in the sky. Many of these so-called exoplanets are small and rocky, like our Earth. Dr Daphne Stam wants to use her instrument, Loupe, to gain new insight into the atmospheres and surfaces of these exo-Earths.

A milk carton. That's roughly the size of Loupe (Lunar Observatory for Unresolved Polarimetry of Earth). And thanks to its small size, it should be possible for the instrument to piggyback onto one of the many missions to the moon planned by space agencies and companies. At least that's what AE's Dr Daphne Stam is hoping for, anyway.


PHOTO: SAM RENTMEESTER

Dr Daphne Stam will observe the atmosphere and surface of the earth from the moon.

From the moon, the instrument will observe the atmosphere and surface of... the earth. Loupe will measure the sunlight reflected by the earth. "Indirectly, it will help us to better understand the properties of exoplanets," explains Stam. "From the moon you can see the whole Earth at once, in one shot. In the same way that large ground-based and space telescopes currently being designed will observe exoplanets. This would give us information about the colour and the polarisation state (vibration direction) of the earth's light, which we could use as reference material for future observations of exoplanets. We know the composition of the earth's atmosphere, the distribution of the oceans and continents, and the behaviour of the clouds. We'll look down on Earth as though we were aliens."

## Researchers can gather a lot of information from the polarisation state of the light

That's necessary, because we only pick up very little light from exoplanets. Scientists can use earth measurements to find out how they can optimise exoplanet measurements.
Researchers can gather a lot of information from the polarisation state of the light. It is very sensitive to the properties of a planetary atmosphere and surface. Water clouds, for example, emit a strong 'rainbow' signal under a very specific angle of reflection, and the polarization signal of surface water should, in turn, be strongly dependent on angles and colours.
Loupe was developed in collaboration with astronomers from Leiden University. Traditional instruments that measure polarisation use rotating discs with filters that each allow light to pass through with a different polarisation direction. But rotating parts should be avoided as much as possible in space travel, as they can easily jam. Leiden astronomers Frans Snik and Christoph Keller developed a new measuring technique based on static crystals that allow light to pass through in different ways each time, depending on the polarisation direction. As such, Loupe is small, robust and precise. TvD



# View

Dr Chris Verhoeven, theme leader of Space Robotics at the TU Delft Space Institute, is a man of many tales. What's his vision on space? Millions of years from now, electric animals will have colonised our solar system.

"People have no business being on the moon or on Mars. We're not built for that. Everything we know about space now, we know from space robots. The real heroes of space travel are the Pioneers, the Voyagers, Spirit, Opportunity. Robotics is Evolution 4.0.
Looking back 65 million years, we have the extinction of the dinosaurs. Looking forward 65 million years, our solar system will be populated by self-replicating electric creatures.
We humans will probably have ceased to exist, but we will have produced this electric animal species.
David Abbink (robot professor at TU Delft, ed.) and I came up with this paradigm about five years ago. We followed nature's example. Each type of robot is a step in evolution, each with its own application, just like animals. We might compare a pocket cube, a 10 x 5 x 5 cm nanosatellite, to a virus. These organisms are not self-contained satellites, but inside a larger body – such as the atmosphere of a planet – they can take reliable measurements. The slightly larger nanosatellites can live in swarms, which together can form large instruments, such as the Dutch Olfar project, a low-frequency radio-telescope in orbit around the moon. Another recent example is the Lunar Zebro, a small insect-like, 1.5-kilo robot that we want to send to the moon in 2022 with iSpace's Hakuto-R mission (see page 12). Large rovers like Curiosity on Mars are annoyingly slow movers, because they have to find their way on unknown terrain and cannot suffer any damage. Lunar Zebros can go ahead of these rovers to explore the route, because they are small and cheap and you can afford to miss a few from a swarm. After that, the larger rover can travel a lot faster with less risk. Zebros can search for water, explore caves for habitation and build a navigation system. Together they can also be the ultimate radio telescope on the moon. We might be able to use it to look back in time to the *big bang* and find exoplanets that produce radio signals pointing to a magnetic field that protects life.
But before we get that far, we want to test whether the main parts of the rover, the radio and the camera, can survive on the moon. We are currently designing and building this LEAP mission. We have to deliver the flight hardware to PTScientist by mid-2020 for the final tests in order to add it to their moon lander, which will land in 2021. It would make headlines across the world: first student project on the moon!
This is the result of a growing trend at TU Delft: the collaboration between the TU Delft Space Institute and the TU Delft Robotics Institute. Both work across faculties, offer good facilities and work together with highly motivated student teams." SB


PHOTO: SAM RENTMEESTER

# Online learning

TU Delft offers many online courses on subjects that matter and built on the strengths of our faculties. The online academy courses below are developed by the faculty of Aerospace Engineering.

## Design of Lightweight Structures I: Composites & Metals

This course is for practicing engineers and managers in industries and engineering disciplines who are involved in the design process of lightweight structures or components. It will also act as a valuable refresher course for experienced engineers.
Weight reduction is a key factor in the development of materials and components for use in many industries. Lightweight structures are widely used for this purpose. However, these structures present challenges: they need to be light but also safe, durable and easy to maintain. How can this be done?
This course provides an introduction to lightweight structures, starting with the "trinity" - the interaction between shape design, base material and manufacturing. The evidence gained from both successes and failures demonstrates that the interaction between these three elements is crucial for successful designs and end products. The course covers the design principles of lightweight structures; durability and fatigue; testing; manufacturing methods and mechanics. The main focus is on structures made with composites but use of metals will be addressed as well.

*Instructor: Otto Bergsma (Associate professor in Fatigue, Damage Tolerance and Durability, Faculty of Aerospace Engineering)*

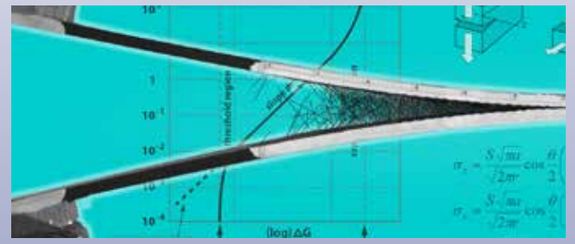
*Starts: 2 September 2019*

## Fatigue of Structures & Materials

For anyone working on development, design or strength justification of engineering structures this course will be invaluable. It will not only learn the methods and best practices, but also explain thoroughly the fundamentals that allow to assess the limits of current practices, and ways to overcome such limitations. In short, you will become a fatigue and damage tolerance specialist!
Fatigue fractures may occur as a consequence of cyclic loading structures. In particular within the context of fatigue and damage tolerance certification, engineers should have the knowledge and skills to analyse and assess fatigue life and fatigue performance. Fatigue fractures and related structural failures may be caused by a variety of factors, such as quality of applied materials, the production technology, the structural design, inappropriate reliability calculations, underestimations of load spectra, and inappropriate use of structures. With so many possible factors an integral and rigorous engineering approach is required.
This course will provide you with the knowledge and skills to identify potential critical locations and sources of poor fatigue performance; to develop strategies to avoid fatigue fractures and to improve fatigue performance of structures.
The course suits mainly aerospace engineers whose responsibilities include aircraft structures. However civil engineers, structural engineers, as well as engineers working in the manufacturing industry would benefit as well from high level review of fatigue life assessment and damage growth.

*Instructor: René Alderliesten (Associate professor in Fatigue, Damage Tolerance and Durability, Faculty of Aerospace Engineering)*

*Starts: 2 September 2019*



**Een volledig overzicht van alle online cursussen staat op: online-learning.tudelft.nl/alumni.**

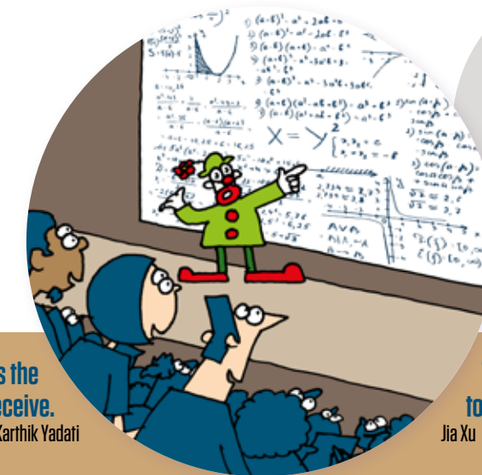


HORA EST

## Smartphones and social media have shaped a generation that is on the brink of a mental-health crisis.

Verena Balz, Diplom-Ingenieur Studiengang Architektur.

"This proposition is based on the observation of my 17-year old daughter, a representative of the generation Y. They have grown-up under a constant online presence. I've noticed that there is a delay in their becoming independent. At her age, I hitchhiked through Europe with my boyfriend. My daughter's generation is constantly looking at others, they are comparing their lives with the success stories and accomplishments of others. This leads to a fear of stepping out into the world and a crisis of self-esteem. In Germany, where I come from, people are much more concerned about their privacy. They are more prudent in their use of social media. Dutch people are more open to various forms of information technology, and yes, also a bit naïve to my taste."



**Humour during a scientific talk is the most efficient way for the speaker to destress and establish connection with the audience.**
Filip Rozpędek

**'Hard work always pays off' is the worst advice one can give or receive.**
Narashimha Karthik Yadati

**There is a fine line between tolerance and indifference.**
Jia Xu

**In a world of alternative facts, the scientific method cannot survive.**
Thomas William Sherson

**Unstanding is an illusion.**
Nick Lindemulder

**There is no place for beards in modern physics.**
Jeroen Theodoor Heldens

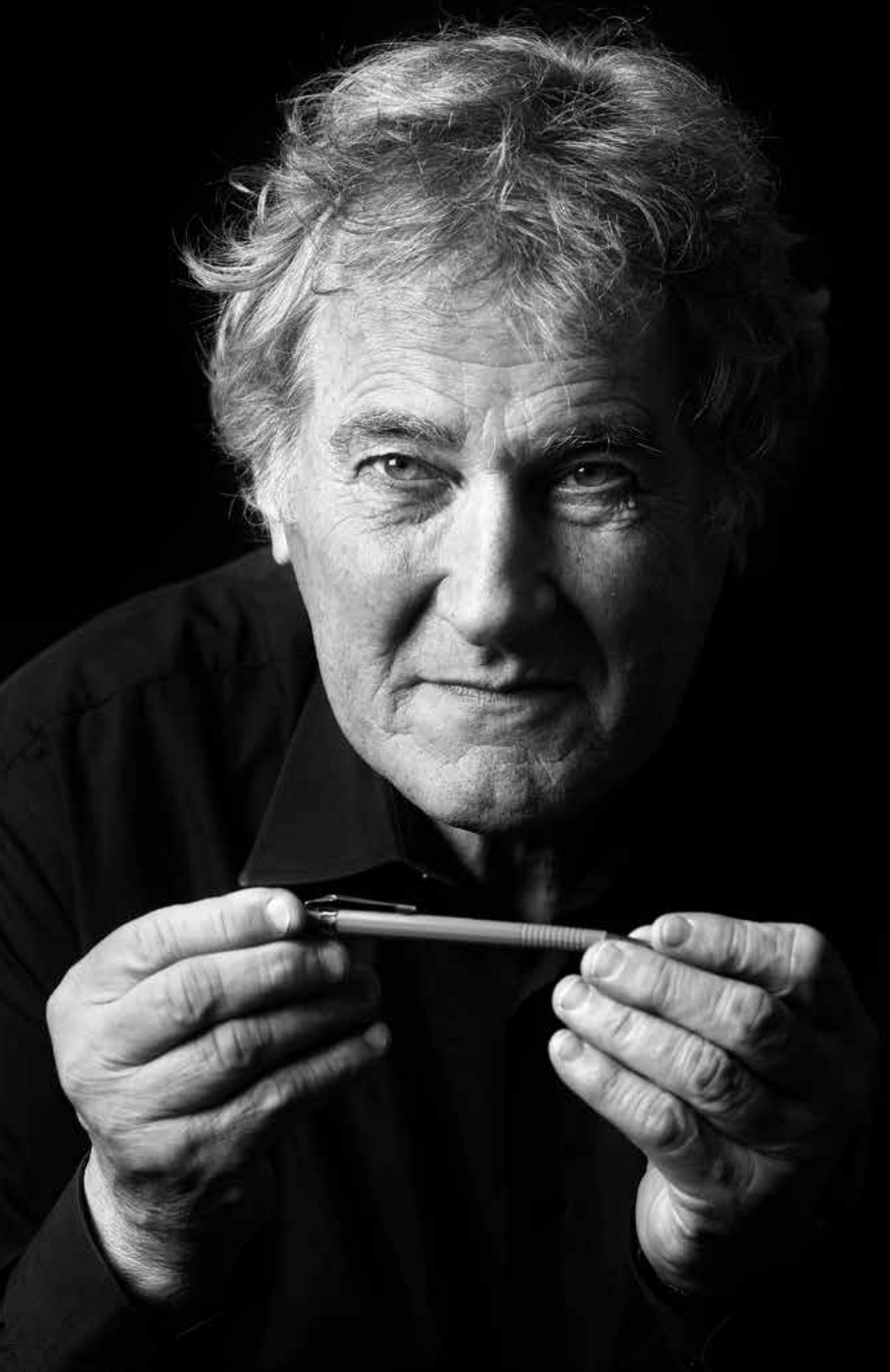
**Research is enjoyable up to the part where you have to write about it.**
Fiona Zakaria

**Public relations in academia is as important as doing good research.**
Victor Ernesto Vega Garita

**Computers are good at specialization, humans are good at generalization.**
Taygun Kekeç

**Uncertainty lies between knowledge and the unknown.**
Sergio Alberto Salinas Rodríguez

**Solving a problem is easier than recognizing a problem.**
Qu Hu



# ‘Why retire if you’re enjoying yourself?’

The president of Huisman maritime equipment, Joop Roodenburg, has been voted TU Delft Alumnus of the Year.

TEXT DESIREE HOVING PHOTO'S SAM RENTMEESTER

**CV**
Joop Roodenburg (1950) is president of Huisman in Schiedam. In 1971 he completed his studies Marine Equipment in mechanical engineering at the HTS and in 1977 he graduated in measurement and control technology at TU Delft. Huisman is a leading player in the design and construction of pipeline systems and is active in next-generation drilling systems, both on land and offshore. It is also working on renewables. In 2015, Roodenburg launched 'Buccaneer Delft', an accelerator for young technology companies in the energy and offshore sector. This way, he aspires to share his passion for innovation and his entrepreneurship with young and ambitious entrepreneurs. Since 2018, the complex has also been home to Kruydt restaurant.

**Congratulations on being voted Alumnus of the Year. Did it come as a surprise?**
"Yes. I'm a lot older than the seven alumni who have received the award in the past. But when I saw that I was to be added to the Walk of Fame, alongside a number of famous alumni such as Cornelis Lely (who devised the plan for the Zuiderzee works, ed.), I thought: I'm in good company."

**Lely was a techie who went into politics. If you were to become a minister tomorrow, what would you do first?**
"First of all, I think there are too few tech experts in the House of Representatives. As such, most politicians know very little about technology, they think it's scary and they have no idea what's going on in industry in this country. If I were a minister, I'd breathe new life into manufacturing. In the Netherlands, we should start producing intelligent structures again, such as the largest cranes in the world that we designed for Heerema. Unfortunately, we had to build those at Huisman China, because it's become just too expensive here."

**The construction of Huisman's 66-metre-high production hall in Schiedam was completed in 2012. Roodenburg shows me a photo in the book 'This is Huisman'. This won't be the only time he reaches for the book to show me what his company has made.**
"At the beginning of last year, we reorganised the company and put our production in the Netherlands more or less on hold. We've built many large structures in our hall, but now it stands empty. It's painful to watch the decline of our manufacturing industry. Politicians aren't doing enough to keep it going."

**Huisman mainly designs and builds equipment for the oil and gas industry, such as pipelines and drill systems, for generating offshore energy. How does that fit in with the theme of this year's Dies Natalis, Climate Action?**
"My company develops and builds equipment for extracting both fossil and non-fossil energy. In 2015, in collaboration with Tocardo, we built the world's largest commercial tidal power station, to produce energy in a sustainable way. This power station was installed in one of the gaps between the pillars on the Oosterschelde dam to generate electricity. The plan was to do this along the entire dam and then to export the system to other countries."

## 'There are too few tech experts in the House of Representatives'

**Was your plan to generate energy sustainably a success?**
"Not really. I wanted the feed-in tariff (a statutory rate for purchasing green electricity at generation costs, ed.) for selling the generated power to the grid. The wind industry received 16 to18 cents per kilowatt hour, and I thought the tidal industry was entitled to the same amount. I still remember that I was supposed to have a meeting with Henk Kamp, the then Minister of Economic Affairs, to talk about it. I was well prepared, but when I opened the door to the meeting room, I saw my whole family standing in front of me. Kamp said: 'We're going to do something a bit different today. You're going to get a medal!' People were filming my reaction; you can see the surprise on my face. In the end we only got 4.9 cents per kilowatt hour, the same as for grey energy. This feed-in tariff would make the tidal power station completely unprofitable, so I sold our shares for a symbolic amount."

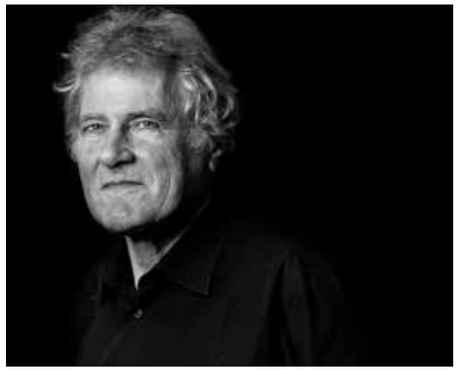
**Huisman is now working on another form of sustainable energy: geothermal energy. Is that more promising?**
"Politicians are keen to say that things are going well, but if you look at the figures it's plain to see that this isn't making much progress either. It's taking a long time for us to get the permits we need to drill the two holes. (With geothermal energy, hot water is pumped up from the ground to heat houses, greenhouses and industry. The cooled water then flows back down through the other hole, ed.). We've previously drilled wells in Bergschenhoek and The Hague, but at the moment the drilling installation is still in our factory because we've had to wait a long time for a permit to drill at Pijnacker. But once those wells have been drilled, you'll have geothermal energy for 20 to 30 years. The government needs to come up with a delta plan to issue those permits faster and to approve more projects."

**So, you do believe in a future with sustainable energy?**
"That could be part of the future. I share Shell 's vision, which predicts that our oil usage will peak in 2025 and gas usage will peak in 2030. That will be replaced by a combination of geothermal, solar, wind, nuclear and thorium-based (a safer alternative to uranium as a fuel for nuclear power stations, ed.) forms of energy. In the meantime, we will still need gas and oil. The development of renewable energy is also very slow. We are only generating 1/7th of the solar, geothermal and wind energy needed to cover the decrease in gas reserves from small fields. So we are actually doing far too little in terms of sustainable energy. Everyone says we should stop using gas. I think that's doable, but then we'll have to take action!"

**So what now?**
"The greatest energy savings can be achieved by working more efficiently. We are extracting oil and gas from the ground quicker and with fewer people. That's a quick win."

## 'So we are actually doing far too little in terms of sustainable energy'

**In 2013, you bought the old arsenal in Delft and converted it into the Buccaneer, where you support young companies developing technological innovations for the energy transition. Are you putting your hopes for a sustainable future on TU Delft students?**
"In a way, yes. The Buccaneer is home to fifteen companies engaged in the energy transition. I want to put them in touch with big companies in my world. We'll also involve TU Delft in this process. For example, I recently invited six deans to brainstorm current issues and to explore areas in which we could work together, such as topics for graduate research projects. Think about the development of non-corroding



plastic tubes – to be used in geothermal energy – or a fundamentally different way of installing wind turbines by assembling them onshore and transporting them in their entirety on a special vessel."

**You are 69 years old. Are you ever going to retire?**
"Actually, I should have retired a long time ago, but I don't intend to anymore. Why retire if you're still enjoying yourself?"

**What's your biggest dream?**
"My dream has always been to develop and produce great machines and systems. For example, in 1986, when the price of oil was only ten dollars, we built an earthquake simulator for an amusement park. We even bought the roller coaster manufacturer Vekoma Rides, which we sold very recently. We also built two sky shuttles for cruise ships. That's just a lot of fun. My dream is to be innovative in different areas. Whether I build theme park rides or drilling systems, it makes no difference to me." <<

TEXT: CONNIE VAN UFFELEN PHOTOS: SAM RENTMEESTER

# 'The material side of design is at risk of disappearing'

The Faculty of Industrial Design Engineering, which is celebrating its 50th anniversary this year, has two new 'home-grown' female professors. Prof. Conny Bakker and Prof. Ruth Mugge both focus on the concept of much-needed sustainability in design.

**The Faculty is proud of the fact that, for the very first time, two professors have been appointed who have completed their entire university education at IDE. What does that mean to you?**

Conny Bakker: "We're proud, too."
Ruth Mugge: "Industrial Design Engineering is multidisciplinary, which is why there are a lot of professors here from other disciplines. It's good that you can offer your own students that chance too. And we are role models for female students."

**Do you see yourself as role models?**

Bakker: "Absolutely! We now have slightly more female students than male students. That would usually be reflected in the academic staff body. Now we have a chance to balance that out a bit. Women also need to be able to see that a career in academia – not just in the professional world – is also an option."

**Did you miss having role models when you were students?**

Bakker: "I started in 1983 and graduated in 1989, and we had one female professor: Gerda Smets, for design. That was unusual at the time, but I didn't think about it much. Gerda Smets was actually Belgian. It's interesting that the first wave of female professors here came from abroad."
Mugge: "I started in 1995 and graduated in 2001. The name Gerda Smets rings a bell, but I don't think she taught me. I think I did miss having a role model, yes. It's much harder for women to break through the glass ceiling."

**And now the Faculty sees you as guides on its path towards sustainable design. What can you tell us about your specific field of research?**

Bakker: "My research focuses on design methods for sustainable design. Since 1992, the world has become more complex and the environmental problem more urgent. For example, how can you assess the environmental impact of a smartphone? There's a whole infrastructure behind it, from satellites to data centres and mobile Wi-Fi networks. Blockchain and the internet of things are making things even more complex. Technologies can help to make product flows and systems more sustainable, but they also have a huge footprint. Is using those technologies worth it, then? We don't have answers to that question yet."
Mugge: "I focus on consumer behaviour, from a sustainable perspective. What do consumers think about certain products and how do they behave? How can you ensure that consumers welcome circular products, such as refurbished phones?

Professor Ruth Mugge: "I focus on consumer behaviour, from a sustainable perspective."



Professor Conny Bakker: "how can you assess the environmental impact of a smartphone?"

When it comes to antiques, people love the fact that they are old. We look at the perception, the product and how people behave when they have a product. How can you convince them to keep their phones longer? How can you help the designer influence sustainable consumer behaviour?"

**How can you do that?**

Mugge: "By adding a story to a product. One of our graduates developed a lamp that was painted entirely black. The idea was to scratch your child's height in it as it grew. Each year you could use the lamp to see how much your child had grown. The lamp then becomes special, unique and irreplaceable. Then you're more likely to repair it than throw it away. You can achieve that through the design."

**What message did you want to share with the audience at your joint inaugural address on 10 May?**

Bakker: "I outlined six changes to visions I've identified in the field over the last few decades. I wanted to explain how they will affect the development of methods."

**What changes are those?**

Bakker: "One is called limits. It was thought that producing more efficiently would lead to both economic growth and environmental benefits. We now know that's not possible. So we need to think about limits to growth and about alternative forms of growth and what that means for your methods. I called the second one radical change. For a long time, it was believed that we could only achieve major changes by taking small steps. In many cases this is true, but it's time we thought about more radical changes that are desperately needed due to the urgency of the situation. I want to show thaat designers have a part to play in presenting radical but exciting visions of the future.

> 'How can you help the designer influence sustainable consumer behaviour?'

A third change is called confronting consumption, which touches on Ruth's work. There has long been a tendency to pass the environmental problem on to individual consumers, although they are often trapped inside a system. For example, after creating a cheap-flight infrastructure we tell them 'you have to fly less'. If we don't tackle these infrastructures, it will be very difficult for individuals to change their behaviour.
I also wanted to talk about circular design. We need to think about what happens to a product when it is no longer used. How to give it a second or third life. You have to make strategic decisions about this from day one.
I also talked about time in design. I am all for extending the design process. Designers should monitor products over time rather than say goodbye to them once they're off the drawing board.
The last change is that, with the rise of the internet of things and blockchain, the world is dematerialising. A classic example is that no one has an answering machine anymore. A smartphone is essentially the equivalent of a room full of computers. The material side of the design is at risk of disappearing. That's reflected in the current overhaul of the Bachelor's degree programme."

**During the inauguration address, Ruth Mugge focused on 'sustainable consumer behaviour'. That sounds like a contradiction in terms.**

Mugge: "As soon as you start consuming, materials and energy are always involved, but you can design the product in such a way that you need as little as possible. Using materials optimally, giving the product three lives and then recycling it, will move us towards sustainable consumption.
I focus on different types of consumer behaviour. One example is choosing alternatives. You can also use plastic from the ocean to make packaging for detergent. It's black, whereas transparent packaging just feels cleaner. So you have to change that perception through the design.
There are also alternative ways of consumption, such as paying per wash: get a washing machine for free and then pay per wash – cold washes are even cheaper. This is how you can encourage people to change behaviour. To do that, you need to offer people extra benefits while making it easier for them." <<

# After Delft

During his time as a civil engineering student, structural engineer Koen van Doremaele developed a taste not only for travelling, but also for writing.

Bridges and books. Mention those words and Koen van Doremaele starts to smile from ear to ear. Take the Botlek Bridge, for example, which had so many structural problems during its construction. Problems that, as a structural engineer at Ballast Nedam, Van Doremaele helped to solve. That was what he calls 'a really cool project'.
He waxes lyrical about the bridge that most likely frustrated many drivers: "The foundations are 20 metres under water and comparable to those laid for a block of flats. And we had sixty-metre-high towers with gearboxes on top and a bridge deck the size of a football field."
When he was at school he considered a career in the army or in sports, yet he decided to study technology. His goal: to design something tangible that can be used for decades. On an information day, he was told that if he didn't like civil engineering, he could always switch to architecture. But he actually liked it.
After a year in the Delftsche Studenten Bond, he joined the Punch basketball association, of which he eventually became president. He wrote many articles for the club magazine. "About both serious stories and rumours, that went down well," he comments.
After six months, he went abroad. He caught the travel bug during a student project in Tanzania. After graduating in 2009 – his project was about metal fatigue in bridge plates – he spent a month relaxing in Costa Rica and Panama before joining Ballast Nedam. His job took him to the Philippines for six months, where he helped a contractor with a power plant.
After 7.5 years he started working for construction firm BAM, for which company he built five wind turbine foundations in Newcastle, England. And he's been to Antarctica several times to dismantle and rebuild a quay wall.
During his travels, he kept a travel blog. He even won a prize for an article about a trek to Machu Picchu. "People suggested I should do something with my writing talent, and write a book. So, one day a week, I would write three pages an hour." And that's how his self-published comedy thriller *Nonius* came into being, about a boy from the polder who wants to conquer an island.
In his second book, *Het Sapri Schandaal (The Scandal of Sapri)*, published in 2018, he incorporated elements from his first book that he believed needed improvement. Sapri is a village south of Naples. Van Doremaele went there on holiday with friends and got an idea for the plot sitting on a café terrace. The story is about a bridge (surprise!) and the mafia sabotaging a construction site. CVD

Name: Koen van Doremaele
Place of residence: 's Hertogenbosch
Civil status: Single
Programme: Civil Engineering
Student association: One year in Delftsche Studenten Bond, six years in Punch Basketball



# THE FIRM

They got the idea to brew their own beer sitting in a pub. That was ten years ago, and meanwhile Frank and Lei van der Linden have their own brewery. Their advice? "Never forget your drunken ideas."

At the time, they were students in Delft. She was studying science communication, he did industrial design engineering. One of them was more into beer than the other. "I was discovering beer in any way I could," Frank quips. She, on the other hand, wasn't the partying type. "I was the stereotypical Asian girl. I never drank beer when I was a student."
"It started off as a wild idea: let's make our own beer!" says Lei. They didn't know the first thing about brewing beer. "But these days, you can learn anything online. That's a skill you can be proud of as a TU student."

## 'It keeps you busy all the time'

Jeroen Canton, chief designer at Frankendael Brewery, is the third member of the founding trio. He studied industrial design engineering at TU Delft and is responsible for the art work. "He designs the labels," says Frank. "They are in a pop-art style: striking, but also a bit nerdy. We're still TU graduates, after all."
Microbreweries are popping up everywhere these days. "It's a hype, not only in the Netherlands, but all over the whole world," says Frank. The initial costs are low, which makes it popular for start-ups. "You can get started with €5,000 of start-up capital," he explains. There are now about 600 breweries in the Netherlands. "When we started, there were only about 300. We were among the early adopters."
The couple's advice to students who are considering becoming entrepreneurs is: don't hesitate. Frank: "Just have a go at it. Don't underestimate the ideas you scribble on a beer mat when you're drunk, because they can be the best ones. And remember, most startups fail. But you don't hear about those, because people prefer to share only success stories."
International students also shouldn't be afraid to start their own company, says Lei. "The perception is that Asian students only spend their time studying at the University Library, they never go out and then they leave the country as soon as they graduate. But I see lots of international students forging careers here."
Are there any misunderstandings about entrepreneurship? "It's much harder than I ever expected," he says. "It's a 24-hour job," she agrees. "It keeps you busy all the time. I often lie in bed at night thinking about things that we still have to do."
They are both addicted to entrepreneurship. Frank: "I get new ideas every day." In the coming years, they hope to be able to expand their brewery internationally. "We're currently exploring opportunities in China," he says. MvP

Company: Frankendael
Name: Frank and Lei van der Linden
Programmes: Industrial Design Engineering (Frank) and Science Communication (Lei)
Product: Specialty beers
Employees: Four employees, including the two founders
Turnover: €200,000 in 2018
In five years' time: One of the most popular specialty beer brands in the Netherlands and worldwide.

Photo: Sam Rentmeester

# Phage Library wants to clarify bateriophage effects

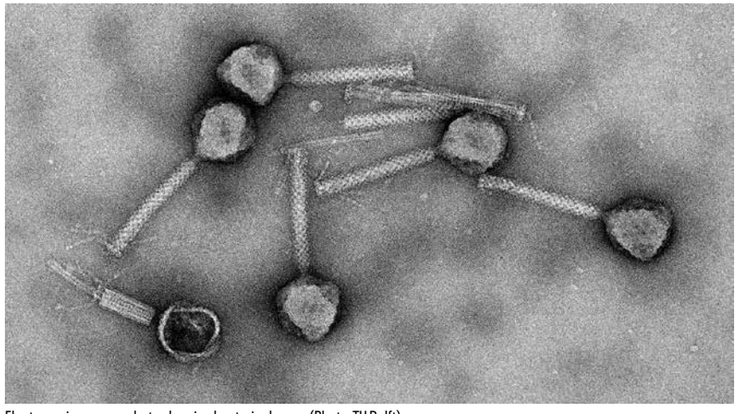
Bacterial infections are becoming increasingly resistant to antibiotics. Bateriophages could offer an alternative. TU Delft Phage Library makes an inventory.

Read further on page 32

TEXT: JOS WASSINK PHOTO: SAM RENTMEESTER



The TU Delft Phage Library (Fagenbank) will be opened during the Medical Delta Conference, the annual gathering on medical technology, on 16 April 2019. The Phage Library is an initiative of microbiologist Dr Stan Brouns (Faculty of Applied Sciences). He is working on developing bacteriophages as an alternative to antibiotics.
In Europe, 33,000 people die every year from infections of resistant bacteria. Experts believe that by 2050, worldwide 10 million people will die from bacterial infections every year. So, alternative ways to treat bacterial infections are urgently needed. But how effective are these bacteriophages? And what are the side effects?


Electron microscope photo showing bacteriophages. (Photo: TU Delft)

## WHAT ARE BACTERIOPHAGES

Bacteriophages are viruses that attack and kill bacteria. Put yourself in the micro-world for a moment. All around you hover bacteria no more than 1-3 micrometres across. Among them swim bazooka shaped structures that grope for prey. These are bacteriophages that have been bacteria's natural companions for billions of years. They have evolved together. Generation after generation they have trumped each other's defences.
So when a bacteriophage recognises a suitable host, the bazooka's barrel will lock onto the bacterium's membrane. This action triggers a mechanism that forcefully releases the genetic content of the phage's head into the bacterium. The bazooka ejects its load. A phage may only be one 10th of the dimension of its host, but it is sublimely suited for its sole purpose in life: getting a bacterium to make as many copies of itself – the phage – as possible.
"These are the ultimate nano machines," says Brouns during the interview in the spectral coloured AS building. "These machines are dozens to hundreds of times more sophisticated than the current state of our nanotechnology."
And yet, these sophisticated nano machines have very humble origins. They mainly come from bowels, sewers and waste water treatment plants. It's funny to think that the frozen and carefully labelled collection at the clinical white Phage Library has such pungent origins.

## CHICKEN TYPHOID

About 100 years ago, the English bacteriologist Frederick Twort and the French-Canadian Felix d'Hérelle discovered the anti-bacterial effect of certain substances. They observed the effect of an 'invisible antagonistic microbe from the dysentery bacillus'. In early 1919, d'Hérelle isolated bacteriophages from a filtrate of chicken shit. And he successfully applied it to cure chicken typhoid. His success bolstered his confidence to such an extent that he decided to release bacteriophages on humans as well. In August 1919, he used phages to cure the first patient of dysentery, and many more cured patients followed.

## BACTERIOPHAGE: THAT WHICH EATS BACTERIA

Although no one at that time knew what a bacteriophage was (literally: that which eats bacteria), d'Hérelle was not far off with his description of 'a biological organism that preys on bacteria'. In fact, he would be excited to see the electron microscope photos of phages as specialised nano machines hunting bacteria.
D'Hérelle acquired fame all over Europe. He was awarded an Honorary Doctorate from Leiden University in 1924, and a Van Leeuwenhoek medal from the Royal Dutch Academy of Sciences (KNAW). Despite this display of honours, bacteriophages were largely forgotten in Western Europe after the Second World War and the introduction of antibiotics.
But on the other side of the Iron Curtain, in Poland and Georgia especially, bacteriophages were cultured for medical applications. The world famous Phage Therapy Centre in Tblisi, which d'Hérelle himself visited, has been bought by an American company.

## ESTABLISH WHAT WORKS

The story of bacteriophages has meandered between hope and fear, promise and scepticism, but lately, curiosity seems to be taking over. "We want to overcome doctor's suspicions," says Brouns about his Phage Library. "We want to establish what works and what does not. And what the risks are."
"We are working on a collection of phages against the 15 most resistant bacteria," says Brouns. That means culturing phages in bacterial colonies and filtering the phages from the solution. The phages are kept in small vials in the freezer, each and every lid neatly marked with a unique code.

> 'These are the ultimate nano machines'

The effectiveness of phages against bacterial growth is recorded in a matrix of phages versus bacteria. Green means the phages win (and kill the bacteria), yellow indicate a reduction in growth, or white if there is no discernible effect. Thus, the team systematically builds up knowledge of which phage is effective against which bacteria.
The craftmanship from the early days of phage therapy has been replaced by genetic analyses, systematic screenings and databases. Microbiology has become an exact science.
Besides the fundamental screening work, the Fagenbank is in contact with medical staff from the UMC Utrecht who has applied for a clinical trial. They're looking for an alternative therapy for pneumonia in patients with cystic fibrosis. Repeated antibiotic therapies in this patient group means that bacterial resistance is a common occurrence. The proposed clinical test will apply a mix of bateriophages that has shown positive against the pneumonia bacillus *Pseudomonas aeruginosa*. Microbiologist Brouns expects the best results from sampling individuals. This implies taking a sample of the infection and determining the bacteria from its DNA. Once that's known, the database can come up with matching bacteriophages. These will be fetched from the freezer, multiplied and applied to the patient.
However, such a targeted approach is at odds with the principle of the double-blind clinical test where all patients, except those receiving placebos, receive the same medication. Instead, this clinical test will see a broad selection of phages that have shown activity against Pseudomonas. <<

The Fagenbank is a particular initiative that relies on donations for funding. A starting subsidy of EUR 144,000 from the Delft University Fund got the collection started. It allowed Brouns to hire an analyst for 2.5 years. For further research, Brouns is on the outlook for additional funding.

**fagenbank.nl**

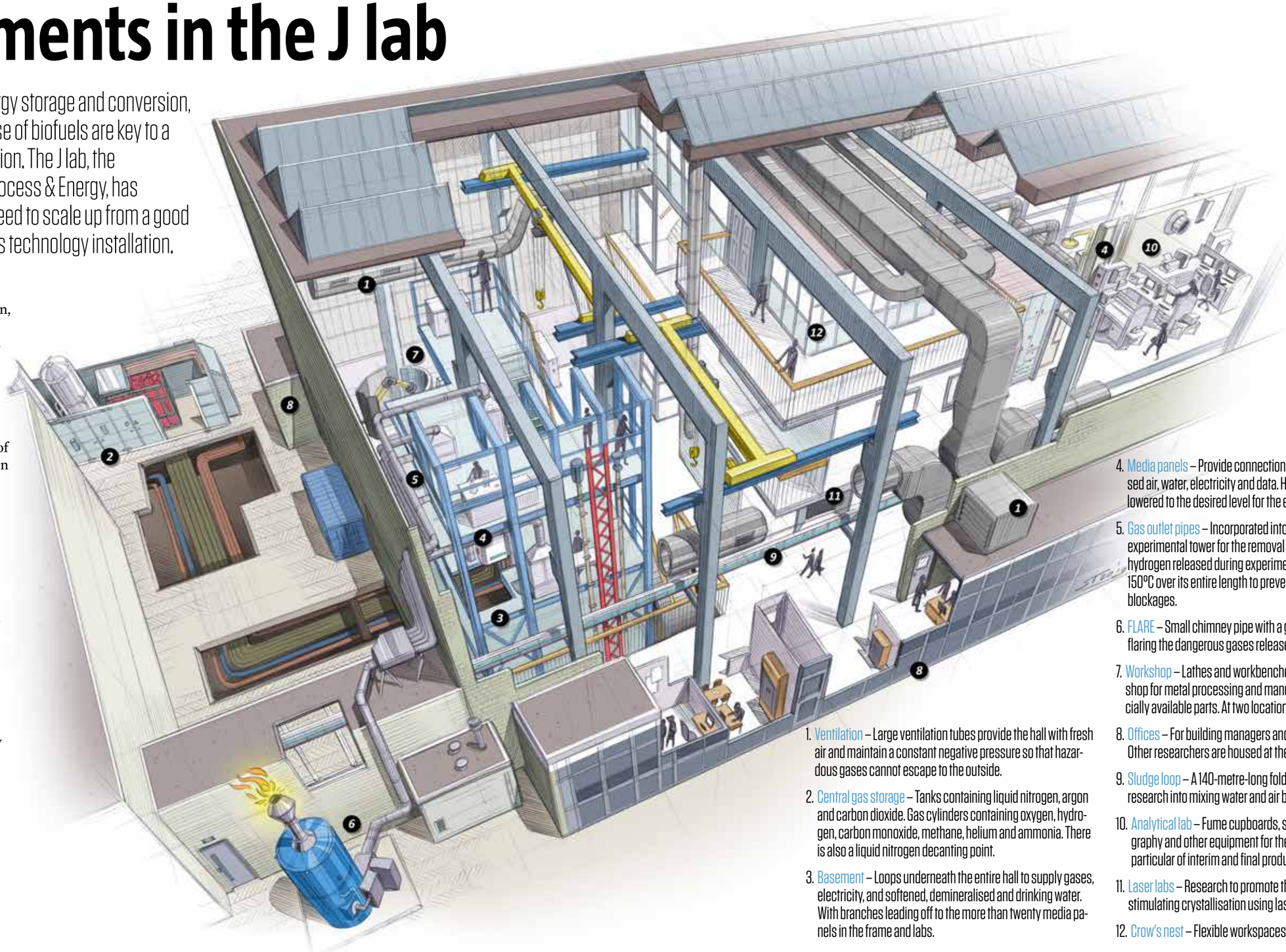
TEXT: MARTIJN ENGELSMAN ILLUSTRATION: STEPHAN TIMMERS



# Experiments in the J lab

Fuel cell innovations, energy storage and conversion, and the production and use of biofuels are key to a successful energy transition. The J lab, the experimentation hall at Process & Energy, has everything researchers need to scale up from a good idea to a full-sized process technology installation.

A prominent blue steel construction, which users call 'the frame', takes up almost half of the hall and provides 300m² of space for experimental installations that are too big for the lab and not yet mature enough for a pilot plant. Most of the other half of the hall is given over to lab areas that support these scaled-up experiments. Small-scale research work is also carried out here.
The interfaculty Negative Emissions Programme, which focuses on the removal of greenhouse gases from the atmosphere and on large-scale energy storage, is conducting lots of experiments in the hall. There is also a wide variety of installations – from research into generating energy from temperature variations in the ocean, to generating electricity by gasifying human waste into plasma.



1. Ventilation – Large ventilation tubes provide the hall with fresh air and maintain a constant negative pressure so that hazardous gases cannot escape to the outside.
2. Central gas storage – Tanks containing liquid nitrogen, argon and carbon dioxide. Gas cylinders containing oxygen, hydrogen, carbon monoxide, methane, helium and ammonia. There is also a liquid nitrogen decanting point.
3. Basement – Loops underneath the entire hall to supply gases, electricity, and softened, demineralised and drinking water. With branches leading off to the more than twenty media panels in the frame and labs.
4. Media panels – Provide connection points for gases, compressed air, water, electricity and data. Here the gas pressure is lowered to the desired level for the experiment.
5. Gas outlet pipes – Incorporated into the structure of the experimental tower for the removal of carbon monoxide and hydrogen released during experiments. Electrically heated to 150°C over its entire length to prevent tar deposits, and thus blockages.
6. FLARE – Small chimney pipe with a gas flame at the bottom for flaring the dangerous gases released. Only used if necessary.
7. Workshop – Lathes and workbenches, cutters and a welding shop for metal processing and manufacturing non-commercially available parts. At two locations in the hall.
8. Offices – For building managers and principal investigators. Other researchers are housed at the 3mE Faculty.
9. Sludge loop – A 140-metre-long folded horizontal tube for research into mixing water and air bubbles.
10. Analytical lab – Fume cupboards, spectrometry, chromatography and other equipment for the analysis of samples (in particular of interim and final products of large installations).
11. Laser labs – Research to promote the deposit of salts by stimulating crystallisation using laser light.
12. Crow's nest – Flexible workspaces for (Master's) students.

# IN PERSON

Professor **Pieternel Levelt** and her team have received the prestigious American Pecora award from Nasa. The team received the prize for their performance in the field of earth observation. They built the Ozone Monitoring Instrument OMI, which has been measuring atmospheric ozone and other gases in the atmosphere since 2004 worldwide. In October 2017, they sent the Tropomi instrument into space, which maps greenhouse gases with unprecedented precision at an altitude of 800 kilometers.

Solar energy expert professor **Arno Smets** is one of the first mission innovation champions, a new initiative to honor pioneers in clean energy. He received the title because of the impact of his education and research in the field of energy transition. The prize was awarded by a coalition of countries that agreed at the Paris Climate Summit to accelerate their energy innovation efforts.

Professor **Ronald Hanson**, scientific director of Qutech, has received the Spinoza Prize from research fund NWO. This prize is the largest scientific prize in the Netherlands. There is a sum of money of 2.5 million euros attached to it. Hanson is working on controlling the quantum mechanics of particles and applications such as the quantum computer and quantum internet. "There is, I think, a life before and after the Spinoza Prize," he responded in Delta.

Professor **Jack Pronk** also received a prestigious prize from NWO: the Stevin Prize. He receives a sum of money of 2.5 million euros due to the major social and economic impact of his research. Pronk tries to understand how micro-organisms function in industrial processes, for example when making biofuels or bioplastics. "We can trace a few wildly exciting things... but it is still too early to reveal them now," he says about his current research.

Dr.ir. **Maja Rudinac**, creator and developer of care robot Lea, has been chosen as Engineer of the Year. She led the interactive robotics group at TU Delft Robotics Institute and launched the Robot Care Systems startup. Lea is an intelligent walker who helps get up and walk and also stimulates exercise, facilitates social contact and sends reminders for appointments and medication intake.

# Two winners for Marina van Damme Grant

Not one, but two female TU Delft alumni won this year's Marina van Damme Grant. Andrea Mangel Raventos and Hanneke Stenfert were both awarded EUR 9,000 each.

TEXT: MARJOLEIN VAN DER VELDT PHOTO: SAM RENTMEESTER

A unique situation presented itself when the jury of the Marina van Damme Grant, an event organised by the TU Delft University Fund, was unable to select a winner. Or as Marina van Damme herself put it, "Andrea Mangel Raventos and Hanneke Stenfert are so different, but at the same time equally good considering their future plans."

**FIRST OF ALL, CONGRATULATIONS TO THE BOTH OF YOU. DID YOU EXPECT THE DAY TO TURN OUT LIKE THIS?**

Mangel Raventos: "I came in with low expectations and tried not to get too excited about it."
Stenfert: "For me, it actually felt really good. Andrea is a very good candidate, so I had no expectations."

**HANNEKE, ONE OF THE KEY POINTS IN YOUR PLAN IS TO CONDUCT THREE INTERNATIONAL CASE STUDIES ON CO-CREATION. CAN YOU ELABORATE ON THAT?**

Stenfert: "I work as an architect for my own company, Open Kaart, with a focus on and fascination for co-creation. I have gained a lot of experience working on projects since 2014. Co-creation is not widespread in urban development and architecture. I would like to contribute to the co-creative discipline. That's why I applied for this grant; it gives me the opportunity to take time to research some international case studies."



Andrea Mangel Raventos (left) and Hanneke Stenfert.

**WHAT PLACES ARE YOU HOPING TO VISIT?**

Stenfert: "I still have to define that, but Chile is on top of my list. There's a really inspiring company there which has been experimenting for years. I know a lot of other interesting projects as well, but I first need to design the case study."

**ANDREA, YOU'RE CURRENTLY A PHD STUDENT AT THE FACULTY OF 3ME, WHAT ARE YOU GOING TO SPEND THE GRANT ON?**

Mangel Raventos: "Besides my research on bridging the gap between how we are going to produce energy in the future and how we are going to consume it, I'm also very interested in developing certain soft skills such as leadership and communication. Universities don't really teach these skills, but they are becoming increasingly important. Subsequently, I found the Homeward Bound Project. It's a programme that teaches these soft skills, but is also committed to getting more women into leadership positions. The yearlong programme will teach me multiple soft skills and concludes with a three-week expedition to Antarctica."

**WHAT ARE YOUR SHORT- AND LONG-TERM GOALS?**

Mangel Raventos: "First of all, I want to finish my PhD. And with the skills I've learned, I hope to find the direction I want my career to take. Right now, I'm leaning towards science communication with a focus on the urgency to take climate action. My long-term goal is to work at breaking down the barriers women face to get into leadership positions."

**AND FOR YOU, HANNEKE?**

Stenfert: "My short-term goals are to visit three co-creative projects and to analyse and write about them. In the long term, I want to keep working on co-creation at the intersection of theory and practice. I hope to develop expertise with impact and try to contribute to the discipline." <<

**Marina van Damme Grant**

The Marina van Damme Grant is awarded each year to talented female alumni from Delft University of Technology, Eindhoven University of Technology, the University of Twente or Wageningen University. It consists of a grant of €9000 and an award. This grant is made possible thanks to Dr. Marina van Damme. She obtained her Master's degree at TU Delft in 1953 and was the first female student to obtain her PhD at the former Technical University College Twente in 1965.

# What impact will quantum have?

Delft is a pioneer in the field of quantum technology. At QuTech, TU Delft and TNO have joined forces to work on quantum computers and the quantum internet. As well as opening doors for the Dutch business community, it raises many questions.

TEXT: AGAATH DIEMEL PHOTO: SAM RENTMEESTER

How will the arrival of quantum technology affect industry and society? A team of Delft researchers has spent the last few months trying to answer this question. Pieter Vermaas and Deborah Nas were two of the leaders of this TU Delft Quantum Vision Team. Expectations are high for quantum technology: soon we will be able to develop materials and medication on a molecular level and unlock secrets of the universe with super telescopes, and we will have an unhackable internet. At least, that's the idea. But much of this is still conjecture. "It's not dissimilar to the arrival of laser, which was developed in university labs in the 1950s and 1960s," says Pieter Vermaas, associate professor of ethics and philosophy. "It wasn't until decades later that our lives changed dramatically with applications such as CD players, laser surgery and laser printers. We expect that quantum technology will also have a major impact on industry and society, but, as in those days, we don't know exactly how and when. What we do know is that completely new technologies like this can have unexpected, and perhaps even undesirable, consequences. It's also our responsibility as scientists to reflect on that."

The Quantum Vision team's exploratory work is a first step towards investigating the impact of quantum technology. "Quantum is still in the research phase. We can only make a realistic impact assessment once we have an idea of the applications," says Deborah Nas, alumna and professor of strategic design for technology-based innovation. "Many of those applications have yet to be discovered. We have been working with the Vision team to identify possibilities, but we also see potential for our alumni to play a key role here. We hope that they will put the subject on the agenda within their own organisations and think about how they could use quantum technology."

## Q CAMPUS

Collaboration with businesses is vital for the development of quantum technology. "Innovation is much more likely to succeed if you involve the government and the business community at an early stage," says Nas. "In Delft, we are building a quantum ecosystem, a Q campus, where we can work together." Such an innovation ecosystem centres around researchers and laboratories, but also includes start-up facilities and links to investors and industry. QuTech, a quantum institute where people from TNO and TU Delft collaborate with Microsoft and Intel, among others, plays a central role on the Q campus. One of the subjects that QuTech focuses on is the quantum internet, which is set to be the first working application of quantum technology. "Building quantum computers with enough qubits to outperform traditional computers is still a long way off, but a quantum internet can already function on the basis of hardware with a few qubits," says Nas.

> 'People like to think in hype or doom scenarios'

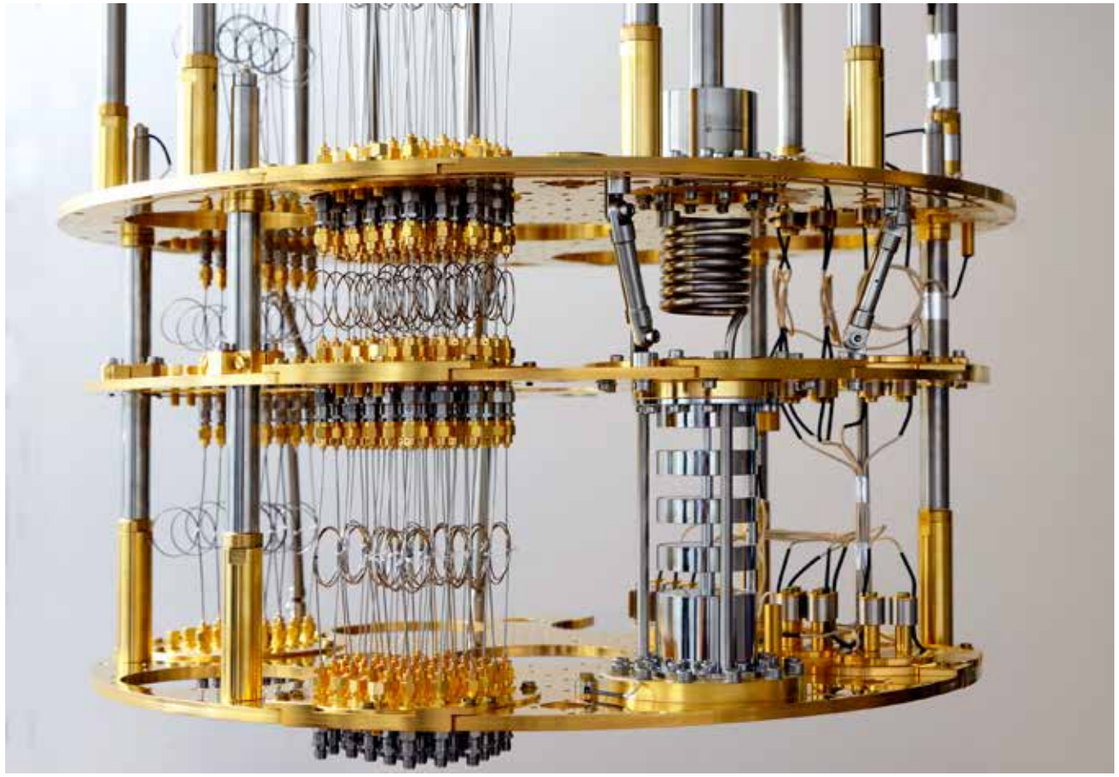
## VALUES

In order to steer the development of quantum technology in the right direction for society, you also need to involve society in the Delft quantum ecosystem. This then leads to socially responsible innovation. As such, in addition to applications such as the quantum internet, the Vision team also looked at governance: "In its current form, the internet complies with all kinds of standards and values that are important to us as a society, such as security, privacy, free access and net neutrality. To safeguard this, over the years we have developed regulations and control mechanisms. We'll have to do that again when developing a quantum internet," says Vermaas. However, our tendency to talk about new technology in extremes is complicating the public debate on this theme. "Look at robotics and artificial intelligence: it is either applauded or reviled. People like to think in hype or doom scenarios. The same thing is happening with quantum technology," says Vermaas. "The fear is that quantum computers will soon be able to decode all our encryption methods, disrupt our financial systems and thus plunge society into chaos."

## EVOLUTION, NOT REVOLUTION

By also thinking about the doomsday scenarios, we can take action early on and thus prevent extreme situations. The discussions that the Vision team had with banks and ministries showed that many agencies are already working on this. Quantum computers may indeed pose a risk to our current cybersecurity systems. "Something that quantum computers will be very good at is factoring very large numbers into their prime factors. Traditional computers can't do this, and that is precisely what a lot of encryption is based on, which we use to secure digital signatures and communications over the internet, among other things. So that's something that a lot of organisations will have to prepare for," says Nas. Fortunately, there's still plenty of time. "From a technological point of view, quantum technology really is revolutionary, but quantum computers are not likely to appear overnight. So, we still have time to adapt." <<





QuTech has introduced the first Dutch simulator of a quantum computer.

**Want to know more?**
**The Quantum Vision team has published its findings in a magazine. "We hope that if offers an accessible introduction to quantum technology and its impact, while stimulating further discussion and collaboration on the subject."**

**You can read the Quantum Vision magazine online at: https://qutech.nl/quantum-internet-magazine**

# ‘Our students are going to be alright’

Arnold de Jager still feels close to the current generation of students, but he is also an experienced businessman and entrepreneur. In other words, he is the ideal alumnus to participate in the mentor programme of the faculty of Aerospace Engineering (AE). “I would have liked to have had a mentor myself when I was studying,” he says.

TEXT: AGAATH DIEMEL PHOTO: GUUS SCHOONEWILLE

Arnold de Jager knows exactly what he wants. Okay, most of the time; he actually chose the wrong career when he first started studying. “I was always interested in airplanes and thought I wanted to be a pilot. But after I joined the Air Force, I found out that I was more interested in discovering how an airplane worked than flying it.” So De Jager switched to Aerospace Engineering. “That was the perfect choice; I was totally in my element.” Being a “systems thinker”, he specialised in Systems Engineering & Aircraft Design, but graduated at a foundation that focussed on improving flight safety in Africa. “That didn’t fit with my specialisation, but the average AE student seldom ends up working in the field he graduated in.”

## FORMULA STUDENT

This applies to De Jager too. He found the inspiration for what he is doing now when he participated in Delft Formula Student, a team of students that designs and builds mini-race cars and races them in a worldwide competition. “That year at Formula Student was really valuable for my development as an engineer. It provides you with an opportunity to put what you have learned into practice. You also learn how to work more efficiently, because the problems you are confronted with have to be solved within a certain deadline. We built parts made of carbon composites. I had learned about the technology, but you really can’t form a proper picture based on the photos in a reader. When you actually work with the material, it’s a very simple and logical process, but you don’t realise that until you’ve held it in your own hands. I need to do this more often, I thought.”

## BLUEBUILD

And so he did. Last year, he and Ivar te Kloeze (whom he knew from Formula Student) founded the company Bluebuild, which helps startups and other companies in the product development phase by building prototypes or mock-ups. “One of the bottlenecks is often the milling. This is a very diverse process.”
For example, Bluebuild built soil analysis instruments for TU Delft’s Geosciences department, but its customers also include various companies throughout the region, including YesDelft startups. “Startups often lack the engineering capacity for a development process nor do they require that capacity permanently. That’s where we come in. The customer always gets a tangible product from us,” says De Jager. “Holding something in your hands that you’ve made yourself feels good for us too.”

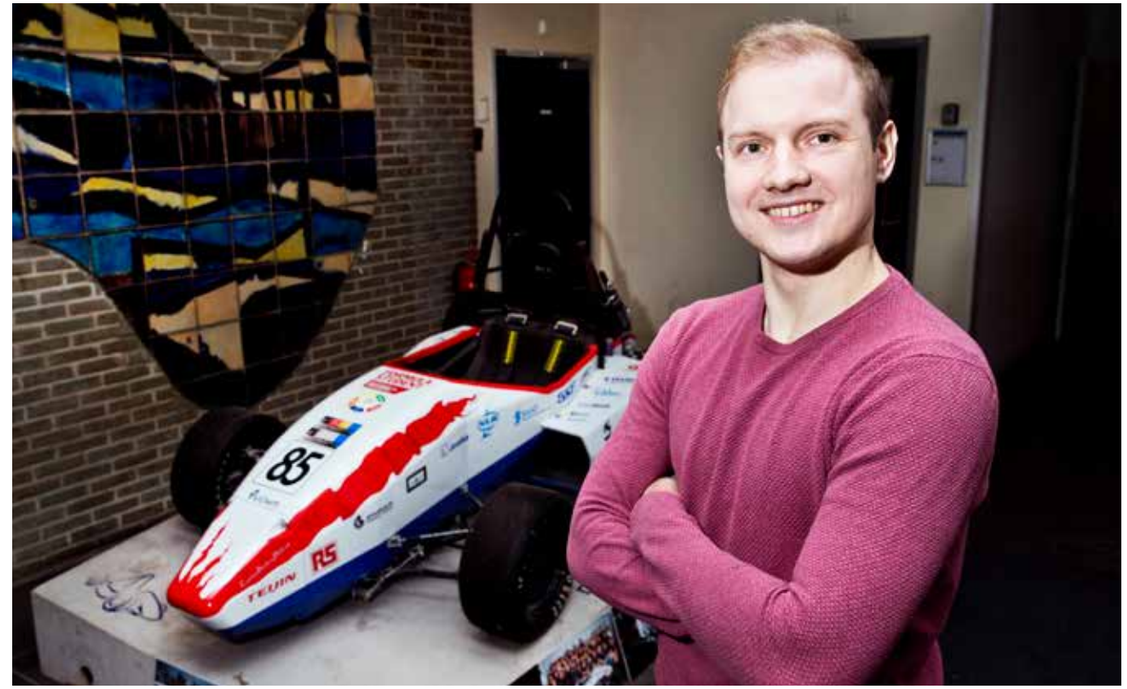
## SHORT TURNAROUND TIMES

This careful decision-making process is typical of De Jager. “At every stage in my life, I have always looked back and considered why I did the things I did and what I learned from them. In fact, he knew exactly what he wanted to do after graduation. “In the aviation sector, product development can take decades and you may never get to see the final result of your work. I wanted to achieve tangible results, and not have to wait too long to see them. And I also didn’t see myself working for a really big company.” De Jager went to Temporary Works Design (TWD), an engineering firm specialised in auxiliary equipment and installation tools for the offshore and civil engineering markets. “At TWD, I worked on offshore wind farm projects with turnaround times of three to six months, so that you got to see your own design in real life. I had four great years there.”

## A SMALL INVESTMENT OF TIME

He also came into contact with AE’s mentor programme through TWD. “I supervised an AE trainee at TWD. After her work placement she became a student teaching assistant with the mentor programme and then she approached me,” says De Jager. Since then, he has mentored students for every edition of the programme. “For a number of months, you regularly get together with the student to discuss their progress. These are generally always the familiar questions; the same questions I had when I was studying. I have since found the answers to some of these questions, while I have gained more insight into others. It’s great that I can do so much for a student with just a small investment of time. I wish I had had a mentor in my student days!” It’s a role that suits him well. “I’m a contemplative type and I am interested in why people do things and what moves them.”





Arnold de Jager: “TU Delft is a positive force in the world.”

## FROM EXISTENTIAL TO PRACTICAL

The questions the students struggle with turn out to be very broad ranging. “They vary from existential questions like “What am I studying for?” and “What do I want from life?”, to very practical questions like “What are my chances on the job market?” and “How can I find my dream job?” So it’s a completely different conversation each time,” says De Jager.

## EXCELLENT PROSPECTS

Not that students have much reason to feel insecure. “They are students of TU Delft and belong to the upper segment of society. If they can’t make it, nobody can! Still, students don’t always seem to realise that they’re already on the right track,” says De Jager. “I always reassure them: you’re going to be alright. You’re getting a good education and soon there will be a whole lot of people looking for someone with your skills. You have excellent prospects.” The high study workload may play a role in the students’ insecurity. “The popularity of the mentor programme does indicate that many students need some extra support. There are even cases of students with burn-out symptoms, so the pressure is clearly intense.”

## MOTIVATION

His motivation to participate in the mentor programme is mainly the students themselves. “It does not take up much of my time and the students really benefit from it. Even if that investment doesn’t directly benefit me, it is a small contribution towards a better world. I do not feel I owe TU Delft anything, but I had a good time there and the University is a positive force in the world. The fact that they have gone to the trouble of establishing such a mentor programme is also motivating. TU Delft is clearly committed to its students, which reinforces my desire to give something back.”

**Are you inspired by this story? And do you also want to explore the possibilities for permanent involvement at TU Delft? Then we would like to get in touch with you. Send an email to alumnirelations@tudelft.nl.**

# ALUMNI NEWS

## Alumni Activities

**10 July**
DEAN (4TU) alumni event Paris

**16 September**
Alumni Backstage Tour Satellites

**24 October**
Alumni Backstage Tour Green Village

**30 October**
Karel Luyben Lecture London

**14 November**
Alumni Backstage Tour Robotics

Sign up on the alumni community platform tudelftforlife.nl or on the alumni.tudelft.nl website.

Contact:
Questions, comments or ideas?
Email: alumnirelations@tudelft.nl
Website: alumni.tudelft.nl
Community: tudelftforlife.nl

TU Delft FOR LIFE

'TU Delft for Life' is the online community for all TU Delft alumni. Expand your network, meet your old university peers and stay up to date on the latest news and events. Sign up on tudelftforlife.nl. You can also change your contact details and communication preferences there.

## TU Delft for Life | Xperience Day

Almost 750 alumni and Delft University Fund contacts took part in eight themed tours on 4 June. Also on the agenda were the Plenary during which Joop Roodenburg was named Alumni of the Year 2019 (see interview on page 20); masterclasses; and the Faculty of Industrial Design Engineering's anniversary programme. If you want to know what you missed, watch the Plenary or see the photos on www.alumni.tudelft.nl/xperienceday.


## From the highest point: surveying in the time of Mesdag

The exhibition 'Vanaf het hoogste punt: Landmeten in Mesdags tijd' (from the highest point: surveying in the time of Mesdag) can be seen at the Panorama Mesdag until 22 September. The exhibition was put together in a partnership between the Panorama Mesdag and TU Delft Library. A special alumni evening was held on 9 May. Ramon Hanssen (Professor at TU Delft) and alumnus Huib Ekkelenkamp gave presentations after which the alumni could visit the Panorama Mesdag. TU Delft alumni may visit the exhibition in The Hague up to 22 September with a 50% discount on their tickets. If you would like to see the exhibition, email alumnirelations@tudelft.nl.



## JOIN AND BECOME A GOOD FRIEND

**The Delft University Fund has more than 100 Good Friends. These are involved alumni who support today's researchers and students at TU Delft with their network, knowledge and donations. Good Friends regularly contribute to pioneering research, revamping education and developing talent.**

The bigger the group, the more we can do for TU Delft. And because friends are there for each other, you get a lot back. You are a member of an interesting network of alumni and are welcome to our annual, exclusive Taste of Excellence dinner, which will be held on 12 November this year. You are also welcome to attend top events at TU Delft and meet talented researchers and students.

## INVOLVED IN TU DELFT

### FRANK VAN DEN BERG

**"I decided to become a Good Friend because it is a good way to give something back for the wonderful time I had at TU Delft. I can also contribute to the innovative and impactful research at TU Delft.**

As an alumnus of an American university, I was used to the idea of financial support. I have donated to the Delft University Fund since the 1980s and am now a Good Friend. It's just part of my life, but it has a significant impact on the talented students and researchers at TU Delft."


**Do you want to be a Good Friend too? For EUR 500 a year for five years you can become a Good Friend. With a donation agreement, your donation is tax deductible. Please contact relationship manager Machteld von Oven for all the information you need.**

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**TEAM** UP WITH **EXCELLENCE**


# The lab of...

## MSE 3mE

First-year mechanical engineering student Alex Gueret is working on a weld for the welding technique course, which is compulsory for all mechanical engineering students. "Among other things, you learn how to protect the welding material against oxygen to keep corrosion from forming," says Gueret. In the lesson, the students aren't working on a final piece – they're practising on a piece of steel. "It's fun to work on a project where you actually create something rather than poring over books."

PHOTO: SAM RENTMEESTER