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Research and education at
Delft University of Technology

Delft Outlook

Magnetic brainwaves

Neural connections visualised

Burgers' Lab • **Guest writer Doeschka Meijsing**
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Delft Outlook

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Asked whether she would like to be TU Delft's guest writer, Doeschka Meijsing needed some time to think about it, she confesses in this edition of Delft Outlook. For her, this university is "the lion's den", a place where that which is researched and taught seem so alien to her. Even so, Meijsing said yes. Then again, the theme she chose, 'house of memories', will probably seem strange to some TU students. After all, what does a house containing the memories of a writer look like? Students who enrol for her lecture series will find out, in Delft and in France. Memories also feature elsewhere in this edition. The Faculty of Industrial Design celebrates its fortieth anniversary, while the Laboratory for Aero and Hydrodynamics has been around for ninety years. Over the years, both of these major institutions have produced groundbreaking research and design. In Focus, Delft Outlook describes the headaches caused by flowing droplets on a sheet of glass, among other phenomena. Looking Back highlights innovative industrial designs, including emergency roadside phones and the Senz umbrella. Meijsing says many of the subjects taught at TU Delft seem so strange to her, yet nowadays a lot of research comes very close to home. Everyone would like the research presented in Background to be successful, as it attempts to map eroding connections within the human brain, allowing us to eventually predict and better treat dementia. This would mean we all would be able to keep our own house of memories.

Saskia Bonger
Interim Editor-in-Chief
Delft Outlook

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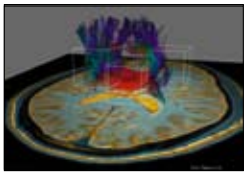

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COLOPHON

cover photo
PHOTO: SAM RENTMEESTER/FMAX

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(ILLUSTRATION: MICHAEL BITTERMANN)

Interior design of an airport based on evolutionary progress.

Design by evolution

The computer as designer is a dream dating back to the 1960s. PhD student Michael S. Bittermann (MSc Architecture) revamped the idea and developed a program guaranteed to find the best design solutions.

On Michael Bittermann's laptop computer screen, elements of an airport terminal slide around like pieces on a chessboard. The computer is busy designing the best layout for the terminal by moving around the stairs, lifts, columns and upper floor. The computer designs each contain a human figure, or avatar, who observes the results. The avatar's point of view determines how the space is viewed. Does the terminal give the right sense of spaciousness? Are the stairs easy to find? The model can provide numerical answers to these kinds of questions.
Bittermann also devised a way for the computer to produce different solutions. He was inspired by evolutionary theory. For an airport terminal, the model starts with random solutions, which nonetheless must satisfy the preset criteria, for instance that the stairs connect to the mezzanine. The computer begins by producing eighty different solutions that are assessed according to fifteen criteria, including spaciousness, daylight on the mezzanine, size of the mezzanine, visibility of the stairs, and location of the columns.
A system of weighing factors then assesses each individual aspect and combines them all into an overall score for functionality and aesthetics. The solutions are then 'cross-bred' with each other, so that the successful solutions have a better chance of survival than their lesser brethren. This process's method of exchanging bits is based on the way chromosomes exchange information in nature.

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Troublemakers

Clouds are surrounded by rings of descending air. This discovery by Dr Thijs Heus of the Faculty of Applied Sciences provides new insights for climate models. Clouds are troublesome in climate models; they can retain heat, but also reflect the rays of the sun and thus have a cooling effect. Determining which of these effects prevails requires insight into how clouds work. Heus discovered that cold air flows downward along the edges of cumulus clouds. This is a radically new insight in cloud research, which until know had always assumed that cold air flows down from the top of clouds in a fan-like pattern, thus affecting large sections of the surrounding atmosphere. This is also the assumption used in climate models.
"Since air ascends inside a cloud, by way of compensation it must come down elsewhere," says Heus, who now works for the Royal Dutch Meteorological Institute (KNMI). "We have demonstrated that most of the compensating downward flow occurs directly around the cloud. This ring of descending air is created when cloudy air mixes with the surrounding air, which is warmer and drier, causing the moisture to evaporate. This evaporation process cools down the air, which then descends." The interaction between the cloud and its surroundings is therefore indirect. The ring around the cloud has a buffering effect on the surrounding air. This buffer layer has never before been included in climate models.

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Fast waves

Dr Neil Budko, of the Faculty of Electrical Engineering, Mathematics and Computer Science, wanted to demonstrate to his students that electromagnetic waves propagate at the speed of light. He set up a simple test in which one aerial transmits an electromagnetic wave that is then picked up by another aerial a little distance away. However, if he put the aerials close together, he observed speeds exceeding the speed of light. "In air or a vacuum, all electromagnetic waves propagate at the speed of light – not faster and not slower."

Photo: Sander Rentmeester/iMax

Dr Neil Budko.

Budko was of course too level-headed to think he had just repudiated the theory of relativity. He repeated his experiment and even observed negative speeds if the aerials where less than one wavelength apart. "The waves aren't really travelling at speeds faster than light," he explains. "We just have an overly simplistic view of how electromagnetic waves move through a vacuum or air."

The face of a packet of waves moves exactly as expected, but the centre section gets distorted while in transit. Budko: "For larger distances, this phenomenon can be ignored, but if you move the aerials close together, our current measuring methods produce unexpected speeds." In his recent publication in Physical Review Letters, Budko proposed to change the way we look at the propagation of electromagnetic waves. "What are known as Maxwell's equations, which explain the behaviour of electromagnetic waves, can be resolved into a three-part formula," he explained. "We currently use only the last part, whereas we should be using all three."

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Scraping scrap

ReSteel, a TU Delft spin-off company, has signed a contract for the first patented Clean Scrap Machine. If all goes according to plan, the machine will start processing scrap metal in early April, as an extension of the recycling facility of the Heros scrap processing plant in Sluiskil. The plant annually processes 130,000 tonnes of scrap metal sourced from waste incineration facilities. Scrap iron from recycling operations is contaminated with copper, which prevents it from being reused to manufacture high-quality steel. Most of the copper comes from electric motor armatures and transformers dumped as household waste. On average, iron scrap contains 0.7 percent copper by weight. Manual inspection of the scrap flow can reduce that amount by approximately half. ReSteel's Clean Scrap Machine promises to reduce the copper content to less than 0.1 percent.

TU Delft researcher Dr Peter Rem of the materials and environment section at the Faculty of Civil Engineering and Geosciences is unwilling to divulge any information about how the system works. "Basically, separating copper from iron is easily done using a magnet, but things like motor armatures contain copper contained in iron, causing them to be treated like iron." Research had resulted in a magnet, that, Rem says, is "sensitive to the shape of the magnetic field", allowing it to separate contained copper from scrap iron. The process has been patented and now forms the scientific basis for the company.

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Illustration: ReSteel

Patented invention extracts copper from scrap iron.

Photo: B. Smets

Africa splits

The eastern part of Africa is slowly splitting apart from the rest of the continent, a process that, until recently, could only be observed indirectly. MSc student Anneleen Oyen was one of the researchers working to find a more direct observation method. The result: co-authorship of an article published last year in the leading scientific journal, Nature.

In an agonisingly slow movement of the underlying plates (three to four millimetres per year), the African continent is slowly splitting apart along an eastern fault line known as the East African rift. The split is not a continuous process, however, but rather occurs in fits and starts. Because it is impossible to predict when the next split will occur, until now researchers could only guess at how it transpired after the fact. However, using a European Space Agency radar satellite, Oyen was able to observe a shift as it happened.

At the European Center for Geodynamics and Seismology in Luxembourg, Oyen processed radar data from the Envisat satellite into interferograms: composite images used to compare the radar reflections from a single satellite in a single area, but at different times. Oyen looked at a part of the rift in Tanzania, close to where some earth tremors were detected in 2007. "We knew that there was geological activity in the East African rift area, because small tremors had been recorded for a month," she explains. She compared the images immediately preceding the tremors with those obtained afterwards, and was thus able to retrace the movement to an accuracy of a few centimetres. The results were unexpected: the eastern part of Africa has torn itself fifty centimetres away from the rest of the continent in a single month. "This is unprecedented," Oyen says.

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Airborne surveyor

In a building on the Rotterdamseweg, start-up company Heering UAS B.V. is constructing an unmanned aircraft for three-dimensional surveying. The company recently received a 25,000 euro grant from the STW Technology Foundation. This new surveying system consists of an unmanned aircraft (UAV) fitted with a high-resolution camera that can autonomously take pictures of the ground. These pictures are then processed into a three-dimensional model. Until now, this technique couldn't match the performance of GPS equipment, the most common type of surveying technique in use today. "By profiting from the progress made in digital photography and the unprecedentedly low flying altitudes of UAVs, we believe we can now compete with GPS," says Pieter Wijkstra, founder of Heering UAS B.V..

PHOTO: TOMAS VAN DIJK

Pieter Wijkstra with a scaled-down prototype surveying aircraft.

Wijkstra laid the foundations for Heering UAS while working on his graduation project at TU Delft's Faculty of Aerospace Engineering. His graduation project research brought him into contact with the TU Delft affiliated Aerospace Software and Technologies Institute (ASTI), which over the years has amassed a wealth of experience in the field of unmanned aircraft development. Meine Oosten, managing director of ASTI: "We are constantly looking for ways to convert the know-how we have at ASTI into business opportunities, and we were immediately convinced of the market potential of airborne surveying." TU Delft is involved as a partner in Heering UAS through its participation company Delft Enterprises B.V.

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IN·BRIEF

Better view of how tumours develop

Dr Bart Vermolen has developed an image processing method that offers a better view of what occurs inside cell nuclei. The method is helpful in cancer research.

Dr Bart Vermolen, who received his PhD degree from the Faculty of Applied Sciences last February, focused on processing images of telomeres, which are the ends of chromosomes that play a crucial role during cell division. Vermolen's technique enables the length of the telomeres to be determined using images produced by a fluorescence microscope.

"Telomeres can be compared to the protective, plastic tips of shoelaces," Vermolen says. "They contain no genetic information, but act as buffers. When a cell divides, the chromosomes end up a little bit shorter every time they reduplicate. Because it's the telemeres that are being interfered with, and not the DNA carrying genetic information, the chromosomes remain intact." Sometimes, however, telomeres get stuck together. This can result in chromosome defects and, ultimately, tumours. Vermolen's technique allows the coagulations to be detected.

"The problem with telomeres is that they are very sticky," Vermolen explains. "Unlike the rest of a chromosome, they consist of single-strand DNA, which makes it easy for them to get attached to each other. The telomeres are protected by protein sheaths to prevent this happening, but if something goes wrong with those proteins, they get stuck together nonetheless."

Leiden University Medical Centre and the Cancer Research Institute of Manitoba in Canada have already started using this image processing method. Both institutes were Vermolen's research partners.

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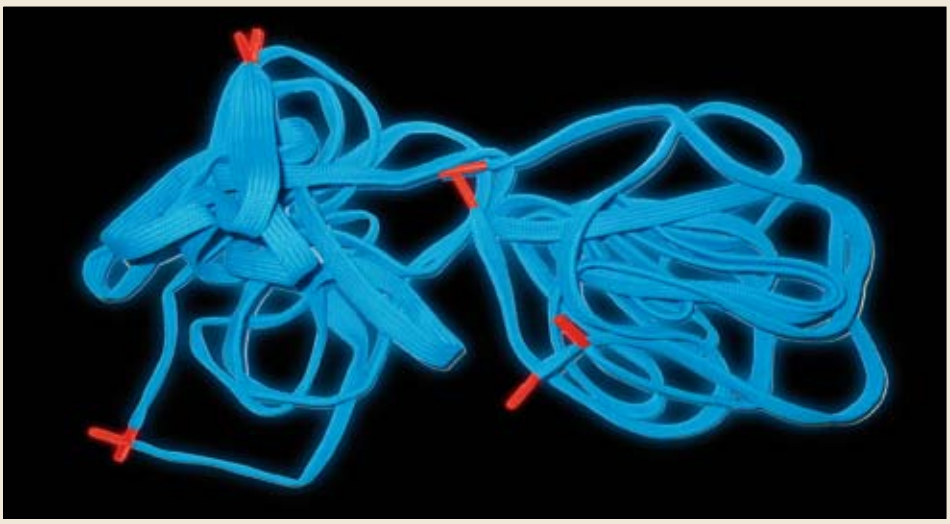

Catching baddies

Every other week, a British organisation sends a batch of test discs to the Reactor Institute Delft (RID) to be examined for the presence of fissionable material. The discs are fed into the reactor through a pneumatic tube. "If they carry any fissionable material, one or more neutrons are sure to hit it," says Dr Menno Blaauw, head of RID's facilities and services. If that happens, the atomic nuclei in the granule of fissionable material will be split and fly off in different directions. This happens with such force that each half of the atomic nucleus leaves behind a scratch on the plastic. The resulting star shape cannot be seen with the naked eye, so the disc must be placed under a microscope, which the British researchers do themselves.
Even so, Blaauw and his colleagues can sometimes tell when they've caught a bad one: "The customer asked us to use gamma-spectrometry to see which materials the sample contains after irradiation." When irradiated, each chemical element emits a flash of light in its own colour. Last month, the Delft researchers observed the colour of uranium. Where the sample came from is something that Blaauw doesn't know: "We can only read the papers and guess where the samples were taken."

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PHOTO: SAM RENTMEESTER/FMA

Tunnel vision

On 16 January, the chairman of the Royal Netherlands Academy of Arts and Sciences (KNAW), Robbert Dijkgraaf, officially switched to the Open Jet Facility. He praised the 'tunnel vision' of TU Delft, which provided its own funding for the research facility. The open jet wind tunnel derives its name from the large open space (8 metres high, 6.5 metres wide and 13 metres long) into which the air flows. This renders the tunnel extremely suitable for research on (models of) wind turbines, heavy goods vehicles and buildings that significantly block the airflow in a closed tunnel. Such blockades severely affect the measurements in a closed wind tunnel, but the open jet facility is much less affected.

The tunnel is capable of accelerating the air up to 120 kilometres per hour (hurricane force), thanks to a 500 kW fan. The facility was designed by Nando Timmer, of the Faculty of Aerospace Engineering, and costs approximately 1.8 million euros, excluding the extension to the wind tunnel building. The dean of the Faculty of Aerospace Engineering, Professor Dr Jacco Hoekstra, emphasised the importance of the tunnel for academic purposes. Commercial wind tunnels are much too expensive for educational use.

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PHOTO: JOS WASSINK

Magda Chmarra being assessed by her own system

Mouse supervisor

The Trendo, a system of three computer mice, can be used to determine the skill level of someone training to do minimally invasive surgery. This type of surgery offers many benefits for patients, but can be difficult for surgeons to perform.
The lack of depth in the video image presents a particularly difficult problem for novice surgeons. In January, Dr Magda Chmarra received her PhD degree from the Faculty of Mechanical, Maritime and Materials Engineering (3mE), for her invention, the Trendo, a system that enables endoscopic operations to be assessed using both a virtual and a mechanical training set. At its core is a gyroscope-like structure through which a long implement has been inserted. The Trendo records every movement made by the instrument in each of the four directions. Chmarra tested the equipment together with interns and experienced surgeons at the Leiden University Medical Centre.
Supervisory professor, Dr Jenny Dankelman (biomechanical engineering at the Faculty of 3mE), is considering producing a limited series of the device for gaining experience, especially now that VU University Medical Centre in Amsterdam has expressed interest. The idea is also to add force-measuring capabilities to the Trendo, but this will be a job for the next doctorate student.

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The cradle of fluid dynamics

Burgers' lab, as the Laboratory for Aero and Hydrodynamics is affectionately known, recently celebrated its ninetieth birthday. To mark this special occasion, we take a look at some of current research projects, from studying droplets to tickling turbulence.

Tomas van Dijk

If you're stuck in traffic and it's pouring rain outside, take a good look at the water on your windshield before the wiper blade sweeps it away. Those zigzagging tracks down the glass have been puzzling fluid mechanics engineers for decades. According to the accepted laws of fluid mechanics, droplets should not be able to stream down a sheet of glass.

This so-called contact line paradox fascinates Professor Dr Jerry Westerweel, section head at TU Delft's Laboratory for Aero and Hydrodynamics. "The paradox states that drops of water are unable to roll across a smooth surface because the water molecules move faster as they approach the front of the droplet, which results in infinitely greater friction," the fluid dynamics expert explains.

A team of Westerweel's researchers is now focusing on droplets. By investigating at a micro level what occurs inside a droplet, they hope to unravel one of the great mysteries of fluid dynamics. But there is more to it than that. The research also has a real-world application; it is intended to help manufacturers of microchip-making machines speed up their machines.

The droplet example is typical of the research conducted at the laboratory. From studying drops of water and tickling turbulence, to investigating blood flows in chicken embryos, it is a place where fundamental and applied research always go hand in hand.

"It's always been like that," says Westerweel, who believes this is the reason for the success of the laboratory, which was founded in 1918 by fluid dynamics researcher Johannes Martinus Burgers and has since become the cradle of fluid dynamics in the Netherlands.

Westerweel says a major factor contributing to the lab's success is the fact that the lab conducts research on turbulence and complex flows in many different ways, such as, for example, through experimentation, by using modern laser technology, and by means of simulations on large supercomputers. Westerweel supervises the experimental research, while the Dr Bendiks-Jan Boersma leads the simulation-based research.

Over the next few years Westerweel intends to join forces with other fluid dynamics groups within TU Delft that are also investigating flows. "Together with those groups I'd like to set up a single, large laboratory that can be used for large-scale experiments and where we can share our expertise. All together we would probably form the largest fluid dynamics laboratory in Europe."

The droplet paradox

Amid loud sputtering noises caused by trapped bubbles of air, a droplet appears on a rotating glass disc. Caught in a laser, the droplet lights up reddish-orange, as a result of a myriad of fluorescent micrometre-sized globules contained by the water.

The test setup used by two PhD students, Hyoungsoo Kim and Mark Franken, and looks a lot like a microchip-making machine. They received it a few months ago from the microchip-manufacturer, ASML. The machine consists of a rotating glass disc (which replaces what would normally be the chip wafer), a lithography head, a pump that deposits a minute droplet on the glass, a laser beam device, and four cameras that record images of the droplet from below.

ASML wants to gain a better understanding of what happens at a micro level inside moving droplets. The company needs this knowledge to improve their latest generation of microchip machines.

ASML wants to gain a better understanding of what happens at a micro level inside moving droplets.

Franken and Kim are helping the company in a research effort aimed speeding up the microchip manufacturing process by reducing the number of rejected microchips. Inside the machine, which uses so-called immersion technology, a water droplet is sandwiched between the wafer and the lithography head's lens. Because water does not refract in the same way as air, the beam of light is refracted in a different way. As a result, the immersion lens machines are capable of creating smaller lithography ▸▸

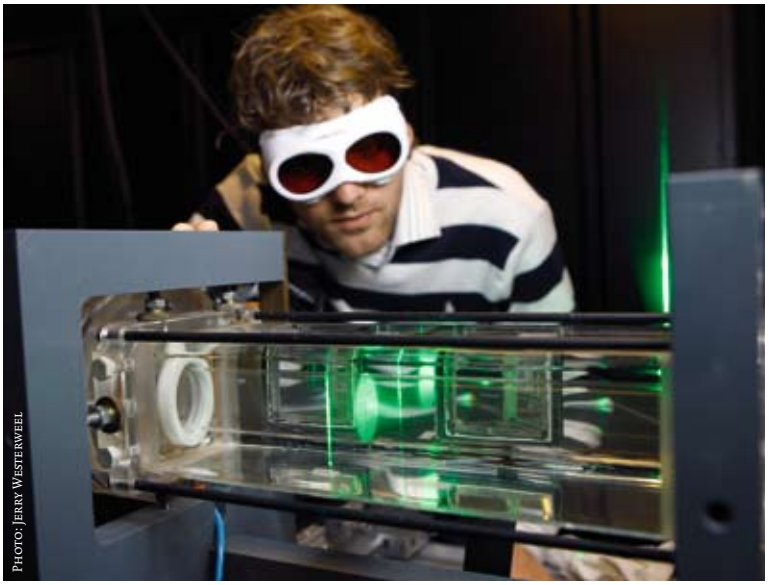


Photo: Jerry Westerweel

Dirk Jan Kuik films how turbulence decays at the halfway point in a 24-metre long tube.

structures, down to as little as 38 nanometres. A few years ago, ASML had to be content with a minimum size of 60 to 65 nanometres.

The drawback of the new technology is that the droplet slows down the lithography process if the wafer is moved too fast as it passes under the lens. "The maximum speed of the wafer during the lithography process is currently half a metre per second," Franken says. "Any faster and the droplet becomes unstable. This could result in air bubbles getting trapped in the water, and possibly even leaving a trail of much smaller droplets behind on the wafer, which is known as pearling. In either case, the lithography results in a malformed microchip."

ASML is now trying to find out whether the droplet will stay in position longer if it is blown upon, if the lithography exerts a little suction on it, or if the wafer is made smoother using special coatings.

Finding the optimum settings for these interventions requires insight into what exactly goes on inside the droplet at the precise moment when things start to go wrong. Franken and Kim are investigating the matter using Particle Image Velocimetry (PIV), a technique in which minute fluorescent plastic globules visualise the flows in liquids. "ASML would like the lithography speed increased to one metre per second," Franken says, as he gradually increases the rotation speed of the glass disc. "It would make their equipment more than twice as fast."

Westerweel hopes the doctoral research project will eventually provide insight into the contact line paradox. "It's one of his hobbyhorses," Franken says, laughing. "Who knows, it might just result in new insights, but it's still very application-driven."

Tickling turbulence

Running right across the Laboratory for Aero and Hydrodynamics is a 24-metre long tube with a diameter of four centimetres, enclosed in a thick layer of insulating material. Halfway down the tube is a pair of cameras, which are to record what has never been recorded before: a decaying packet of turbulence. The ultimate purpose of this experiment conducted by PhD student Dirk Jan Kuik is even more remarkable, as he intends to 'tickle turbulence'.

"On one end of this tube I inject a little extra water to induce turbulence at regular intervals," he explains. "These turbulence packets decay to nothing at various points along the tube. If we understand how that happens, we might just be able to 'tickle' turbulence in such a way that it speeds up the decay, for example by injecting a little extra water into the turbulence, or by vibrating the tube."

That would make the oil industry very happy. Pumping turbulent oil through pipelines consumes a great deal of energy. "Oil companies in Alaska add polymers to the oil to increase its liquidity and thus reduce the flow resistance," Westerweel explains, "but it would be much better if we could simply eradicate the turbulence." Kuik nods in agreement. "But eradicating turbulence is still far off in the future," he adds.

Kuik's research builds on a spectacular discovery Westerweel and his colleagues made and was published in NATURE in 2006, when they demonstrated that eventually turbulence always decays to zero, regardless of how fast a liquid flows. The problem however is that it can take a very long time to stabilise. For example, it would take 10 to the power of 3000 (i.e. 1 followed by three thousand zeroes) years for the water in the mains network of a medium-sized city to stabilise..

Even so, the conclusion that eventually all flows must stabilise was completely at odds with what fluid dynamics had predicted until then. According to Westerweel, this means that theoretically it should be possible to cause turbulence to decay at an increased rate.

Of course, Westerweel and his colleagues didn't conduct their experiment on a city water mains system; instead, they allowed water to flow through a thin, 30-metre long copper tube. It was a bit like a significantly scaled-down version of a water mains system, but with a much lower Reynolds number – a key number in fluid dynamics – to somewhat speed up the stabilising process. Prior to this discovery, the theory was that whenever the Reynolds number of a flow exceeded a certain critical value, as was the case in the experiment, the turbulence would never decay to zero. The researchers injected a little extra water at regular intervals to create turbulence in the flow. At the other end of the tube, the water occasionally stabilised. Even in Kuik's setup the turbulence decayed to zero. "We measure this by means of the pressure gauges attached to the tube at two-metre intervals," the PhD student explains. What are the chances of a pocket of turbulence decaying exactly at the spot where his cameras are recording the events? Kuik doesn't know. "I haven't done those

For the first time, blood flows were filmed inside a living embryo

FOCUS

calculations yet," he says, "but I'm assuming that I'll be able to record the event before I conclude my doctoral research."

"What you see on the recordings looks like a starry sky," Kuik says. "Minute hollow spheres in the water light up when they are picked out by a laser beam."

The recording sessions each last twenty seconds, or about as long as it takes a turbulence pocket to decay to zero. The cameras record a thousand images per second. A special computer program reconstructs the velocity fields in the water by tracking each individual polyester globule.

"Each image takes up one megabyte," Kuik says, "so twenty seconds of recording requires quite a lot of computer memory. A computer analysis of one sequence takes several days, so we only transfer the data to the computer if we think we have actually recorded a decaying turbulence pocket. The pressure gauges will show us. Who knows, we might get a good result. It's a pity about all the building work going on nearby, though. The vibrations interfere with our tests."

Using a plastic coffee stirrer, Ruitao Yang carefully prods a few lugworms lying in a plastic container. "I'm trying to find the most cooperative of the lot," the guest researcher from Bath University in the England says, laughing.

At Bath University, Yang worked on amphibian robots that crawl and swim. He draws his inspiration from what he observes in the animal kingdom. At TU Delft, the researcher is temporarily working on an EU project that aims to develop pumps for 'labs-on-a-chip', minute microchip-mounted laboratories that can perform chemical analyses.

"All the current-generation pumps work at high Reynolds numbers only," Yang says. "Inside a lab-on-a-chip, the Reynolds numbers are very low, so the pumps don't work. By studying this worm I hope to discover a method which will work at microscale."

"Aha!" Yang suddenly exclaims, "Here's a worm that moves a lot." He takes the lugworm and places it on a tray with a thin layer of water. A camera mounted over the tray records the flows that occur all around the worm as it starts to wriggle with the whole length of its body and paddle with its many leg-like parapodia.

"You can see where the strongest flows occur near the parapodia," Yang says. He then laughs, adding: "It's a brilliant motion. For a pump at least, not for swimming."

Chicken embryo

Over the past few years, Dr Christian Poelma and his colleague, Dr Peter Vennemann, peeled hundreds of eggs, preparing them for filming the blood flow inside the embryos.

Together with development biologists from Leiden University, Poelma is trying to determine what effect the flow of blood has on the development of blood vessels.

"One of the processes we're interested in is the development of the heart," Poelma says. "The heart is formed by a blood vessel folding back on itself and then becoming constricted. Biologists think that the forces exerted by the blood flow against the vessel's walls activates genes inside the endothelium cells that form the lining of the blood vessels. This biomechanical stimulus would cause the blood vessel to transform itself into a heart. To prove this concept, we need a clear image of the forces acting on the walls of the blood vessel."

Poelma, together with Vennemann, who last year received his doctorate with honours and now works elsewhere, used an optical flow measuring method called Particle Image Velocimetry, which uses minute globules that light up when they are hit by green laser light. Because the globules had been given a special coating, the body's immune system failed to recognise them as foreign bodies and did not reject them. Their research gave them a first: never before had blood flows been filmed inside a living embryo.

"By focusing the camera on different depths of the blood vessel, and then superimposing the various images, we can create a 3-D reconstruction of the blood flow," says Poelma, who is still busy processing the data.

Poelma also collaborates with researchers at Rotterdam's Erasmus Medical Centre in research on capillaries. He would like to know how capillaries change into larger blood vessels. "If you constrict a blood vessel, the surrounding capillaries create a new blood vessel," Poelma says. "They create a kind of bypass."

To some of the embryos, Poelma has added a hormone, homocysteine, which occurs naturally in the human body. Elevated or reduced levels of this hormone can result in congenital defects in the cardiovascular system. Poelma intends to find out how this process works. The research is a massive undertaking. "Ideally, we want to film a thousand embryos," he says. "Only then would we be able to use the results for statistical analysis."

Microscopic globules in the blood of a chicken embryo become fluorescent and visible in the blood stream when Dr Christian Poelma shines a green laser beam on a peeled egg.

Racing against the clock

Sixty student members of TU Delft's DUT Racing Team are working on DUT09.

The racing car they plan to enter at Silverstone in July is still on the drawing board.

Maaike Muller

"The technology behind it is fascinating, but you don't see that on the race track. All you see on the track are cars making laps and lots of noise," says mechanical engineering student Thijs Papenhuijzen, who clearly isn't a big fan of Formula 1 racing. Nevertheless, he spends his days working on fast racing cars. He and the other members of the DUT Racing team are building a car that must be ready to race on the Silverstone track in July. It is the ninth car from TU Delft to be entered in Formula Student, a worldwide competition in which students race cars they have designed and built themselves.

Each year a new team starts work on a new car. "Sometimes you wish you had an extra year to further improve the car," says Papenhuijzen, who also worked on two previous DUT Racing cars, "but it's also great fun to start on something new. Anyway, they change the rules every year, so you can't keep racing with the same car."

In a large room full of DUT Racing cars from previous years, the DUT08 car is propped up on a platform like a piece of art. "Last year, it was the fastest and most fuel-efficient car," says Papenhuijzen's fellow team member, Christiaan Menkveld. But this year, DUT08 wouldn't be allowed to start, because the driver's compartment is too small according to this year's rules.

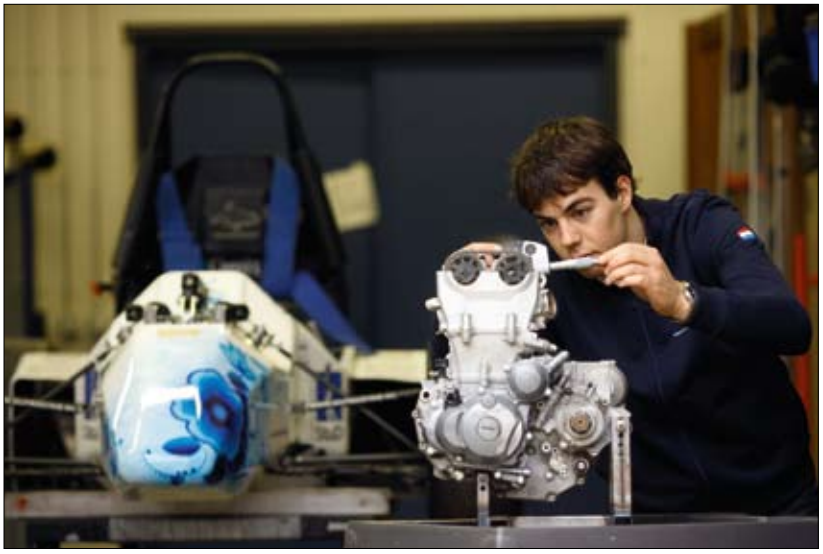
Menkveld, DUT Racing's operations and finance manager, actually has nothing to do with the technical side. "Such a race is a great goal to strive for, but what I like the most is achieving that goal together with lots of other really enthusiastic people." And the team has plenty of those. In addition to seven students with scholarships who work full-time on the car (including Menkveld and Papenhuijzen), fifty-five other students devote their spare time to working on the car.

"Working with such a big group can be quite difficult," Menkveld says, "but it's also great fun. Of course everybody wants their part to be the best, so you must ensure they reach compromises that are in the best interests of the overall result." For the seven students of the core team, synchronising all the various ideas is a full-time job. As is - now that the car's design is finished - planning the construction.

"This is where all the parts go," says Papenhuijzen, as he opens a storage cabinet that is still practically empty. A few shock absorbers and some ball bearings have been delivered. The students make many of the other components themselves in their own workshop. In amongst the other TU Delft student teams working on the Nuna solar car, and the fuel-efficient eco-runner racer, the DUT Racing team has its own area full of portable workbenches. These workbenches are brought to the races. "We're the only team that brings a fully-equipped workshop with us, so that we can manufacture parts on site," says Papenhuijzen, who doesn't mind at all when other teams turn to him for help. "One time in England," he says, laughing, "I repaired a part for the car that later went on to beat us."

That the atmosphere at Formula Student races is a lot more relaxed than at Formula 1 events is also shown by the fact that the various team members casually stroll through each other's 'pits'. "It's great fun to see how another team solved a problem that you were pondering for a year." The thick competition rulebook does however leave enough room for creativity and variations between the competing cars, Papenhuijzen says. "It's a real mishmash out on the race track. There are teams from India that arrive with a car that isn't finished yet, but there are also 35-member teams from German automotive institutes that show up with a high-tech racing car."

A fuel-efficient engine earns points.



Reliable

However relaxed the atmosphere at the events, the racers do come to win, so they organise go-kart races to find the best drivers, and they do their utmost to build a fast, but most of all reliable, car. "The high-point of the event

Foto's: Sam Rentmeester/FMax

A completely new racing car is built each year.

is the 22-kilometre endurance race, in which many cars fail to reach the finish line," Menkveld says. "Winning is primarily a question of keeping your car going."
Last year, in Michigan, the team failed to do so. "We were far ahead of a field of 150 competitors," Papenhuijzen recalls, "but then a wire came loose and our car stopped."
Earlier in the race, a broken drive chain in a car from Stuttgart had worked to the TU Delft team's advantage.
To maximise reliability, the latest DUT Racing team car contains no experimental innovative devices. "We once used a pneumatic muscle to make the clutch lighter, but we abandoned the idea because of reliability issues," Papenhuijzen explains. "All the principles embodied in this car have been around for a long time. It's complicated enough just to apply those correctly."
In the office over the workshop, Papenhuijzen shows the drawings of the new racing car. If he is to add a few more winners' trophies to the respectable number on view in the display case next to him, the car's speed must be optimised. "The computer will calculate where we can remove a little more material. The lighter, the better." The designers must be careful, though. Menkveld: "The DUT03 car weighed only 135 kilogrammes, but so much material had been removed that it broke."

'Winning is primarily a question of keeping your car going'

The race is not just about speed; it's also about the design. The brief is to design a racing car for amateur drivers who occasionally race on the weekends. "The car must therefore be inexpensive, easy to maintain and suitable for long production runs," Papenhuijzen explains. "We have to include a comprehensive report listing the price of every nut and bolt."
A fuel-efficient engine is another way to score points. Last year's car scored high because of its excellent fuel economy, and the DUT09 team is also intently focusing on low fuel consumption. Papenhuijzen: "Our engine has only one cylinder, instead of four. It produces less power, but it is much more efficient." And environmental considerations aren't the only reason why the team has opted for bio-ethanol rather than petrol. They think bio-ethanol will improve the car's fuel efficiency.
It will still be a race against the clock to get the car ready in time for the Silverstone event. "The car must be ready by early May," Papenhuijzen says. "That would still leave us time to test drive the car and make the necessary adjustments." While the students crowd the workshop until deep into the night, Menkveld is searching for a suitable place to conduct the test drives. He has a lot of requirements: "We want to test the car every day, which means every day we'll be making a lot of noise. And we would prefer a smooth tarmac, no lampposts and no manhole covers."

www.dutracing.nl
www.formulastudent.com
www.formulastudent.de

Monocoque
The car's chassis 1 uses a carbon-fibre reinforced monocoque construction. TU Delft's DUT Racing team produced the chassis by placing three layers of carbon-fibre matting (each 0.3 mm thick) in a wooden mould. Foam cores 2 (15–25 mm thick) are then placed on top of the matting to increase the structure's rigidity. Another three layers of carbon-fibre are added and then the mould is wrapped airtight. A vacuum pump then sucks resin through the layers of carbon-fibre. The contents of the mould take one day to harden, after which the outside is painted. The monocoque structure (approx. 24 kg) is produced in two separate halves (top and bottom), which are glued together.

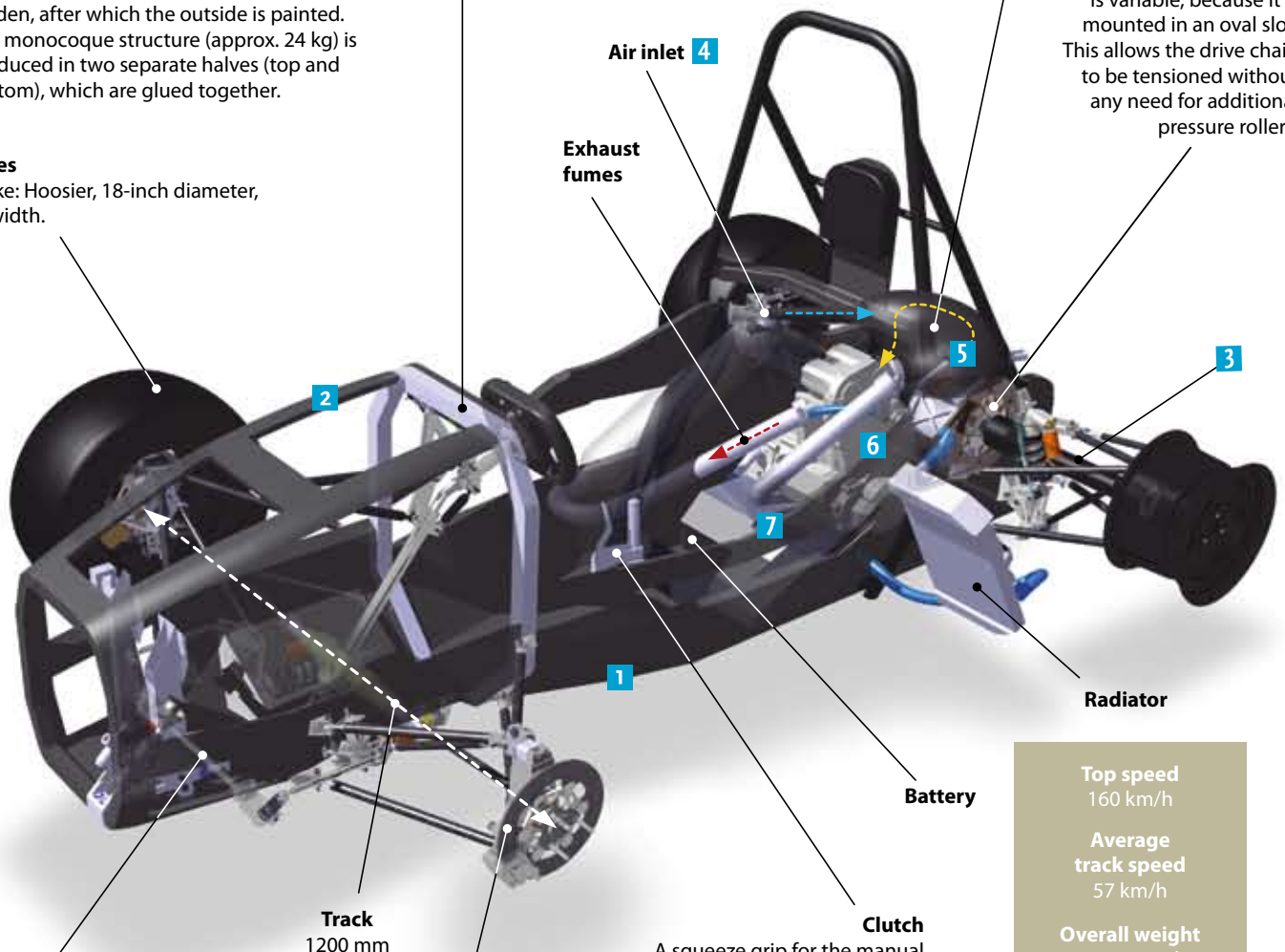
Drive shaft
Each of the carbon-fibre drive shafts 3 weighs only 300 grams. A heavily stressed steel shaft connects the homokinetic coupling at the end of the drive shaft to the wheel. For the first time, the wheel rims were also made using carbon fibre.

Aluminium cage
A compulsory aluminium ring is intended to improve the car's survivability in a crash.

Air chamber / fuel injection
The engine's air inlet 4 has a diameter of no more than 19 mm (using E85 fuel), in order to limit engine power. A fuel injection system developed by the DUT Racing team injects the fuel into the air chamber 5 before the mixture is fed to the engine.

Differential
The differential's position is variable, because it is mounted in an oval slot. This allows the drive chain to be tensioned without any need for additional pressure rollers.

Tyres
Make: Hoosier, 18-inch diameter, 6- width.



Torsion bar
A torsion bar prevents excessive chassis heel-over in corners, so the car's weight will remain more evenly distributed across all four wheels.

Slip detection
Sensors inside the wheels detect any difference in rotation speed between the front wheels and the driven rear wheels. The motor management system uses a variable ignition to ensure the rear wheels do not turn more than 10% faster than the front wheels. At 10% slip maximum friction between the wheels and the track surface (and consequently maximum acceleration) is achieved.

Top speed
160 km/h

Average track speed
57 km/h

Overall weight
approx. 155 kg

Acceleration
0 to 100 km/h in 4 s

Engine 6
The rules prescribe a maximum engine capacity of 610 cc. Most teams use a 600 cc four-cylinder engine. The DUT Racing team however is using a 450 cc single-cylinder (off-road motorbike) engine. The engine will be adjusted for minimum fuel consumption rather than for maximum power. According to DUT Racing, many teams overestimate the importance of high peak power. The twisting track makes it almost impossible to use that peak power to advantage. The prerequisite for success with the small, thrifty 450 cc engine is keeping the car's weight as low as possible. At low revs, the single-cylinder engine also produces a relatively high torque compared with the four-cylinder engine, which will come in handy in the acceleration test.

Fuel tank 7
In 2008, the DUT Racing team was one of the first to make the switch from Euro 95/98 petrol to E85 bio-ethanol. The latter is a mix of 85% ethanol and 15% petrol and produces fewer CO_2 emissions than petrol. E85 is popular in the racing industry, because it is believed to be more powerful than standard fuel. The DUT08 car used 14% less fuel than the runner-up at the 2008 Formula Student race in the UK.

Formula Student competition

Formula Student competitions are organised all over the world. Formula Student allows students to gain practical experience by designing, building, and racing their own race cars. The 2009 Formula Student competition in Germany will host 78 teams from universities and polytechnics in 19 countries, including teams from TU Delft and TU Eindhoven. Each team can score up to 1000 points for their car's design and performance on the track. The team accumulating the highest score wins the competition.

FORMULA STUDENT COMPETITION

Expert score – 325 points

Experts/engineers score the design (produceability, innovation, sustainability, reliability, etc. – 150 points), the cost (expensive components and production techniques result in fewer points – 100 points) and the commercial feasibility of the car (75 points).

FORMULA STUDENT COMPETITION

Race – 675 points

Acceleration test – 75 points
The car must be driven 75 m in a straight line. In 2008, the DUT Racing team finished in second place at 4.07 seconds (the winner's time was 3.99 seconds).

Skid pad – 50 points
The racing car must be driven two laps of right-hand and left-hand corners around a figure eight track (8 m track radius) to measure the car's lateral acceleration.

Autocross – 150 points
The driver is given two opportunities to achieve the fastest time around an 800 m circuit full of corners and slaloms. The average speed is about 60 km/h.

Endurance – 300 points
The car must complete a 22 km race without any repairs.

Fuel consumption – 100 points
The car with the lowest fuel consumption during the endurance test scores 100 points (50 points in last year's event).

DUT Racing team scores

2006 FSG - 3
808.41 points

2007 FS UK - 2
888.9 points

2007 FSG - 21
501 points
electrical fault

2008 FS UK - 2
751.57 points

2008 FSG - 1
919.66 points

Driver
The rules state that every car must provide sufficient space for a driver 1.95 m tall.

Nose
The nose has been designed (and crash-tested) to withstand a deceleration of up to 20 g. The nose will be covered with a layer of aramid to prevent splintering in the event of a crash.

Ground clearance
30 mm

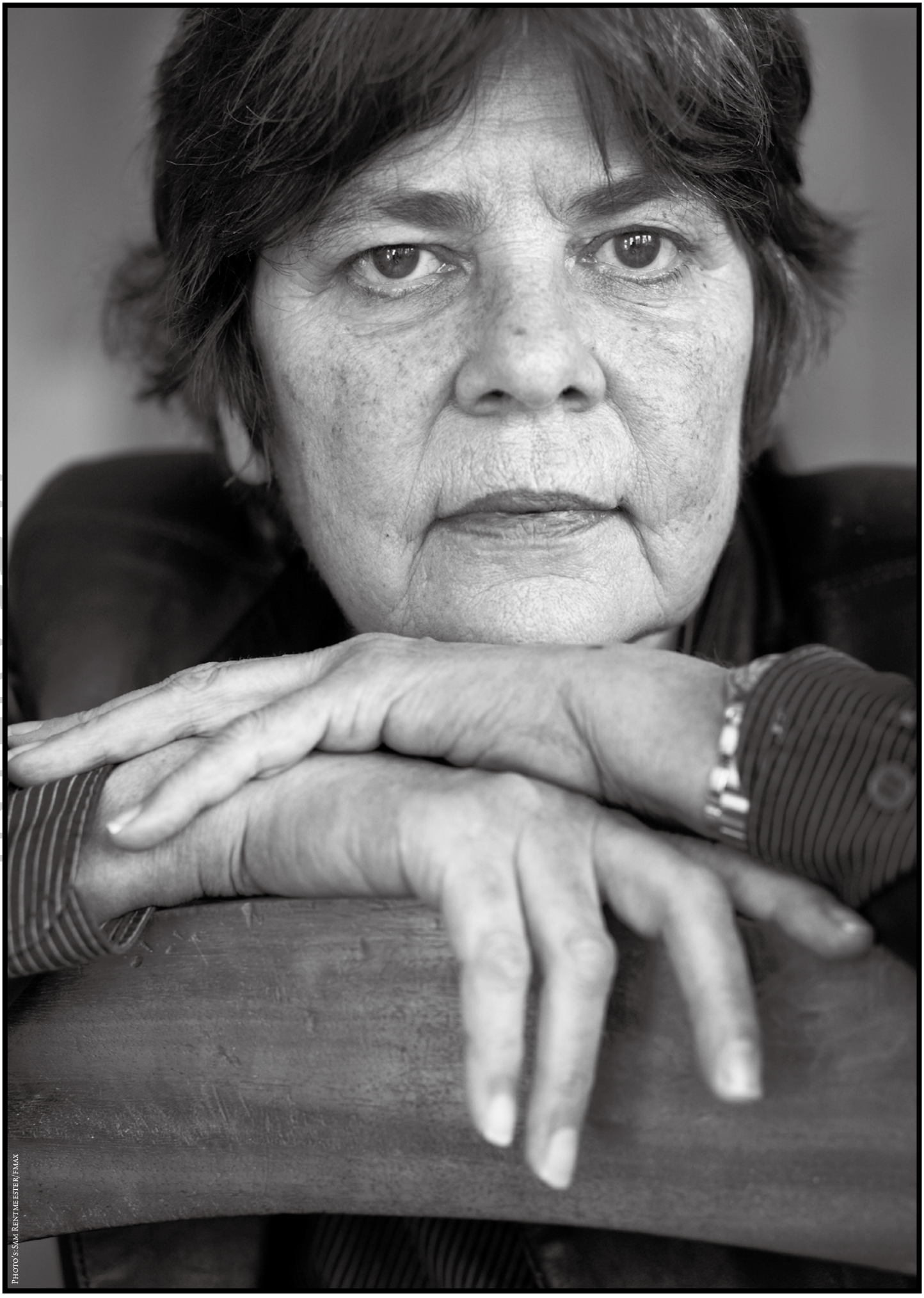
Wheelbase
1540 mm

Side pods
The covers on each side of the car shield the radiator and the exhaust, preventing bystanders from coming into contact with hot engine parts.

Test drives
The DUT Racing car will be completed by early May, when testing can commence. The team intends to complete at least 500 km of test drives. The main points will be fine-tuning the engine, adjusting the engine management system, an endurance test of all components, and training for the racetrack.

Low weight
For the 2008 Formula Student Germany race, most cars weighed about 210 kg. Only five cars weighed less than 180 kg (the DUT Racing car weighed 155 kg). One car with a steel frame instead of a monocoque carbon-fibre reinforced chassis even weighed 350 kg.

DUT Racing team, winners of FSG 2008
In 2001 the DUT Racing team participated for the first time in the 'Formula Student UK' race. Since then, each year a new team has built a new car that was lighter and more reliable than the previous one. In 2008, the team finished in first place at Formula Student Germany. The car was the fastest in the endurance race, and used the least amount of fuel. Thanks to these results, the DUT Racing team now ranks fifth on the world list (out of 420 teams).



Photo's: Sam Rentmeester/fmax

Humour is my saviour

Doeschka Meijsing is this year's guest writer at TU Delft. "It's like the lion's den to me."

Connie van Uffelen

If you were a student at TU Delft, what would your subject be?

"Architecture. To build houses that people would enjoy living in for a change. No glass cubes with glass stairs you see through – useless for anyone who is afraid of heights. No triangular buildings, where you can never find the boss's office, and with lifts that open on both sides. And no smoked-glass windows for hiding people behind."

Did you have to think long and hard before agreeing to become TU Delft's guest writer?

"I did for a while. After all, for me, TU Delft is the lion's den. Of all the universities I've visited so far, the subjects that seem the strangest to me are those taught here at TU Delft."

How did you come up with the theme for guest writership: house of memories?

"My grandfather and my father's brothers were all Delft School architects, so I'm no stranger to architecture. It seemed like a good idea to build a house in the world's most beautiful spot: the Swiss side of Lake Maggiore. This is where I would build my house of my memories. The Romans used to build houses of memories, imaginary houses – you could almost call them theatres – in which they gave every memory a certain place. I'll need the help of engineers for the job. With the house also comes a garden, with a bridge of sighs, in which you place the loss of a memory. The house will have to be very avant-garde and modern. Experimental, not an ordinary house. In your memories, you always live somewhere. I will investigate how we can give shape to this. One of the most important and difficult things is deciding what items to choose for such a house. You might end up with a very metaphorical house, in which a bicycle symbolises a memory. I once said to some people who wanted to know what writing was like, but couldn't imagine it themselves: 'Just write down what it was like the first time your mother took you to buy a new pair of shoes.' Everybody remembers that. Don't you?"

I don't, but nowadays there are so many gadgets that keep us from using our memories. Is that one reason why you chose this theme?

"The drawback of having all these machines taking over our memory functions is that reality is becoming an unappreciated aspect of our lives. The real world is no longer so important. Only recently I was on the motorway to The Hague, and my GPS showed that I was passing lakes where I often used to sail. The lakes were just to my left, but you couldn't see them. Without the GPS you'd have no clue where you were in the Netherlands. Our collective memory is deteriorating by leaps and bounds. This is destroying a capability that is essential for survival. I've noticed how very quickly you become dependant on all these gadgets."

What other gadgets would that include?

"Google. The writer H.C. Brandt Corstius put forth one argument and that was enough for me. If I fracture my elbow, Google will give me eight million hits telling me to keep it warm, and eight million hits telling me to keep it cold. I have an encyclopaedia dating from 1934, and when I open it, I enter a vast world of knowledge. And my eyes will fall on a word like epitaxis. That doesn't happen with Google. I'm not a fan of Google."

How bad is it that the art of remembering is being lost?

"You miss the pleasure of remembering things, which always happens suddenly. Remembering also means that you have more baggage, knowledge and ability for expressing more specific opinions about new things. It builds up your resistance to all those buttons. I really hate the dictatorship of buttons. Nowadays, if you want to shut yourself off from the world, you first have to push fifteen buttons, each one with its own beep. All the beeping drives me mad."

Are you afraid of a time when perhaps your own memory will fail and you'll become dependent on technology?

"I'd be very unhappy if I lost all my memories. Writers write at the mercy of their memories and of all that has been stored away in the nooks and crannies of the mind."

Do you actively train your memory, for instance by going shopping without a list?

"No, I like making shopping lists. I do still try to learn poems by heart though, just so that I'll always have them with me. It's a nice way of training your memory. We were taught to do so when we were young. A family tradition. If my ninety-year old mother can't sleep, she recites Rilke. I prefer learning poems to going to the gym."

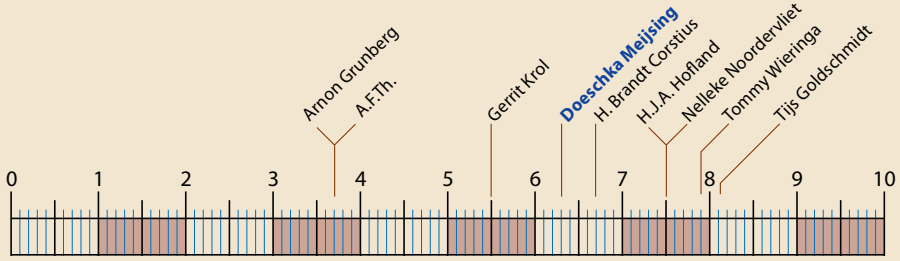
The failure of memory plays an important role in your books. In your latest book, 'About love', the main character, Pip, who has just been left by her lover Jula, loses her memory in an accident. In her quest to find the missing pieces, all kinds of memories of lost loves well up inside her. Why does this fascinate you? ▸▸

Doeschka Meijsing

She would have liked to have attended a basic technical training school, "because it's handy for a housewife to be able to keep all the nuts and bolts in their proper place." Doeschka Meijsing (Eindhoven, 1947) however eventually decided to study Dutch literature and general linguistics at the University of Amsterdam. She writes stories, poetry, essays and novels. Her debut came in 1974 with The cockerels and other stories. For Tiger, tiger! (1980) she was awarded the Multatuli Prize. The Second Man (2000), and her family chronicle, '100% chemistry' (2002), made the shortlists of the AKO Literature Prize and the Libris Literature Award, respectively. With her brother, Geerten, she co-wrote Murder & Manslaughter (2005), and last year she won the AKO Literature Prize for About love.

INTERVIEW

Guest writers measured by the Technologist's Yardstick



2009 standings:

Doeschka Meijsing in mid-table

Despite the fact that Doeschka Meijsing considers TU Delft to be "the lion's den", she scores well above average, as measured by the technologist's yardstick. This was an especially good performance by Meijsing, because the leader Goldschmidt once worked as a scientific researcher. Arnon Grunberg, the self-declared 'a-technologist', and A.F.Th. van der Heijden, can both breathe easy: they remain firmly in last place. The winner will be announced in 2010.

	Question	Answer	Doeschka Meijsing	A.F.Th.	Tommy Wieringa	Tijs Goldschmidt	Arnon Grunberg	Nelleke Noordervliet	H. Brandt Cortius	H.J.A. Hofland	Gerrit Krol
			2009	2008	2007	2006	2005	2004	2003	2002	2001
1	Do you ever change a light bulb? When was the last time you did so?	*"I do. A month ago, I think."*	1	1	2	2	2	2	2	2	2
2	Do you ever patch a bicycle tire? When was the last time you did so?	*"I have, but I no longer have the strength. It takes some strength to pull the tyres onto the wheel rims. The last time probably was in the late 70s or early 80s."*	1	0	2	2	0	2	2	1	1
3	Can you change the oil in your car? When was the last time you did so?	*"Yes. When did I last take a long car trip? In 1994. And I could still do it."*	1	0	2	2	0	1	0	1	0
4	Can you change a car tire?	*"Yes, and I did, on a busy country road in France in 1987. I'm very good with dates."*	1	0	0	2	0	1	2	1	1
5	Do you ever use a power drill?	*"Yes, I don't have a problem with them."*	2	1	2	2	1	2	2	1	2
6	Can you follow the instructions and assemble Ikea furniture?	*"No. Sure, I can put up a bookcase. And I can put together a baby chair as well. The manuals are usually all right, there are no sudden Japanese words in them. The problem is that there is always one part that is either too big or too small for the hole it's supposed to go into."*	1	1	-	1	0	1	1	0	1
7	Can you assemble Ikea furniture without following the instructions?	*"No."*	0	1	-	0	1	0	0	0	1
8	Are you able to understand consumer electronic instruction booklets?	*"No, no way. I can't even read the stuff."*	0	1	1	1	0	1	0	1	0
9	How many toolboxes do you have?	*"One. It holds a hammer, a pair of pliers, screwdrivers, rulers, a spirit level, a small saw and a welding set. I can't weld, but it's in there anyway."*	1	1	2	1	0	2	1	1	2
10	Do you write using a computer?	*"Yes, up to the summer of 2007 I wrote longhand in large folio volumes. I stuck to longhand because the hand is closest to the heart, but all that writing gave me arthritis."*	1	0	0	1	1	1	1	1	1
11	Do you use the Internet?	*"Yes."*	1	0	1	1	1	1	0	1	0
12	How many hours per day do spend at your computer?	*"One day a week when I'm not writing. And when I'm writing, three to four hours a day. That's my limit."*	2	0	1	2	2	1	2	2	1
13	Can you fix computer problems yourself?	*"Some very minor problems. I can find the battery. When I need to change things, I know to look under 'programs', but I do lose texts. Even when I was writing 'About love'. I suppose it just has to be that way."*	1	0	2	0	0	2	2	2	0
14	Is your computer protected by a virus scanner and/or firewall?	*"Yes."*	1	1	1	1	1	1	0	1	0
15	Do you install and maintain them yourself?	*"Yes, I do the updates."*	1	0	1	0	0	0	0	1	0
16	Can you communicate with the helpdesk if you're able to reach it?	*"No, not at all. I don't understand what they're talking about."*	0	1	1	1	1	1	0	1	0
17	Have you ever had an idea for an invention, or did you ever formulate a technological question?	*"No."*	0	1	1	1	0	1	1	1	1
18	Have you ever actually invented something or put something similar down on paper?	*"I know how to use one hand to flip matches like flaming arrows. Lots of children must have discovered that trick. I've also discovered how to make my entrance at a reception. I also know how to lie. I seem to have made quite a few inventions after all…."*	1	1							
19	Have you ever actually realized an invention and how often?	*"Lots of times."*	1	0	0	1	0	0	1	1	1
		Total points:	17	10	19	22	10	20	18	20	15
		Final score:	6.3	3.7	7.9	8.1	3.7	7.5	6.7	7.5	5.5

"When I was thirteen-years old, I already couldn't stand the idea that all things must pass."

"Evelyn Waugh once said: 'My theme is memory'. And so it is for me. When I was thirteen-years old, I couldn't stand the idea that all things must pass. Happy out on my swing in the sunshine I would think: 'How can I hold on to this? I really need to remember what this was like.' I started doing that because I thought: 'By the time I'm stuck in one of those hairdresser chairs in an old folks' home, unable to do anything, at least I'll be able to reread everything.' Even if I were to lose the ability to speak or read, even if I couldn't recognise my own mother. If I'm not demented, perhaps I'll always have that book, that overflowing book of memories."

Pip's memory of her first crush on a female gym teacher is triggered by a DVD. Another one of those things that replace memory, but it can also help memory.

"Pip is given the DVD. There are also songs that make you think of an LP cover. All these things that make it easier for us... I often have trouble getting to grips with new updates for computers. And why must I take photos with my telephone? I think it's foolish. My girlfriend wanted a digital camera for her birthday, so that she could burn the photos onto a CD. Those photos will never get printed, because you can look at them on your computer. And that's why I don't have a photo of my stepson. They're all on Xandra's computer. Of course you could have them printed, but you don't. It used to be such fun to receive the printed photos from your film roll in an envelope."

'About love' is a largely autobiographical book about your break-up with Xandra Schutte [a well-known Dutch journalist – ed.]. In writing this book, you exposed a lot about yourself and Schutte. What gave you the nerve and courage to do this?

"Looking back, I no longer know. Of course, the book was written close to the edge. Truth and fiction are very close to each other. It's frightening to offer a glimpse of what's within. It most definitely wasn't going to be a militant novel against an ex. But I had to write that book. What else could I do? Jump in front of a train? My fear was that the reviewers would start to unravel exactly who's who, but there was no trace of that in the reviews, and this is owing to the incredibly restrained style I used in the book. To a certain point and no further. When I printed out the first chapter, I didn't like it at all. But then I was in no mood for laughter. My publisher said: 'Doeschka, I think this is the best stuff I've ever read on the subject.' That was the first time I misjudged myself. Later I thought: this is indeed funny. Good jokes. And that's also what gave the book its fame: how heartache is mixed with harsh jokes."

Even though you weren't in the mood at the time.

"Yes, but regardless of how dark my outlook is, I always make negative, blackly funny jokes. It's a god-given piece of luck, an associative mind. Humour is my saviour. The mechanism is built into me: always see what a rotten position you're in, and then have a good laugh at your own expense. After all, we are often in rotten situations, or at least we think we are."

The book also touches on a mathematical problem, the Poincaré conjecture. 'Something involving a lasso around a spherical object I think,' a friend of Pip says in your book. Can you explain what the mathematical problem is about?

"No. I couldn't even do so when I was writing it down. I'll have to look it up in the encyclopaedia. [Meijsing thumbs through her old encyclopaedia.] 'Poincaré achieved fame for his research in the field of function theory and partial differential equations.' A few years ago I saw a drawing in the newspaper, showing a red thread and a sphere. The thread was curled, and the question was if the point where the thread touches the sphere could be calculated using differential equations. It's said to be possible."

The Russian, Grigori Perelman, whom you also mention in your book, solved that problem. He then refused the prize offered for the solution, worth millions, and disappeared from the face of the Earth.

"That is the epitome of effective mind power. I read about him in the newspaper. His mother fed him while he worked relentlessly on his calculations. And then I suppose he just decided enough was enough. He didn't understand this world anyway. He just understood Poincaré's numbers."

Students at a university of technology won't be quick to associate this conjecture with the break up of an older lesbian's relationship.

"No, but they should be able to imagine someone who desperately wants to reach a certain point and then disappear. Everyone has these moments when everything seems to be going against you and you feel the best thing you could do would be to jump off a bridge."

Have you done anything nice with your prize money for winning the AKO Literature Prize?

"I bought a gift, and then there's my mortgage to pay off. I'd like to take a trip to New York with Xandra. The rest will just be spent on living."

Photo: Sam Rentmeester/fmax

Q-dots

It's the latest rage in solar cell research: semiconductor crystals measuring only a few nanometres. These crystals could provide the basis for inexpensive and extremely efficient solar panels, but research on them has only just begun. Even so, chemical engineers at DelftChemTech (Applied Physics) are now able to create crystals exactly how they want them. Nano crystals absorb light with a wavelength that is dependent on their size. Being able to control their size means the quantum dots can be tuned to any colour. The 'bigger' they are, the redder they are.

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Magnetic brainwaves

TU Delft researchers visualise neural connections

The mental disorders that often accompany old age can largely be attributed to the erosion of connections in the brain. Researchers at TU Delft are now developing new ways of mapping the decaying brain. "This project is of great social importance."

Jos Wassink

Hemmed in between three high-rise apartment blocks lies the unimposing grey building of the Ommoord Health Centre. From the outside, nothing suggests that this is where the Rotterdam Study (see text box at page 22), a major epidemiological study of health in old age, is being conducted. Ommoord, a district in northwest Rotterdam, was selected because the area was deemed a representative model for the Dutch population as a whole, and perhaps also because Ommoord is situated close to the Erasmus Medical Centre (Erasmus MC), the Netherlands' largest academic medical centre.

At the Ommoord Health Centre, a steady flow of people aged 45 and over comes in to enrol for the population survey. Upstairs they undergo bone scans, eye tests, and ultrasound tests of their cardiovascular systems and blood vessels. Downstairs is where the neurological tests are done for cognitive alertness and motor skills, plus a brain scan using the centre's MRI (magnetic resonance imaging) machine. The neurological aspect of the Rotterdam Study is the responsibility of Dr Monique Breteler, professor of neuroepidemiology at Erasmus MC.

Essential

In a recent article in NeuroImage, a journal of brain function, researchers at Erasmus MC wrote that a special imaging technique known as DTI (diffusion tensor imaging – see text box at page 22) could shed new light on how white brain matter changes as the brain ages.

A section of the brain showed grey matter on the brain's outer part, and white matter on inner part. The grey matter mainly consists of the cell bodies of nerve cells, whereas the white matter is comprised of connections between brain cells – extensions of nerve cells sheathed in a layer of protective white myelin, which explains the white colour. Good connections are essential for the brain to function well. A loss of white matter is associated with Alzheimer's disease, dementia, and schizophrenia. The question now is what causes the loss of white matter to commence.

"We know that various diseases and ageing cause myelin to break down. The result is that axons – the nerve cells' extensions – are dismantled," says Dr Wiro Niessen, who as professor of medical image processing works at both Erasmus MC and TU Delft. "This causes a fibrous microstructure of nerve bundles to change into a more amorphous structure.

'If you can delay the onset of dementia by one year, it will save society billions'

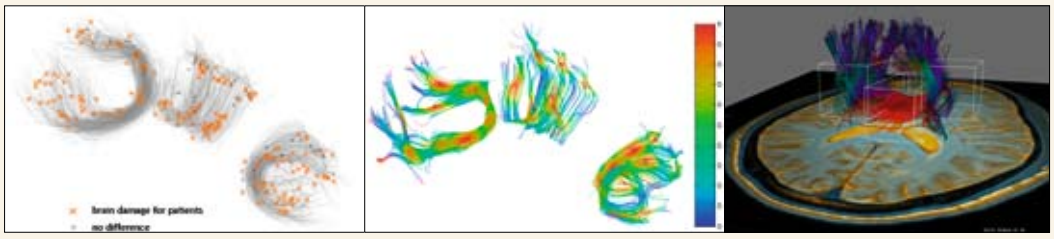
Something changes inside the brain's nerve channels at a microscopic level and this alters the MRI signal. The current thinking is that we may be able to use DTI techniques to measure the damage to the white matter at an early stage." It is hoped that early detection of dementia could help slow down the progression of the disease. Niessen: "This knowledge will certainly allow us to better manage patients. If we could delay the onset of dementia by a year, it would save society billions. This project is of great social importance."

"Do you know what diffusion is?" lecturer Dr Frans Vos asks, when asked to explain the principle of diffusion tensor imaging, or DTI. This new MRI technique is currently being developed further ▸▸

Photo: Noor Steenkamp/fmax

The Rotterdam Study

The Rotterdam Study (RS) is a world famous epidemiological research project that since 1990 has been conducted by Erasmus MC in Rotterdam, upon the initiative of epidemiologist professor Dr Albert Hofman. The research focuses on the study of cardiovascular diseases, neurological disorders, ophthalmology, and metabolism disorders. The study was conceived in the mid-1980s in the context of an increasingly aging population. Experts, foreseeing a sharp increase in health problems among the elderly, wanted to initiate a study that assessed the risk factors of diseases associated with old age. The research was set up as a continuous study over a long period of time. In 1990, every person aged 55 and over and living in the Rotterdam district of Ommoord was invited to participate. A total of 7,983 people (78 percent of those invited) agreed to participate. Every four years the participants are given repeat examinations. In 1999, a new group of people aged 55 and over was added to the survey (the RSPlus group), and in 2006 another 6,000 participants from a younger group of 45 and over (RSYoung) were added. In total, the study currently involves 15,000 participants aged 45 years and over.
An MRI brain scan is part of the examination. The brain scans revealed that many people in the study group suffer from brain disorders, often without them being aware of it. In addition to unnoticed infarcts in apparently healthy participants, the researchers noticed changes in the brain's white matter (containing the connections between brain cells), which is assumed to be associated with increased risks of dementia, strokes or depression. This raises the question as to what causes the onset of brain disease.



About DTI

DTI is a technique that uses MRI (magnetic resonance imaging) to visualise nerve paths. The idea dates back to 1991, when neurosurgeon Dr Aaron Filler postulated that it would be possible to trace the path of nerves by means of the differences in the diffusion of water molecules in various directions. Water will easily diffuse along the length of a (insulated) nerve fibre, but hardly at all in a direction at right angles to it, unless, that is, the myelin insulation breaks – but we are getting ahead of ourselves. Diffusion is based on the Brownian motion of molecules, which under normal circumstances is identical in every direction. Put a drop of ink into a glass of water and you can observe the process in action. In 1827, Robert Brown, a Scottish botanist, ascribed the spreading motion to molecular collisions. In a living organism, however, cells, blood vessels and nerve fibres prevent unlimited diffusion. An MRI scanner can visualise the diffusion. This is done by using two strong, short pulses. The first pulse knocks the nuclear spin out of phase, and the second pulse realigns it. In a stationary water molecule, the two pulses will extinguish each other, but if diffusion has caused a water molecule to move in the meantime, the second signal is attenuated. The attenuation level is a measure of the extent of the diffusion. However, diffusion is also direction-dependent. This is why in DTI (diffusion tensor imaging), the diffusion is measured in at least six directions. For each volume element, or voxel, this results in a kind of zeppelin shape that reveals the extent of the diffusion in each direction — a slender zeppelin points to a more directional diffusion. The main diffusion direction is often indicated by means of a colour code, with red for left-right, green for front-rear, and blue for up-down. Researchers have also developed an indicator value – the FA (fractional anisotropy) – to show the degree of directionality, or anisotropy, of the diffusion. If the myelin sheath around a nerve strand is damaged, the FA value will be measurably reduced.
A DTI scan results in fifty to sixty slices of 128 x 128 pixels, each of which represents a 2 × 2 × 2 millimetre cube. Such a DTI scan takes approximately ten minutes to complete.

Healthy senior citizens undergo MRI brain scans as part of the Rotterdam Study.

by the Quantitative Imaging research group of TU Delft's Faculty of Applied Sciences' department of Imaging Science & Technology. To explain anisotropic diffusion, Vos uses a piece of tissue paper and a sheet of newspaper. A drop of ink spreads evenly (isotropically) on the tissue, forming a wet circle; however, on a newspaper, the result is an oval-shaped spot, because diffusion takes place more rapidly in one direction than in the other. In other words, anisotropic diffusion occurs. To explain the diffusion that occurs in nerve strands, Vos is ready with an analogy: "Isotropic diffusion is water that

'A biomarker allows you to recognise whether a person is destined for normal old age, or for one that involves Alzheimer's'

can go anywhere. Now, suppose you drop a bunch of spaghetti into water. The water can flow along the length of the spaghetti, but not at right angles to it. The same happens in white matter – water molecules inside white matter strands can move easily along their length, but with difficulty at right angles to them, because they are stopped by the cell wall and myelin layer."

DTI is an imaging technique that so far has been used mainly in academic medical centres. Neurosurgeon Aaron Filler invented the technique in 1991. DTI adds a sensitivity for biological microstructures to MRI, which is a technique suitable for making images of the body's various biological tissues. This specific sensitivity renders the technique highly suitable for creating images of nerve bundles, as MRI images are often too coarse for this. More generally, DTI is considered a suitable method for brain scans, allowing for clear images of strokes, white matter, and interconnections inside the brain.

Even so, DTI technology is far from fully developed. "Making images is only the first step. After that comes the interpretation stage, and that's not simple," Niessen says. "There is a lot of noise, we're dealing with complex anatomy, the nerve strands are narrower than the resolution of the scanner, and the nerve strands are all criss-crossed. We end up with an enormous amount of data about nerve strand topology, but is requires modelling to convert that data into a useful image. And a medical degree can't help you there: you need engineering, mathematics and information technology. That's where TU Delft comes in."

Using DTI to study the development, diseases and degeneration of the brain's white matter is an active research area: since 2005, more than 2,500 research papers have been published on the subject.

Less damaging

"We are always on the lookout for new ways to extract additional information from the data," says Matthan Caan, a PhD student who, like his supervisor Dr Frans Vos, also works at both TU Delft and the Amsterdam Medical Centre (AMC). At the AMC, Caan researched the side-effects chemotherapy had on the brains of young cancer patients. To do this, he used a form of DTI analysis, ▸▸

called tractography, to track the paths of the nerve extensions. Put simply, this amounts to picking a starting point and then following the direction of greatest diffusion, assuming that this corresponds with the direction of the nerve strand. This results in an image of gossamer-thin traces that represent the tracks of nerve strands inside the brain.
For his research, Caan had two sets of six brain scans from children being treated for cancer with chemotherapy. Half of the patients had received a high dose, while the other half a lower dose. Could Caan tell the difference? To measure the diffusion, he decided to focus on the corpus callosum, which is the thick nerve bundle that connects the two halves of the brain. He collated the data for all the young patients to get average values, and then, for a certain length of the nerve strand, calculated the deviation from the average value. Caan: "Normally, you'd be looking at each individual point in turn, and you wouldn't notice much of a difference from the average. We combine measurements across a much wider range to see whether the anisotropy decreased across the entire bundle. This better matches the hypothesis for the side-effects, which is that chemotherapy affects the white matter."

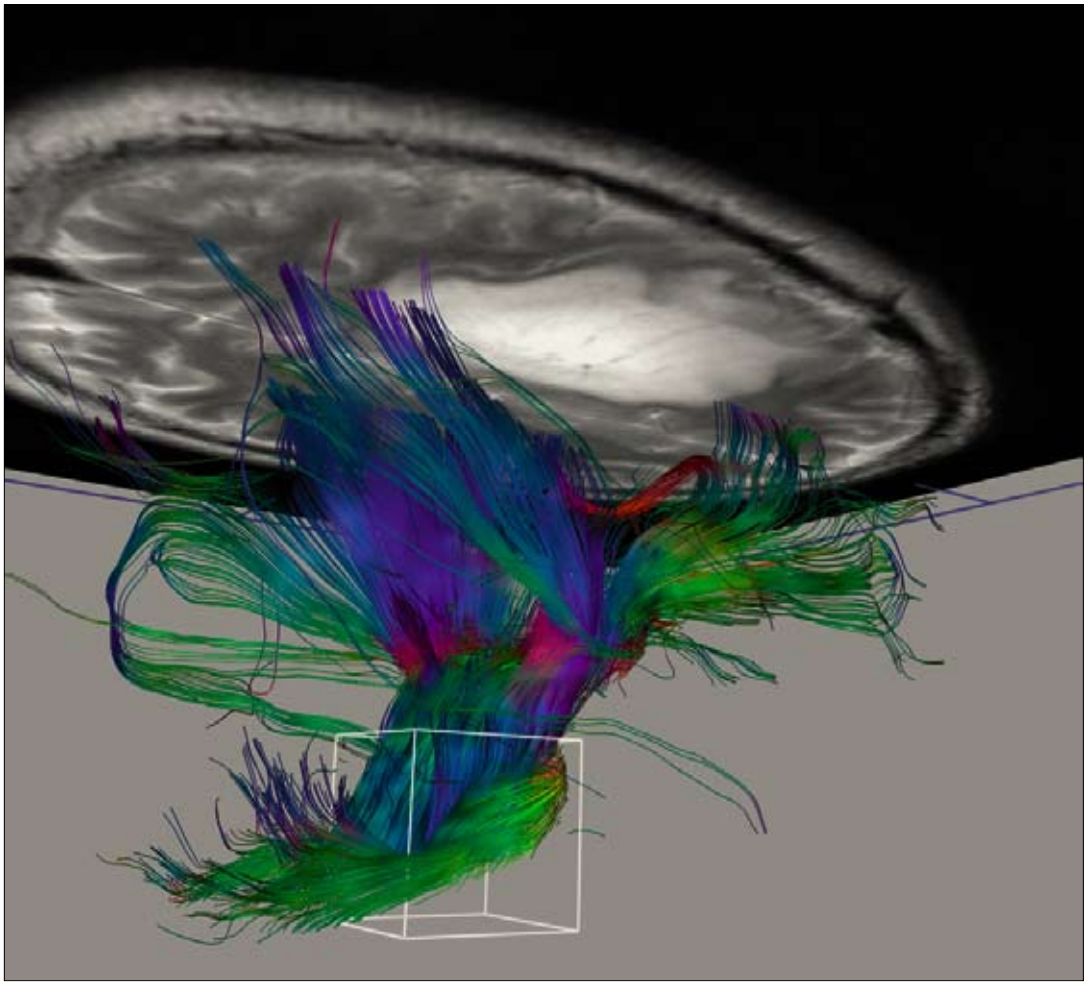
'Interpreting the vast amount of data requires engineering and information technology. That's where TU Delft comes in'

Caan was able to demonstrate that reduced doses of chemotherapy cause considerably less damage to the brain. The brain damage in the images produced by Caan also matched the clinical data – the worst affected patients had on average a lower IQ and took longer to understand a joke. Other research has shown that the lower dose was just as effective in terms of fighting the cancer, meaning the treatment could be safely adapted.
One reason Caan chose to study the corpus callosum is that its nerve bundles largely run parallel to each other. Once nerve bundles diverge, their paths become much more difficult to trace. This is the job of yet another PhD student, Ganesh Khedoe. He will expand the tractography (i.e. the tracing of nerve strands) to include crossing strands that cannot be differentiated using a standard DTI. Khedoe: "I want to identify specific strands inside the brain. They could come from different brains, or from the same brain but at different times. I will look for differences between them."

Biomarker

"We're concerned with the clinical added value of images showing the degeneration of nerve strands," says Niessen, who is involved in the Rotterdam Study. "It's not about a single image, but about statistical analysis. We collect hundreds, thousands

Frans Vos: "Water molecules in the brain's white matter can move easily length-wise, but with difficulty in a perpendicular direction."



A reconstruction of the nerve bundles of the corpus callosum.

of images of people's brains, and we track what happens to them. This provides us with a gallery of images and a library of life stories and problems. Statistics and the way Alzheimer's disease affects the aged have led us to believe that DTI images could be used for early diagnosis of neurodegenerative disorders. We are now in the process of finding out whether that is true."

Research like this requires a long-term population study, because researchers are looking for brain scans that long predate the moment when a person visits a neurologist. Among the roughly 5,000 people participating in the Rotterdam Scan Study, a significant number of them will ultimately develop Alzheimer's disease; however, by that time there will be scans showing their brains before and after the onset of neurological complaints. This constitutes unique material for scientific research. Niessen: "We will use statistical methods to look for differences between people who do and do not develop Alzheimer's. Will we then be able to use brain scans to predict how the disease progresses? Thanks to our collaboration with TU Delft, we are now better able to quantify the images, and ultimately answer the question as to which number best predicts the course the disease will take."

"That is the holy grail of this research," Vos acknowledges. "We are looking for what we call 'biomarkers', specific indicators of a certain disease. A biomarker allows you to recognise whether a person is destined for normal old age, or for one that involves Alzheimer's. We believe such a biomarker is hidden among the diffusion data."

According to Niessen, discovering an Alzheimer biomarker is mainly a question of time. The DTI scanner tests in Rotterdam started in 2005. "In two to three years' time we will have a follow-up covering five to six years," Niessen says. "A number of people will have then been scanned a second time. I expect that we will have conducted the first tentative studies by then, and we can look forward to a solid statistical basis in five years' time. Whatever the case, we're certain to get some results."

The question remains as to how this knowledge will be used. After all, you can hardly perform preventative scans on every Dutch person aged 45 years and over. Niessen's view is that an MRI scan would be reserved for people with an increased risk of Alzheimer's disease, assuming, of course, you can indeed identify this group.

Niessen: "Initially we hope to discover more about what takes place during dementia. Such knowledge would certainly help improve the treatment of patients. The obvious course would be to apply it to early diagnosis and preventative therapy. But how exactly everything would work out depends on the accuracy of the prognosis, among other factors. There is still a lot of research required for this."

Ganesh Khedoe: "I want to identify specific strands inside the brain."

Life begins at forty

The red Dutch mailboxes, the emergency roadside telephones, the Senseo coffeemaker and the SENZ umbrella. Alumni and staff of the Faculty of Industrial Design Engineering have certainly made their mark on the Netherlands. In 2009, the faculty celebrates its fortieth anniversary. A proud milestone, yet the faculty's innovative drive remains as great as ever.

Robert Visscher

Entering the Faculty of Industrial Design building, one cannot help but notice the bright green banner proudly proclaiming that the faculty has now been around for forty years. Scores of students bustle past, narrowly avoiding the car chassis parked beneath the banner. In this cavernous space, students sit busily sketching their latest new design ideas between the empty coke cans and yoghurt containers strewn across the lunch tables.
This relaxed atmosphere of lunching, sketching, thinking, tinkering, and organising has characterised this faculty since its inception. Even so, a lot has changed over the years: the number of students has increased considerably, the faculty's home is now a state-of-the-art building on the Landbergstraat, and even the faculty's reputation stands in stark contrast to what it was in the 1960s.

Hardly academic

In 1968, a handful of pioneering students were the first to enrol in what was then known as the Technical Industrial Design programme, and which, as an enrollment prerequisite, required students to have their first-year architecture diplomas.
Industrial design engineering in Delft was born, but the achievement did not come without a fight.
In the early 1960s, various Faulty of Architecture instructors, led by Joost van der Grinten (1927), had embarked on a lengthy struggle. "It wasn't until 1969 that our programme received the recognition it deserved. That was when Technical Industrial Design received an independent status with an engineer's degree of its own," says retired professor of industrial design and former faculty dean, Dr Hans Dirken. In 1968, he was one of the three people who began teaching this new course. "We were rather looked down on by the rest of the university," Dirken recalls. "They thought we were too much into aesthetics, and that we would probably be more at home at an art college. The general view was that our programme was hardly up to academic standards."
There was little truth in this criticism, Dirken says. "We engaged in research right from the start. Of course, we didn't have many people with PhD degrees on our staff at the time, but the same applied to the rest of the university up until the 1980s. I had always tried to get the name of the faculty changed from Applied Industrial Design to straightforward Industrial Design Engineering. Applied design led to a misconception, as if the outside of an object was all that mattered to us. Nonsense, of course. The technological side has always been just as important as the design."
Despite such misconceptions, Dirken looks back on the early years with nostalgia: "We were pioneers. We actually had to invent the course from the ground up. It was pure improvisation. Teaching industrial design was the red thread running through the entire enterprise."
The students in those days were drawn from a wide variety of backgrounds, and included former chemical and mechanical engineering students.
The now professor of Industrial Design, Jan Jacobs, was one of the first students to enrol in the new programme. He began his university studies at the Faculty of Architecture, but wasn't satisfied. "All of us wanted to design products. We had young teachers, and everybody was really enthusiastic. Protests at our faculty were practically non-existent in the tumultuous 1960s and 70s."
Initially, the industrial design students had to visit other faculties for many of their courses. "Analysis, for example, was taught at the chemistry faculty. We also had to take lots of mathematics and metallurgy courses to keep up to TU Delft standards."

'We were pioneers. We actually had to invent the course from the ground up'

The first assignment the students were given was to design a fishing cabin at the Faculty of Architecture. This was followed by a prefab doorframe. The nutcracker was another notable assignment. Jacobs: "Today, that nutcracker wouldn't be made much differently. At that time the object was made of wood, while today you would use plastic, but the stresses are still the same."
Jacobs graduated in 1973: his graduation project was the design of a piece of office furniture. "That was a great shock," he says, laughing. "It just wasn't done at a polytechnic institute. Automotive design was another definite no-no in Delft. Now, of course, things have changed for the better. One of my graduates, Adriaan van Hooijdonk, is now a top designer at BMW, the car manufacturer. At least today we're allowed to be proud of that."
A vital part of the industrial design training was the graduation project, which the students completed during a one-year internship at a company. ▸▸

Former dean Dr Hans Dirken: "We were rather looked down on by the rest of the university."

Anniversary festivities

The fortieth anniversary of the Faculty of Industrial Design Engineering will be celebrated throughout the year with lectures, conferences, and an exhibition in the Kunsthal museum in Rotterdam. On 8 April, Dr John Ehrenfeld will give a luncheon lecture at the faculty. Prior to retirement, Ehrenfeld held a position at the prestigious MIT Center for Technology, Policy and Industrial Development. Late last year he published his magnum opus, 'Sustainability by Design'. The anniversary year will also be marked by a number of conferences. On 13 May, the conference subject will be Context Mapping; in September, a conference will celebrate a decade of Design & Emotion; and in October, the Living Symposium will be held. The anniversary year concludes on 19 December with the opening of an exhibition covering forty years of TU Delft Industrial Design, held in the Kunsthal in Rotterdam.
For more information: www.io.tudelft.nl/evenementenagenda.

Dirken: "In that commercial context, the students were forced to think about the development of a new product. And as a teacher you also learned a lot there, because you were exposed to every aspect of the design process."
As an example, Dirken recalls the design of an ambulance that provided space for a traumatologist. "It turned out that many people died in the ambulance en route to the hospital. Since a traumatologist greatly improved a person's chances of survival, the new design included space for this important member of the medical team. This assignment brought me into contact with vehicle technology." Dirken, who studied at the University of Amsterdam and Cambridge University (UK), specialising in statistics, psychology, physiology and ergonomics, considers the multifaceted nature of the industrial design programme to be one of its major assets.

Milestone

During those early years, the faculty had no home of its own. Students and staff would roam between buildings scattered all over town, from the Oude Delft and Julianalaan to the Ezelsveldlaan. In 1973, however, Industrial Design won a major battle: the programme was awarded the status of sub-department (in those days, TU Delft had departments rather than faculties). In addition, a dean was appointed: founding father Emile Truien (1928-2003), who since1962 had joined with Van der Grinten in fighting hard to get the new faculty off the ground.
The ultimate victory however did not come until the 1984, when Hans Dirken, who had succeeded Truien as faculty dean, was appointed TU Delft's rector. The faculty staff regarded this as a milestone on the road to recognition for the Faculty of Industrial Design Engineering. "As rector, you would of course never favour your own faculty, but I also never discredited industrial design either," Dirken says. "It was important that for once the rector was an industrial design man. This showed that we were indeed being taken very seriously."
In the meantime, student enrollment numbers were rapidly increasing, making Industrial Design a large and important faculty – no longer the odd one out in Delft. Its acceptance and popularity were partly due to the efforts of the staff and teachers who left their mark on the Netherlands through a series of eye-catching designs, like the red Dutch mailboxes and yellow emergency roadside telephones.
The success of Industrial Design can also be traced back to the fact that from the very beginning the subject was wide-ranging. "In alumni surveys we always ask what graduates really learnt during their student days," the current dean, Professor Dr Cees de Bont, says. "The results show that students appreciate the fact that they really learnt how to analyse problems. Our curriculum teaches them to investigate the origins of a problem, and provides them with the necessary techniques for tackling the problem. They learn how to think outside the box and how to turn improvements into concepts."
De Bont studied the psychology of economics at the University of Tilburg, and in 1992 he received his PhD degree from TU Delft's Faculty of Industrial Design. Looking back, he believes the main difference between today and twenty years ago is that the programme has become more international: "That goes for the nationalities of the students and staff, as well as for the way we

collaborate with companies abroad."
De Bont says that today there is greater focus on finding "different design approaches". To illustrate this, he cites an industrial design PhD student who is currently developing an information system for people in remote areas of India, where illiteracy is rife. "Information about hygiene often fails to reach these people. Some women don't even know why they menstruate. Many of the infections that occur in these rural areas could be prevented. Our PhD student is developing a system that can impart this kind of vital information."
The first pioneering industrial designers were of course also engaged in tackling social problems. "However, they primarily designed things that go thud when you drop them," De Bont says, "and although that is still a feature of industrial design, we also teach students that a 'thing' is not always the best solution to a problem."
Jacobs provides the figures that support De Bont's assertion. In the early years of the faculty, ninety percent of the graduation projects involved an object, compared with thirty percent today, with the other projects now involving concepts, ideas, plans

'They primarily designed things that go thud when you drop them'

and strategies. "On the one hand, it's a pity for the pioneers like me, but on the other it reflects the spirit of the age. Today, Western society carries the conceptual side of design on its shoulders."
New products designed by former faculty students are still conquering the world – just think of the Senseo coffeemaker. "It was designed by an industrial designer, but the product manager, the business manager, the packaging designer and the person who designed the sound also came from our faculty," De Bont says. The most recent success story is the SENZ umbrella, which is also enjoying commercial success in the United States and Japan. "And let's not forget Windows Vista, which was partially designed by one of our alumni," De Bont adds. "All this illustrates the great versatility of our alumni, which we're very proud of. Industrial designers bring experts together, consider the context, and are very good at directing specialists. They have a bird's eye view."
This is also becoming increasingly apparent within TU Delft, De Bont adds. The Faculty of Industrial Design Engineering participates in numerous research projects, including one, involving electric cars, that entails collaborating with the faculties of Applied Sciences and Electrical Engineering. Such

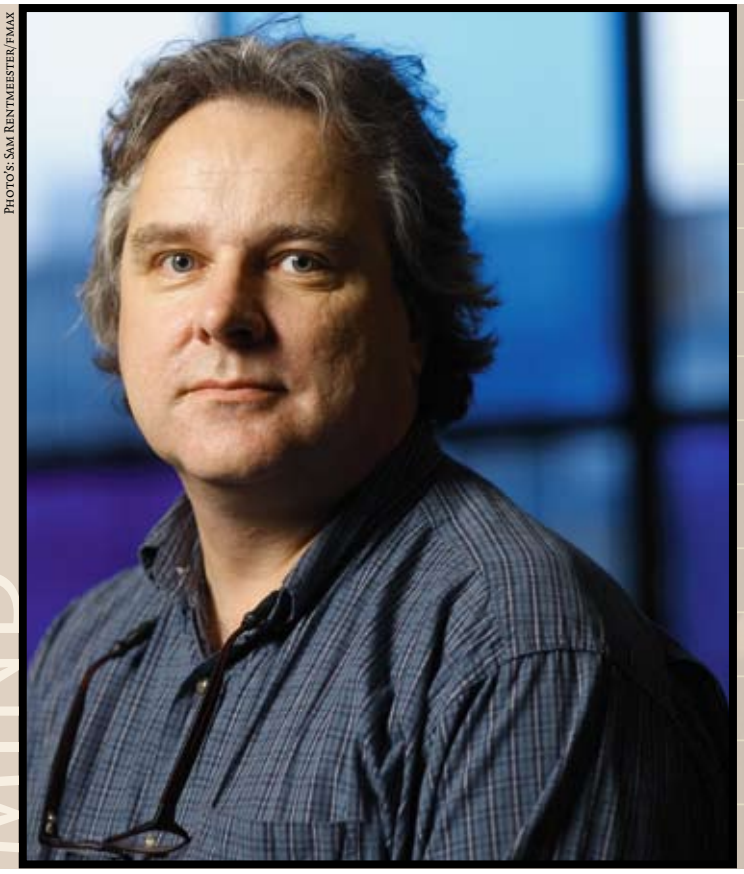
The former Faculty of Industrial Design in the late 1980s.

initiatives have gradually led to the acceptance of Industrial Design as a fully-fledged member of TU Delft's technological team, despite the occasional grumbles to the effect that the curriculum is too light on mathematics.
The faculty's great diversity is also prominently displayed in De Bont's conference room, where visitors can view a new design for a guitar, a 'lifestraw' that turns polluted water into clean drinking water, a wheelchair that can do wheelies, and a colourful cake stand.

Innovation

De Bont points to the inauguration of the new faculty building in 2002 as a high point in the history of Industrial Design at TU Delft. This however was preceded by an all-time low in the late 1990s, when the faculty was merged with the Faculty of Mechanical Engineering, because the then TU Delft Executive Board decided it wanted to reduce the number of faculties. "We were being marginalized," De Bont says about that time. Jacobs also vehemently opposed the plan, and led the opposition against the merger, which was finally rolled back in 2004. During the same period, several of the faculty's professors left, leaving a large void in the teaching staff, which happily has now been filled. Jacobs: "Seven or eight new, young professors are now leading the way, which is great for the faculty's dynamic and revitalization."
The three generations of industrial designers are extremely proud of the forty-year milestone. "Forty years seems young for a university faculty," De Bont says, "but in the world of design that's quite a respectable age. We are one of the world's oldest industrial design faculties. Fortunately, forty years is an age you can still celebrate. At forty, you're in your prime. You've passed puberty and gained your independence from your parents, but you're not yet overripe. At forty, you're still very ambitious in wanting to change things. It's a good age, and one that reflects the current state of our faculty."


Jacobs: "Seven or eight new young professor are now leading the way, which is great for the faculty's dynamic and revitalisation."



Photo's: Sam Rentmeester/fmax

Professor Dr Nick van der Giesen

"Supervising a doctoral student is a subtle game. It takes mutual trust."

Relaxed

Professor Dr Nick van der Giesen began his academic career at the University of Wageningen, where he studied land and water management. For his doctoral research he moved to the United States, where he conducted research at Cornell University as a land and water engineer. His work took him to Rwanda and later to other parts of the African continent. In 1998, he moved to Bonn, Germany, to take up a position as a university researcher. It was at Bonn University that he met Jan Friesen, who was still a student at the time. In 2004, Van der Giesen was appointed professor of water management at TU Delft, where he met up with Friesen again, and served as Friesen's supervisor during his doctoral research on groundwater in West Africa.

George van Hal

In the **Mastermind** series a professor and a (former) student each answer the same questions to create a double portrait.

How would you describe one another?

Van der Giesen: "Jan is a bit dour, but a hard worker. Very reliable. If he can't do it, nobody can. It won't be an excuse. He doesn't normally use a lot of words, but he did when he was defending his thesis. That surprised me. My conclusion is that he knows how to talk, but he just doesn't like to."

Friesen: "I've known Nick for a long time. He knows a lot about a lot of things. Not only does he understand his own field, but he also knows a lot about the life sciences and economics, for instance. And you can trust Nick. I started here on a one-year contract and knew in advance that if the remaining funding for my doctoral research failed to materialise, I wouldn't find myself out on my ear. Nick takes care of things like that. On top of that, he's very relaxed to work with. I've never seen him angry. And he's a good squash partner!"

What has the other done for you?

Van der Giesen: "We've known one another for nine years now. When Jan received his doctorate, some people in our department put up a picture on the bulletin board as a joke. It showed his face gradually changing into mine. The message was clear: we've grown increasingly more like each other. A bit like a dog and its master, although I wouldn't want to nominate either of us for the role of the dog. Over the years we've become real friends. Next Friday, Jan will be moving abroad, and I will be helping him carry his washing machine downstairs, just like I helped him carry it upstairs when he moved in. He's also helped me move house three times now. So, while we may be student and teacher, that is only one aspect of a larger whole."

Friesen: "Nick's door is always open. The thing is, he's getting busier all the time, so it was becoming harder to arrange meetings. Even so, I'd often see him during the weekends. On holiday I'd talk to him using Skype or a webcam, often from one time zone to another. He helped me enormously with the most complicated parts of my thesis. All in all he's a very good guy to work with. On the other hand, he does sleep very late."

What's the essence of a good teacher-student relationship?

Van der Giesen: "Mutual trust. Supervising doctoral research is a subtle game, because the doctoral student gives more to the supervisor than vice versa. All that time the doctoral student is slaving away, yet the supervisor's name is also listed in the publication. On the other hand, the supervisor provides the means and his network, makes sure his student succeeds, and teaches him proper scientific thinking. It's a symbiosis that is not always fully understood."

Friesen: "Nick was my daily supervisor, which I think is fairly unusual here at TU Delft. It was

Dr Jan Friesen

"We've grown increasingly more like each other"

Dour

Dr Jan Friesen was born and raised in Bonn, Germany. In 1996, he attended Bonn University, where he majored in geography, and minored in urban planning, land and water management, and sociology of developing countries. He conducted research on rainfall in northern Ghana, and completed his Master's degree in 2002. He then decided to go abroad, ending up in Delft in 2003, where he started on his doctoral research. His supervisor turned out to be Nick van der Giesen, whom he knew from his Bonn years. Friesen has recently completed his research on groundwater in West Africa, and has received his doctorate.

important to me that he was honest. I had to really know when he could help me and when he couldn't. He was also very important to me in a networking capacity, knowing who knows what, who my colleagues are, and so forth."

Name a recent event that left a deep impression.
VAN DER GIESEN: "The Gaza war. The news usually doesn't affect me much, as it fluctuates too rapidly, and for an engineer it's just noise superimposed on the essential signals. I normally pay attention to the wider view only. Although my sympathies lie with Israel, this was a very strange and cynical action."
FRIESEN: "I defended my thesis in December. I'm also starting a new job in February, for which I'm moving house abroad. These things tend to crowd my mind a bit at the moment."

What is your favourite television programme?
VAN DER GIESEN: "I don't have a television. On purpose. If you have one, you tend to get sucked into watching. People everywhere are just sitting there, staring at the box. Sixteen million Dutch people not using their brains at all. What a waste! If all those people were to start doing something intelligent for just one hour, we'd have the credit crunch cracked in no time. Of course there is good television too, but there's so precious little of it. I've seen Geert Mak's modern history of Europe, on the Internet. And I've only just recently watched 'My Name is Earl' on DVD. Jan has also seen it."
FRIESEN: "Yes, that was fun. I've also watched the occasional 'Mythbusters' episode on Discovery Channel, which I liked very much – especially the way they kept blowing things up!"

Name a place you don't like to be in.
VAN DER GIESEN: "I don't like buses and DIY stores. I used to suffer from travel sickness, and I really hate the way a bus interior smells. When I was a student in Wageningen, I often had to take the Sunday evening bus home. It would always be raining, and I'd be standing there waiting in the cold. Those are not happy memories. DIY stores are a bore because they take so much time. You go in to get something at two 'o clock, and it'll be quarter to four before you come out again."
FRIESEN: "I don't like public transport during the rush hours. I much prefer cycling to work; it's more relaxing. I also hate Ikea, most of all the awful Ikea feeling you get of being stuck in a cramped space with a crowd of deranged people."

Name your favourite film.
VAN DER GIESEN: "One would be CHINATOWN. It's about water, so it has to be all right. I also think GROUNDHOG DAY is brilliant. February 2nd was Groundhog Day, and we watched it again. Finally there's THE BIG LEBOWSKI, which is a very funny film."
FRIESEN: "I don't normally watch films a second time, but I'd nominate 'Black box BRD'. It's about ▸▸

Photo : Jan Friesen

Marital status
Jan Friesen: single
Nick van de Giessen: married

Hobbies
Jan Friesen: climbing, cooking
Nick van de Giessen: walking

Favourite newspaper and magazine
Jan Friesen: die tageszeitung, no special magazine
Nick van de Giessen: Economist, Wired, Haagse Straatkrant, International Herald Tribune

Invention you would like to be yours
Jan Friesen: Duct tape
Nick van de Giessen: A beautiful old mathematical theorem, like the square root of two irrational numbers is, or there is an infinite number of primary numbers. Those were the days.

the German terrorist organisation, the Red Army Faction, and it's better at showing how these people were terrorists, lunatics who were unable to control themselves, than the recently released film on the subject. Also, not many people have seen the film, which is a point in its favour."

Name a book that left an impression.

Van der Giesen: "I don't read very much. If I had to name something, I'd go for 'Malay Archipelago' by Alfred Russel Wallace, in which a biologist tells about his experiences in Indonesia. He picks up beetles, looks at butterflies, that kind of thing. Very pleasant."

Friesen: "'Travels into the Interior of Africa' by Mungo Park. The writer travels through West Africa, but whereas people like David Livingstone and others took lots of money and armies of helpers to trek across the continent, Park went on his own. He was always getting the short end of the stick, but usually managed to come out on top. For example, fairly early in his journey he loses all his clothes and has to continue on naked, wearing only his hat. Eventually he is murdered, but before that he overcomes endless adversity. If you travel through West Africa today, you can still see many of the things Park wrote about. It's a lot safer though these days."

Whom do you admire?

Van der Giesen: "People who constantly radiate energy. We have a colleague like that. He also knows how to manage his energy efficiently. He goes to sleep the very instant he lies down, and when he wakes up, he's really awake. Very impressive."
Friesen: "I admire people who are able to find the right mix between their private lives and their work, but even though I admire them, I wouldn't want to be like them. In any case, there's not a single person I admire in every respect."

An overview of the most important awards, appointments and other remarkable personal milestones at TU Delft

In December, **Professor Dr Marija Ilić** (former Yugoslavia, 1951) was appointed visiting professor of intelligent networks, a combined chair of the faculties of Technology, Policy and Management, and Electrical Engineering, Mathematics and Computer Science. **Ilić** is a professor of electrical and computer engineering, and engineering and public policy, at Carnegie Mellon University in Pittsburgh (USA). She is a world renowned expert on electric networks, a reputation she earned with Dynamics and Control of Large Electric Power Systems, which has since become a standard textbook, and with the introduction of computer control systems on mains networks after the large-scale power failures in the US during the 1970s.

Upon his retirement as professor, **Dr Joop Schoonman** was made a Knight in the Order of the Lion of the Netherlands. He received this honour for his efforts and services both to TU Delft and society at large, including extensive research in the field of sustainable energy. In 2006, he was voted the most important Dutch materials scientist of the past eighty years. Schoonman retired from the Faculty of Applied Sciences in December.

Earlier this year, transport researcher **Dr Caspar Chorus** received the prestigious Eric Pas Award for his doctoral thesis, 'Traveller Response to Information'. The award is given by the International Association of Travel Behaviour Research. In February 2007, Chorus received his PhD degree from the Faculty of Technology, Policy and Management, where he developed a model that predicts the effect of travel information on the behaviour of travellers.

In January, the British-Russian physicist **professor Andre Geim**, and the innovative entrepreneur, **Mr. Wybren Jouwsma**, received honorary doctorates as part of the festivities marking the occasion of TU Delft's 167th anniversary. Jouwsma was honoured for the innovations in gas and liquid metering he developed for his company, Bronkhorst Hightech. Andre Geim, a versatile physicist who once received the Ig Nobel Prize for keeping a frog suspended in a magnetic field, also contributed to the development of gecko sticky tape and to the current research into graphene (sheets of carbon atoms only one atom thick). "An inspiring physicist and an example to many," his supervisor, Professor Ekkes Brueck, declared.

"The Netherlands currently produces four percent of its electricity by means of wind turbines, and this figure can and must be increased," said **Dr Gerard van Bussel**, professor of wind energy at the Faculty of Aerospace Engineering during his inaugural speech on 16 January. "Denmark is already producing 23 percent of its electricity from wind energy, and they have resolved to increase that proportion to 50 percent." Van Bussel expects the growth to be effected by increasing in the size of the wind turbines and increasing the number of wind turbines. This would enable a capacity of 14,000 megawatts to be realised, or 35 to 40 percent of the electricity consumption of the Netherlands.

Kees Kaan, professor of professional practice of architectural design, was given the go-ahead to start building in a new district of Barcelona. In January, he won an international competition for the project. The district, which is to be called Central Prat, lies on the outskirts of Barcelona, between the airport and the city centre. In addition to office buildings and commercial premises, the district will include housing and a city park. Solar panels on the roofs will heat and cool the apartment buildings. However, it may be another twenty to thirty years before the new district becomes a reality.

'Didactics of exact sciences: ability rather than art or artistry', was the title of the inaugural speech given in February by **Marc J. de Vries**, professor of science education. De Vries graduated in physics from VU University Amsterdam in 1982. His thesis concerned problem-solving in physics education. In 1988, he was awarded his doctorate from TU Eindhoven for a thesis on the use of technology in physics education. In 2003, he was appointed professor of Reformational Philosophy at TU Delft's Faculty of Technology, Policy and Management, and he has now taken up the post of professor of science education at the Faculty of Applied Sciences.

Dr Arne Verliefde has won the 2009 Water Cycle Innovation Award. Verliefde received the award, which includes a prize of 10,000 euro, for his thesis on the removal of organic pollutants from drinking water. Verliefde was awarded his doctorate with honours last October. A dozen PhD students who completed their research in the field of water cycles at TU Delft and Unesco-IHE in 2007 and 2008 competed for the prize. Verliefde's research investigated the use of a variety of advanced filtration techniques to remove hormones and traces of drugs during the production of drinking water.

[HORA·EST]

Propositions

One can in fact live on wind.
Bart J. Ummels
Policy engineer

Results produced by computer programs, designed by humans, are subjective.
Bart Vermolen
Physics engineer

Hype within the scientific community slows down the progress of science.
Iddo Heller
Physics engineer

Clouds and washing machines show that virtual potential temperature and socks are non-conserved quantities.
Thijs Heus
Meteorology

Practicing science is believing.
Willemina Anna Kleefsman
Applied pharmacology

String theory is often referred as the first candidate of Theory of Everything. This claim is bold. Since we do not know everything about the universe and it is not possible to know what we do not know.
Praveen Kumar
Electrical engineer

If time is money, do we have a time crisis now?
Heidelinde R.C. Dietrich, Biomolecular engineer

[Sound]bites

"If I've lost my book, I can send out a signal asking, 'where's my book?' The return signal then tells me in which room in the faculty building I can find my book."
Professor Dr Koen Langendoen about his work on wireless networks, in NRC Handelsblad

"One week people in the Netherlands are seeking shelter from torrential rains, and then the next they'll be sitting under blues skies at pavement cafés for weeks on end."
Dr Frans van de Ven about climate change, in Het Parool

"It was about time the housing market cooled off. Lower prices are good news for practically all consumers in the property market, not just first-time buyers, although they do profit most."
Professor Dr Peter Boelhouwer, in de Volkskrant

"I suddenly had 100 kilowatts under my control. I was going incredibly fast! I stopped near a group of boys, rolled down the window and asked: 'what do you guys think of that? All electric!' They were flabbergasted."
Professor Dr Wubbo Ockels about a test-drive in the solar-powered Nuna student racing car, in NRC Handelsblad

"We have 4,000 alumni in the upper echelons of Philips, Microsoft, Apple and Lenovo, and we have excellent relationships with universities in China, South Korea and Japan. People here in the Netherlands don't always realise it, but for builders and designers TU Delft is the Mecca of the world. We have a vast network."
Professor Dr Cees de Bont, in NRC Handelsblad


Photo: Hans Stikelbeek/FMax

Proposition
Pregnancy is a productive break in a PhD study.

Defence
"It is literally a productive break, because you're actually busy making something – a baby. A break like that is also good for getting your mind off your work. I had been doing research for three years when I took my maternity leave. I think everybody hits a low point after three years. I did, anyway. I had really dug myself into a hole. I'm doing numerical research on liquid-solid interactions – think airflows along aircraft wings. It's far from simple. But when I picked up where I'd left off after four months, I was able to take a fresh look at my work. I then made a final dash to finish. I was also working much more efficiently, because I had to be at the crèche at five o'clock every day."

Aukje de Boer
Mathematical engineer

An alumnus of TU Delft writes a column and then passes the pen on to another alumnus of his or her choosing.

I was keen on mathematics and physics, but most of all I knew what I didn't want to do. This made it easy for me to choose to study engineering. What appealed to me about mechanical engineering was the subject's broad orientation and specific applicability.
After graduating I soon found that as an engineer, I could go in many different directions. Logistics clearly attracted me, although initially I found it difficult to decide what exactly I wanted to do, and where. I gravitated from simulation of confection flows, via distribution and warehousing, to creative applications of GPS data. And from road transport I moved into sea transport as well.
Land or water, as long as the channels kept flowing, the light was green for me, because without transport everything indeed grinds to a halt.

Although my work is still closely associated with technology and requires analytical qualities, in daily practice it's a level head, a good set of social skills and a talent for getting things done that are required for me to achieve my goals. I have also discovered that I especially find the human aspect extremely interesting and important. But that isn't to say that I no longer use the knowledge I acquired during my university studies in my daily work. Thinking in terms of process and taking a well-structured approach towards logistical problems has played a major role in every job I've had so far. Besides learning to think systematically, the social activities I engaged in while at university really did a lot to help develop certain qualities, like organisational and coordinating skills.

I'm currently employed as a Process Excellence Manager at Maersk Logistics, for the central European region. For this job I completed a Lean Six Sigma Black Belt training course. And then what happened? All of a sudden I keep encountering many aspects of the technological subjects I studied at university – mathematics and physics are especially fundamental to the work I do now. The international nature of my job and the different cultures I come in contact with make it a pleasant journey of discovery. I now really feel as if I've found my niche. The technical and analytical aspects play an increasingly larger role in my job, and this, combined with lots of human interaction and interrelations, is where my satisfaction comes from. I'm still a long way from my final destination though; it's more like I've reached a crossroads from where I can develop in many different directions, allowing me to travel to many other places and professional fields.

Hanneke van Oerle (35) is a Process Excellence Manager at Maersk Logistics. She studied mechanical engineering at TU Delft from 1991 to 1998. Hanneke passes on the baton to Marcella Tabeling, a friend and former fellow mechanical engineering student.

Electrocuting bacteria

Photo: Sam Rentmeester/fmak

Tomas van Dijk

Fresh orange juice from the supermarket must be drunk quickly, because in no time it is already past its sell-by date. If, however, an invention by Sjoerd de Haan and Bart Roodenburg works out, this problem will be solved, and you will simply be able to buy the cheapest juice with a long shelf life, because it will taste just as good.
The two researchers are improving a technique to electrocute the bacteria found in the food products we buy. A major worldwide research effort into this method, which is known as pulsed electric field (PEF), is now underway. "Juices, ketchup, liquid cheese... anything that is somewhat liquefied is being used in the experiments," says Roodenburg, whose doctoral research is on this technique. "We're focusing on fruit juices, because there is a big market for them. Just look at the endless shelves of juice in any supermarket."
In simple terms, the method works as follows: liquidised foods are pumped through a tube and subjected to electric pulses measuring a couple hundred amps. After being hit with a few of these pulses, each of which lasts only a few microseconds, the bacteria die, torn apart as the electricity perforates their cell membranes. The voltage across the cell membranes mounts, because they conduct the current less well than the liquid around the micro-organisms.
Although this appears to be a promising technique, it is struggling to get off the ground. "The problem is that you need a large and expensive system that can supply 100,000 volts and is capable of processing thousands of litres per hour," De Haan explains. "After that the food must be moved from the storage tank and packaged, without becoming contaminated with fresh bacteria, and this requires an expensive aseptic filling machine."
De Haan and Roodenburg have come up with a cheaper alternative; they wait until the juice has been sealed into cartons before killing the bacteria. Two small electrodes move from top to bottom along the outside of the carton, ensuring that all the contents are electrocuted equally well. The TU Delft researchers are currently testing the new method on behalf of the STW Technology Foundation. To ensure that the method works, the packaging material must be made of a weakly conductive material. "Otherwise you get discontinuities in the electric field, which causes the liquid to heat up too much in some places, while in other places the bacteria isn't killed," says De Haan, who recently applied to patent the idea.
The PEF preservation process heats the product up by only a few degrees. A breakthrough of this new technique would rid the world of the peculiar taste associated with pasteurised and sterilised products.

WHO & WHERE

Delft University of Technology has eight faculties, each of which is engaged in education and research in one or more disciplines. The University was founded in 1842 by King William II. With 13,000 students, 2,800 scientific staff members and 2,000 technical and administrative employees, it is the largest university of technology in The Netherlands.

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Central Library

Delft University of Technology Library (dutl) supplies information and provides services, particularly in the area of the technical sciences. It comprises a central library and twelve sub-faculty libraries housed at the respective sub-faculties and institutes. The dutl is intended for students and staff at the Delft University of Technology. However, as the task of the library is to provide scientific and technical information at a national level, its facilities are also available to the general public. As well as all areas of technology and natural sciences, the library also contains a general collection in the social sciences, economics etc. This relates not only to books or periodicals, but also to standards, reports, reference works and congress proceedings. Literature not in the collection or not on hand can be obtained through Delft University's Central Library from other libraries in the Netherlands or abroad.

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