Delft Outlook
MAGAZINE OF DELFT UNIVERSITY OF TECHNOLOGY 2011 • 1

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The movement of magma

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# no. 1 2011

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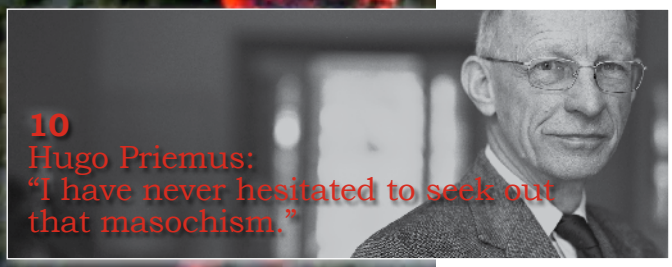

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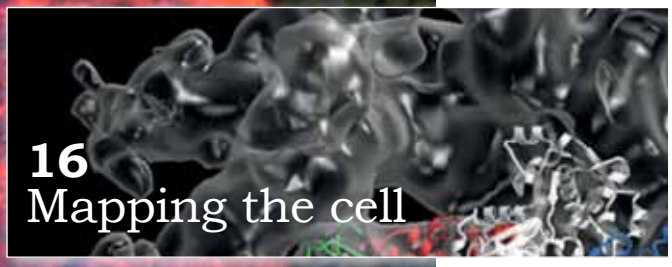

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## Edit

Welcome to the new edition of *Delft Outlook*. And this issue is newer than new this time, because the magazine has had a makeover. In the past, the cover always featured the heading, Research and Education at TU Delft. But, of course, TU Delft does much more, including knowledge valorisation, engaging in public debate and organising events for its alumni. In addition to the familiar articles on science and technology and the interview, you will also discover numerous new features, such as *The Firm*, where we explore the business of aircraft recycling, and *Life After Delft*, a feature in which we interview an alumnus about his work at a patent office. In *The View*, Professor Bert van Wee looks ahead to the world of transport in 2030, and in his column, award-winning writer (and TU Delft alumnus) Tonie Mudde thinks hard about a common fly. From now on *Delft Outlook* will not only be printed on paper, but can also be read in tablet form – just go to www.tablet.delftoutlook.nl in your iPad or Galaxy Tab browser. We look forward to hearing your feedback about the new look *Delft Outlook*.

Frank Nuijens
Editor-in-chief, *Delft Outlook*

## Colophon


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# Toga protest

Approximately 1,000 professors dressed in their formal professorial robes joined the student street protests held on January 21, in support of the Dutch knowledge economy and preserving the quality of higher education. According to TU Delft's Rector Magnificus, Karel Luyben, the Dutch government has "not properly thought through" the cuts to education and the knowledge economy in the Netherlands will be "disproportionally" affected by government policy.


Photo: Hans Stakelbeek/FMAX

# Photon in a box

In the coming years, researchers Dr Val Zwiller and Dr Ronald Hanson aim to enclose photons in a miniscule cube with a side length of just 50 nanometres. The aim is to garner more information on the interaction between photons and matter. This research into nano-scale optics is to receive €3 million in funding from the Foundation for Fundamental Research on Matter (FOM) over the next six years. TU Delft is collaborating with researchers from TU Eindhoven, the University of Leiden and Amolf.


Photo: Hans Stakelbeek/FMAX

# Remote-controlled hand

If PhD students Pablo Estevez and Patrice Lambert have their way, trembling tweezers under the microscope will be a thing of the past. They are working on a system that enables people to make high-precision movements with ease and to sense what they are doing at the same time. People working on IVF will soon be able to use it to feel when they penetrate the cellular wall. Lambert developed the 'haptic remote control', while Estevez worked on the actuator. Five different signals run from the remote control to indicate the 3-D position, the angle and the grip of the pincer. These are converted a thousand times per second into operative power for the platform that is suspended above three powered coils (and moves just like the cone in a loudspeaker). Five signals then return from the platform to the remote control to enable the contact forces to be felt. The movements are scaled down by a factor of 500, while the contact forces are scaled up by the same factor. A Swiss watchmaker has already shown interest in this remote-controlled micro-manipulation system.

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# Pico pump

"It's not a world record, but it's definitely one of the smallest pumps ever made," says Dr Friedjof Heuck, of the microscopic pump he developed at Dimes. Its diameter is 40 microns (half that of a human hair) and the active part is only 10 microns. It can pump 35 picolitres (a millionth of a millionth of a litre) per second. It would take the pump nine centuries to pump just one litre. Heuck developed the 'micropipette' as an extension for the scanning force microscope used by Professor Urs Staufer at the faculty of Mechanical, Maritime and Materials Engineering. The pump can be used to drop a miniscule amount of liquid, which the microscope can then measure. Prof. Staufer hopes to use it to examine how the pore of a cell opens or how materials can be processed at an extremely miniscule level.

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Illustration: Martine Poolman

# *Don't talk,* **draw**

In discussions about the construction of hydraulic engineering projects, people can tend to talk over one another. As part of her work, expert in hydraulic and marine engineering Dr Martine Poolman went to Ghana and Midden-Delfland, taking coloured pencils and flipcharts with her. Her aim was to use drawings to bring together the various interested parties, such as farmers and water board officials. In January, she defended her thesis, entitled 'Present and Future, visualising ideas of water infrastructure design', in which she describes the communication method she has developed, called Yourscape. In Midden-Delfland, Poolman asked farmers and water board officials to sketch the nature-friendly banks that had been planned for the area. Both parties drew a fence which was intended to protect the vulnerable banks from cows. Previously, the farmers had seemed to be opposed to the measure, but this proved to be a misunderstanding. In fact, the farmers just didn't want to pay for it. Poolman: "The problem with heated discussions is that they can often lack focus. Drawing can actually prevent misunderstandings. Unfortunately, people sometimes find it childish."

For more information:
www.yourscape.nl
www.delta.tudelft.nl/22394


Photo: Sam Rentmeester/FMAX

# Building with nature

'Building with Nature' pioneer, Dr Ronald Waterman, received a PhD at TU Delft on 21 December. His name is inextricably linked with visionary extensions to coastal and dune areas. This is because, as the longest sitting member of the Provincial Council of Zuid-Holland, he is already the architect of a whole 'family' of coastal extensions, from the Tweede Maasvlakte near Rotterdam to the Seaport Marina in IJmuiden. Waterman has received more than a dozen awards, including a Dutch knighthood (1993). In 2008, he published the weighty volume, 'Integrated Coastal Policy via Building with Nature'. His supervisors, Professor Marcel Stive and Professor Han Vrijling, encouraged Waterman to take his PhD based on that book.

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# Snooker

Professor of Process Intensification, Andrzej Stankiewicz (3mE), has been awarded an ERC Advanced Investigators Grant worth €2.3 million by the European Research Council. Over the next five years, Prof. Stankiewicz will use the money to conduct research on molecular level improvements to chemical reactors. The effectiveness of a reaction depends in part on the number and frequency of collisions between molecules, the relative position of the molecules to each other when they collide and their energy. "Today's chemical reactors, such as those used in industry, actually offer very little control over the molecules, which means that the chemical reactions are far from energy-efficient and also cause a lot of unnecessary waste."
The solution to this problem is a perfect reaction environment, in which the geometry of the molecular collisions can be completely controlled and energy transferred selectively. Stankiewicz: "It's like playing a game of snooker with molecules. The structured reactor is the snooker table and we use a variety of forms of electromagnetic energy fields as snooker cues."

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Photo: Khino Pizzato

# Sensitive layer

Researchers in Professor Lis Nanver's micro-electronics department (EEMCS) have created the world's most sensitive photodiode. It can be used with electrons with an energy level of less than 200 electron volts. "The diodes currently on the market only work efficiently with electrons from 1000 eV upwards," says Prof. Nanver. "Based on current knowledge, we are the best. But businesses do not always publish every detail of their own projects, so we do not know for certain."
Microscope manufacturer FEI, with which Nanver's group has been working closely, plans to market the photodiodes this year. The diodes have been developed for the SEM (Scanning Electron Microscope) and the SDB (Small Dual Beam). "Thanks to the extra sensitivity, samples in the microscope can now be bombarded with a layer of energetic electrons, which is really useful because the particles do not penetrate the samples so deeply, providing a better image of the surface," explains the professor. The diode consists of a layer of silicon with a layer of boron only a few nanometres thick on top. By using chemical vapour deposition, Prof. Nanver managed to create this extremely thin layer (the thinner the layer of boron, the more sensitive the diode).

**For more information:**
**www.delta.tudelft.nl/21875**


Photo: Sam Rentmeester/FMAX

# Alcohol-powered **MP3 player**

The design is complete, but it has not yet been built: an MP3 player that you can charge up with methanol. Usually, the electronics are fed by a lithium-ion battery, but this can also be done using a methanol fuel cell. "A fuel cell system is typically twice as expensive, twice the size and half as heavy as a standard battery," says Dr Bas Flipsen who developed the design. He recorded the most suitable components, including tank and pump, in a database and then made a selection based on the greatest power per volume and weight. A smart computer program then calculated the smallest possible combination of components. With his digital approach, the aeronautical engineer has developed a useful design tool for Industrial Design Engineering. Dr Flipsen: "Computer-controlled decision-making can support designers when they make aesthetic choices."

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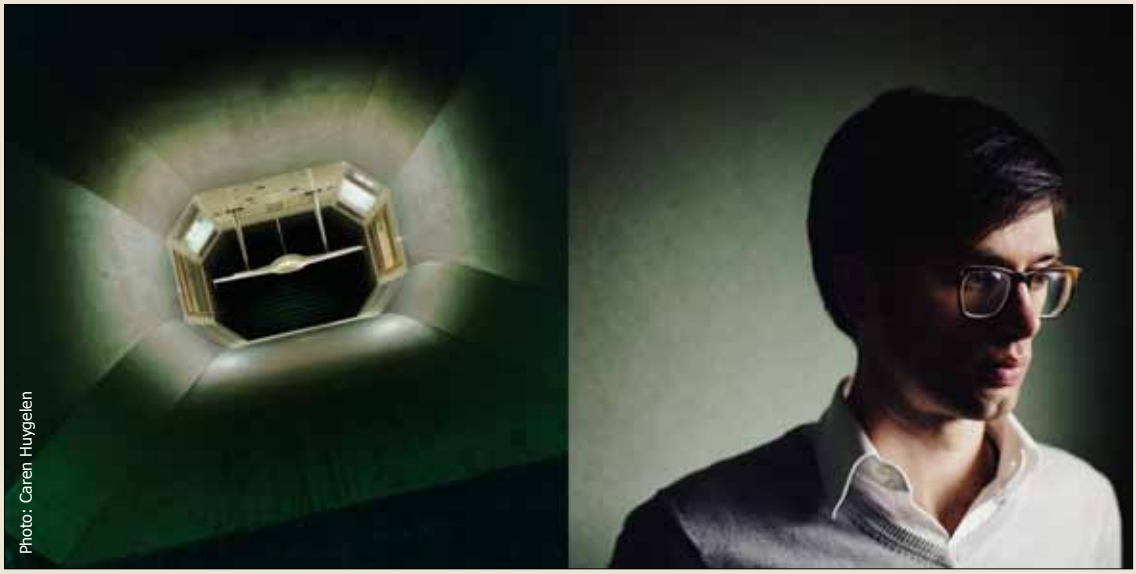

Photo: Caren Huygelen

In her work 'Master of Science', TU Delft alumnus and photographer Caren Huygelen captured TU Delft researchers at work in their labs. Her admiration for intensive scientific research prompted her to take a new look at her 'old' TU Delft world, this time from her 'new' perspective as a photographer.

**For more information:**
**www.huygelen.nl**

# Round the bend

A surgical instrument that can be controlled and negotiate bends is set to make knee operations faster and safer. Tim Nai, who recently graduated from the biomechanical engineering department (3mE), has developed the instrument, which can remove damage to the meniscus. In December he won the Professor Wim van der Hoek Constructors Award, given annually by the Dutch Society for Precision Engineering to the best graduation projects in the field of mechanical engineering construction.

# Just shake it

Telephone manufacturers who wish to integrate external components such as a gyroscope or camera currently use steady but very slow robots for this purpose. There are easier and quicker ways of doing this, thought Dr Iwan Kurniawan. He developed an original technique to position chips correctly on a silicon wafer by applying a shaking method. Although this cannot yet replace the current method of 3-D positioning, it can be seen as a step in the right direction, says his supervisor, Professor Urs Staufer. 'Shaking' sounds a little easier than it actually is. The position where the chips need to be placed is given an insulating layer of silicon dioxide and charged using a charging device to a surface potential of several hundred volts. The chips are given an opposite charge. For the assembly process, the chips are placed on a silicon wafer and shaken. Miniscule pegs on the chips prevent the charged surfaces from coming into contact with each other and accidentally discharging. It is only when the pegs align with the special slots by chance that the chips fall into place with micrometre precision. In tests, all chips were in place after 30 seconds of shaking.

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# Anti-stress pen

It's a familiar sight in the examination room: students who play, twist and chew their pens, anxiously hoping for inspiration. During his doctoral research in Industrial Design Engineering, Dr Miguel Bruns Alonso developed a pen designed to reduce that stress. The pen responds to various nervous movements or twitches by subtly counteracting them. Dr Alonso: "People enjoy whirling around the little loose ball in the top of the pen, but if they do it too fast, the pen activates an electromagnet, reducing the movement of the ball." Tests of the pen proved somewhat disappointing because the test subjects said they could not tell whether the pen was active or not. There was therefore no conscious stress-reducing effect. However, the pen appears to work subconsciously: with the pen in its active setting, the test subjects' heart beats were 5% lower.

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Photo: Hans Stakelbeek/FMAX

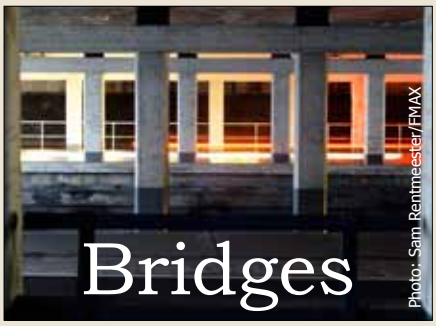


Photo: Sam Rentmeester/FMAX

Good news for the Dutch Treasury: bridges and other civil engineering structures have a hidden capacity. They are better able to withstand the increased burden of traffic, which means they will not need to be replaced or reinforced as quickly as was previously thought. This was the conclusion reached by Joost Walraven, professor of Concrete Constructions at CEG. His staff combined his experiments with advanced mechanical analyses. Prof. Walraven's findings could save the country €300 million in the next five years.

# Anatomy of a volcano

Jos Wassink

The Icelandic volcano Eyjafjallajökull caused major disruption in European airspace last year. According to his co-author, Freysteinn Sigmundsson, the reconstruction published in *Nature* six months later by aerospace engineering researcher, Dr Andy Hooper, opens up a new direction in volcanology. “We want to see how the magma moves inside the volcano.”

When the confusingly-named Icelandic volcano erupted in late March, geophysicist Dr Andy Hooper rushed to book a flight to Iceland. This was just before parts of the European airspace were closed to traffic, owing to the Eyjafjallajökull volcano’s huge ash clouds. “It’s great to see such an eruption up close,” Hooper recounts. “Our pilot made a special detour to give us a view of the volcano.” But Dr Hooper, who has worked in the faculty of Aerospace Engineering’s remote sensing department since 2008, was looking for more than sensation alone. This kind of eruption is certainly exciting - his grinning face on the accompanying photograph, taken on the volcano, leaves little doubt that Dr Hooper enjoys the sensation of feeling -15 °C on his face and 30 °C on his back. His primary objective however was to gather as much data as possible during the eruption. “This is a fascinating volcano because it erupts only occasionally [four times in the last 1,000 years, ed.]. In recent times, Hekla [a neighbouring volcano – ed.], has erupted

Photo: Andy Hooper

Eruption of the Eyjafjallajökull.

Andy Hooper: "We intend to engage in volcanic anatomy."

every ten years. As pressure builds, the volcano rises a few centimetres before sinking again after an eruption. But in the case of Eyjafjallajökull - the name literally means 'island-mountain-ice cap' - the pattern is far more complicated."
In order to acquire data at the site, Dr Hooper contacted the Nordic Volcanological Centre, which is now part of the University of Iceland. The centre's director, Dr Freysteinn Sigmundsson, was a familiar face from his time as a postdoc at TU Delft, from 2006 to 2008. "If you want to study volcanoes, there's no better place than Iceland," Dr Sigmundsson says, and it was this that prompted his move there. He and his team have been observing the volcano for 18 years now. As recently as the summer of 2009 there was just a single GPS station on the volcano's flanks, but as its activity increased, this was quickly extended to three. The fixed GPS stations have an accuracy of 2 mm per year, explains Dr Sigmundsson, before adding: "Just before it erupted, the volcano was moving 5 mm a day!"
Dr Hooper had also secured additional data from the German operator of the TerraSAR-X radar satellite, which orbits the Earth at a distance 500 km, passing over each area every 11 days. The satellite, which emits microwave radiation and then records its reflection, uses the phase differences between the emitted and reflected waves to calculate the distance to the Earth's surface. By comparing the figures to its previous orbits, it becomes possible to record movements in the Earth's surface down to the level of a millimetre.
This meant that Dr Hooper had a secure supply of data when the eruption started, but he never could have imagined that this minor eruption on the volcano's flank, which lasted from 20 March to 12 April, would be followed just two days later by a sudden explosive eruption from the volcano's summit, or that the volcano would remain active for an entire month. As much of Europe groaned under the ash cloud, data continued to flow into the aerospace faculty.

## Reconstruction

Six months later, on 17 November 2010, Dr Sigmundsson, Dr Hooper and a dozen other researchers published a reconstruction of the eruption in the scientific journal Nature (*).

Although Dr Sigmundsson was the primary author, he was full of praise for Dr Hooper in our telephone interview: "Andy combined the interferometric data with the GPS data. He was also responsible for much of the modelling. The work he did was extremely significant." Dr Hooper is equally complimentary about his Icelandic colleague: "Freysteinn has pioneered the measurement of volcanic deformations in Iceland and has amassed years of experience in this field."
In the article, the co-authors reveal the complicated pattern of magma flows beneath the volcano: as early as 1994, magma was already spreading in a horizontal sill beneath

*'Our pilot made a special detour to give us a view of the volcano'*

the volcano at a depth of 5 km. A second sill developed a kilometre deeper some five years later. Then, 11 years later, in 2010, the magma forced its way upwards and spread into horizontal, 4 to 5 km deep sills and into a vertical dike reaching just beneath the volcano's surface. The GPS stations recorded a movement of 6 cm.
On 20 March 2010, the magma broke through the volcano's flank, spewing lava downwards over a three-week period. Strangely, two of the three GPS stations did not return to their pre-eruption values, indicating that the residual pressure remained undiminished. On 14 April 2010, after two days of calm, a further explosive eruption came from the volcano's snow-covered crater. According to the analysis, this was because, at a depth of 4 km, the magma had come into contact with an older magma sill. Dr Hooper: "This magma had been there for some time, which meant it had increased in viscosity and also contained lots of gas. The gas caused an explosive eruption, and the denser magma produced smaller ash particles that reached higher into the atmosphere, from where they spread further."
The article presents a fascinating picture of the course of the eruption, and, according to Dr Sigmundsson, this is just a foretaste of future developments in volcanology. The ultimate aim is to provide a comprehensive picture of the magma flows within the volcano. "We intend to engage in volcanic anatomy," he explains.
The reconstruction results from a type of reverse design. In this, Dr Hooper assumes that there is an 'elastic' substrate or sections of earth where the deformations reflect the build-up of pressure in the magma flow. He assumes that this substrate contains a series of cracks through which the magma flows. He then calculates the deformation on the Earth's surface as the magma forces its way through a vent around 20 cm in width. He then compares these calculations with the measurements in order to make adjustments to his reconstruction. After repeating the process a number of times, Dr Hopper reached a result that effectively corresponded with the measurement data.
Does this new understanding also help to predict future eruptions? "In Iceland, you never know which volcano will be the next one to erupt," Dr Sigmundsson says. "It's impossible to make predictions," Dr Hooper adds, "but you can more effectively forecast the progress in the course of eruptions. This is something that will certainly interest the world of aviation."

*(*) Dr Freysteinn Sigmundsson, Sigrún Hreinsdóttir, Dr Andy Hooper, et al.: 'Intrusion triggering of the 2010 Eyjafjallajökull explosive triggering', Nature, 17 November 2010.*

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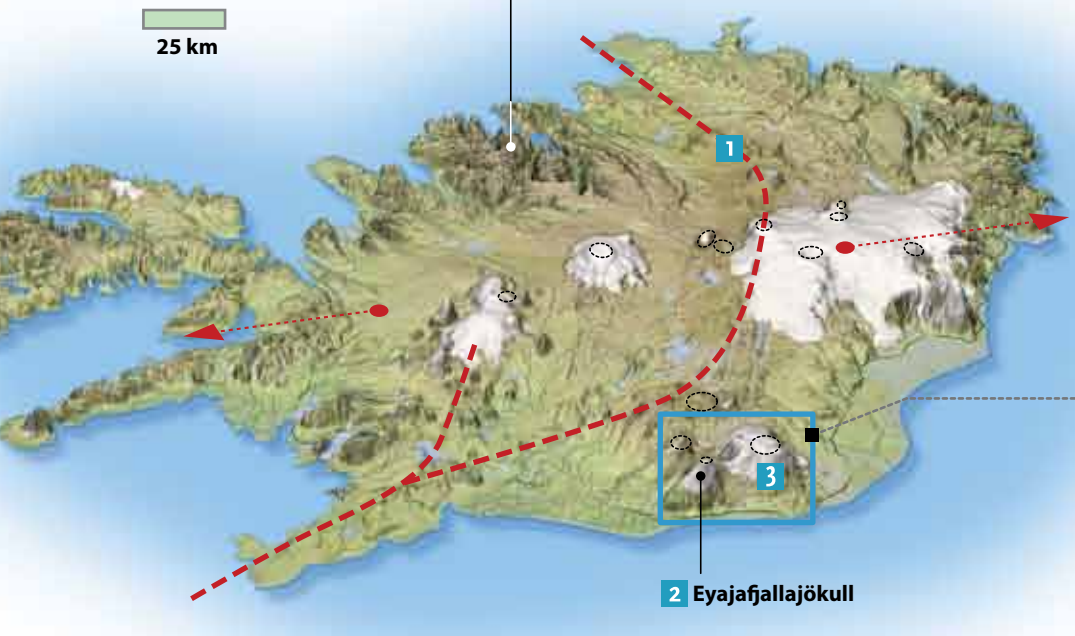
**Land of volcanoes**
Iceland is situated on the Mid-Atlantic Ridge. 1 Every year, the North American and Eurasian plates shift away from each otherby almost 2 cm. It is these plate movements that cause volcanic activity.

**Eyajafjallajökull** 2
Very little is known about the behaviour of less active volcanoes, such as Eyjafjallajökull (the Icelandic word for 'island-mountain glacier'), which is not situated above the Mid-Atlantic Ridge. What does the magma chamber of a less active volcano look like and how does it behave?

**Big neighbour**
Next to Eyjafjallajökull (surface area 50 km$^2$), is its bigger neighbour Ketla 3 (surface area 600 km$^2$). In the past, these two volcanoes were often active at the same time. Magma flows in the earth close to one of the volcanoes can cause the other to erupt. The most recent eruption of Ketla, in 1918, was larger than that of Eyjafjallajökull in 2010. Although there are no concrete indications that would suggest an eruption, volcanologists expect Ketla to erupt in the coming years. The volcano has a history of erupting every 40 to 80 years and is therefore already overdue.

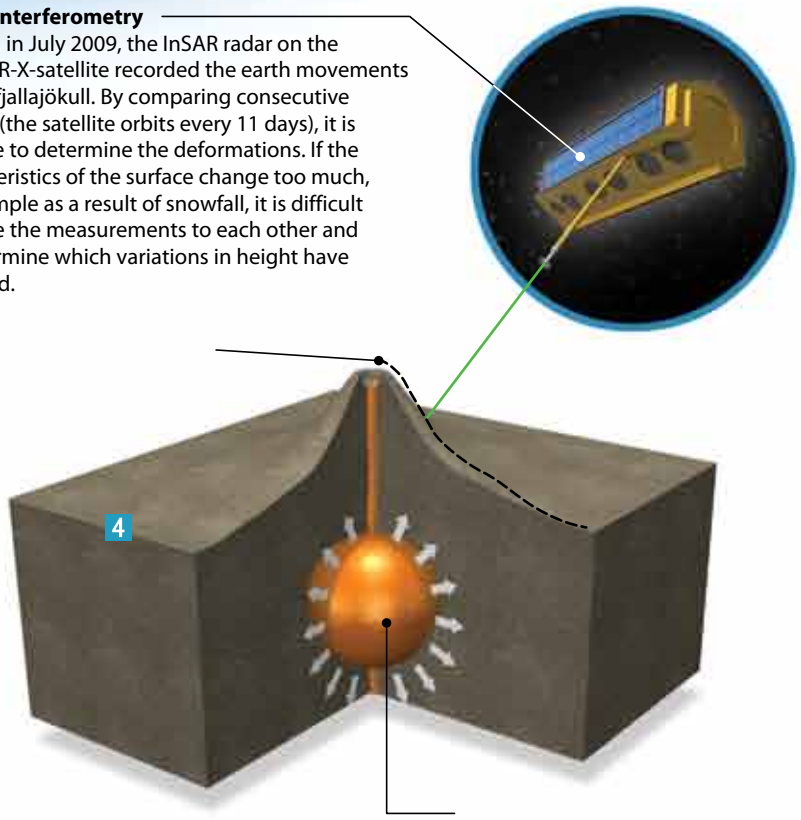



REMARKABLE OBSERVATION

**No subsidence after eruption** 6
Usually, after an eruption, the Earth's crust subsides as the magma chamber empties. However, when the flank expanded after the eruption in 2010, this did not happen. This means that the magma from the flank eruption did not originate from the magma chamber under the flank but rather was fed directly from a source deep in the Earth's crust. The crustal expansions continue to exist, even today, and the magma chambers therefore remain under pressure.

**Classic volcano** 4
The classic image of an active volcano is of a cone-shaped mountain with one large magma chamber. Before an eruption, magma flows into the chamber, the pressure increases and the chamber gradually expands. During an eruption, magma flows away, reducing the pressure and causing the chamber to contract again. The expansion and contraction of the magma chamber can be measured through satellite monitoring of the shape of the volcano (GPS and radar interferometry). Before the eruption in 2010, there were five GPS receivers around Eyjafjallajökull 5 . These receivers measure 3D displacements semi-continuously.

**Radar-interferometry**
Starting in July 2009, the InSAR radar on the TerraSAR-X-satellite recorded the earth movements on Eyjafjallajökull. By comparing consecutive images (the satellite orbits every 11 days), it is possible to determine the deformations. If the characteristics of the surface change too much, for example as a result of snowfall, it is difficult to relate the measurements to each other and to determine which variations in height have occurred.




## Earth simulation

In the TU Delft computer model, the earth of the volcano is comprised of an elastic material that can develop fractures under the pressure of magma flows, which then fill with magma. The model attempts to simulate the movements measured on the surface by assuming that one or more (expanding or contracting) magma chambers are present underneath the volcano.

**A** 1994 — **Major earth deformations**
In 1994, major earth deformations (more than 18 cm) were measured. In the computermodel simulation, the magma flows penetrate the earth, creating a horizontal magma chamber.

**B** 1999 — **Major deformations**
Magma flows form a second horizontal magma chamber.

**C** 2000-2009 — **Earthquakes**
There are one to four earth-quakes per month.

**D** JANUARY - FEBRUARY 2010 — **Major earth deformations**
There are earthquakes on a daily basis. Major earth deformations are being measured. The computer model calculates the formation of a horizontal magma chamber.

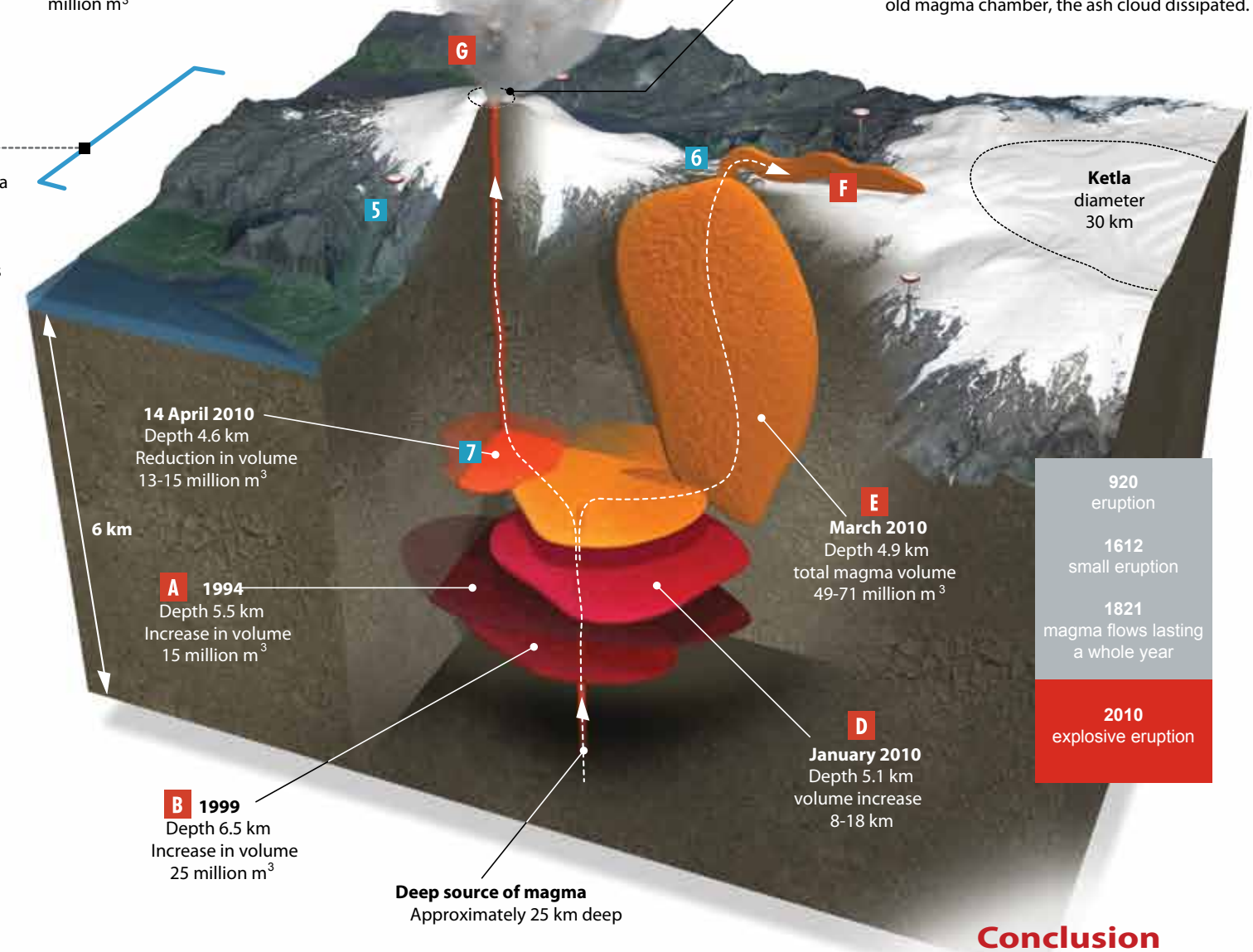
**Small ash cloud**
Because the 'young' magma in the flank eruption 6 was less viscous, the gases were able to escape from the magma before it was ejected. This meant that the flank eruption was less explosive and produced no large ash cloud.

**Large ash cloud**
Starting on 14 April, a small section of 'evolved' magma is released, a remnant from an old magma chamber from previous eruptions. This 'old' magma is more able to hold gases than the 'young' magma (which originates directly from a deep magma source). As the magma is ejected, the gases make the magma explode into very fine ash particles which rise high into the air. Interaction between the magma and the ice cap causes more gas to form, making the ash cloud even more explosive and the particles even finer. The result was an ash cloud reaching a height of 10 km and closing European airspace for days on end. Once the evolved magma had been spewed out of the old magma chamber, the ash cloud dissipated.

**Magma speed**
30-60 $m^3/s$

**Magma volume**
Approximately 100-200 million $m^3$

**Eyjafjal-lajökull**
diameter 10 km




## Conclusion

The explosive eruption of Eyjafjallajökull on 14 April 2010 was the result of 18 years of volcanic activity in which several flat horizontal and vertical magma chambers had formed above and alongside each other. This cumulative behaviour makes it difficult to detect warning signs in less active volcanoes and to use them to predict eruptions.

**E** MARCH 2010
**Major earth deformations**

After 4 March, the earth rises by more than 5 mm per day. By the end of March, the slopes of Eyajafjallajökul have risen by approximately 10 cm. A second horizontal chamber and a vertical magma chamber have formed.

**F** 20 MARCH - 12 APRIL
**Eruption on the flank**

On 20 March, the magma spews out of the flank of the volcano. After being dormant for two centuries, the volcano erupts. The eruption lasts until 12 April. The eruption ejects lava at an average rate of 13 m /s (magma volume 25 million $m^3$).

**G** 14 APRIL - 22 May 2010
**Explosive eruption**

The second eruption takes place in the crater (caldera) of the ice-covered summit of the volcano. The eruption lasts for more than a month. During this second eruption, measurements do show subsidence of the magma chamber under the caldera. 7

# ‘Dying on the job’

Saskia Bonger

A quarter of a century ago, Emeritus Professor Hugo Priemus was one of the founders of the OTB Research Institute for the Built Environment. “We may not have developed any fantastic new theories, but we do contribute to the political decision-making process.”

*What is the legacy of a quarter of a century of OTB?*

“The OTB delivers scientific work of the highest quality and forges links with the latest issues in policy and practice. Research institutes are often set up as independent legal entities. Even in Delft, people used to ask: isn’t it rather masochistic to try to juggle everything within the university when you can actually be independent? I’ve always fiercely resisted that idea and never hesitated to actually seek out that masochism. I believed that scientific work could find its inspiration in topical issues. And equally, that you can make a major contribution to solving current problems if you are backed up by trenchant scientific research.”

*What actual influence has the OTB had on the built environment?*

“There is a great deal of stupid policy that we’re powerless to resist. Nowadays, there is a surge in populism that we can do little to oppose. But in the end, civil servants and politicians tend not to rush into things; they base their policy on firm evidence. This is probably best reflected in the role we’ve played in three Parliamentary inquiries.”

*Can you elaborate on this?*

“When I heard, in the mid-1980s, that there was to be a Parliamentary inquiry into subsidies within the construction industry, I modestly put myself forward. There were suggestions that property investors were playing fast and loose with the conditions for awarding housing subsidies. It was also thought that some civil servants were behaving unethically. We conducted two major inquiries. The most important result of all this was that politicians began to question the effectiveness of making such significant capital injections. This in turn led to a major restructuring of housing subsidies.”

*This was then followed by the construction fraud scandal?*

“That’s right. Competition is something that the construction industry finds difficult to handle. Construction companies do not want to be taken advantage of by their clients. Consequently, for decades the companies would decide amongst themselves who should take on a particular project. It was something that had almost become automatic, a tradition. Strangely, it was often actually inspired by good intentions. Construction companies are keen to create continuity, yet, in their view, clients are not interested in this.”

*It was primarily the faculty of Technology, Policy and Management (TPM) that contributed to the Parliamentary inquiry into the role of government in major infrastructure projects from 2003 to 2005.*

“The inquiry was instigated when I started as the new Dean at TPM. I was approached to lead the inquiry, but actually couldn’t spare the time. I put forward seven TPM researchers for the job. We conducted a superb analysis and helped kill the *Zuiderzeelijn* [a proposed rail link from Groningen to Amsterdam – ed.].

*Your influence on national politics is significant.*

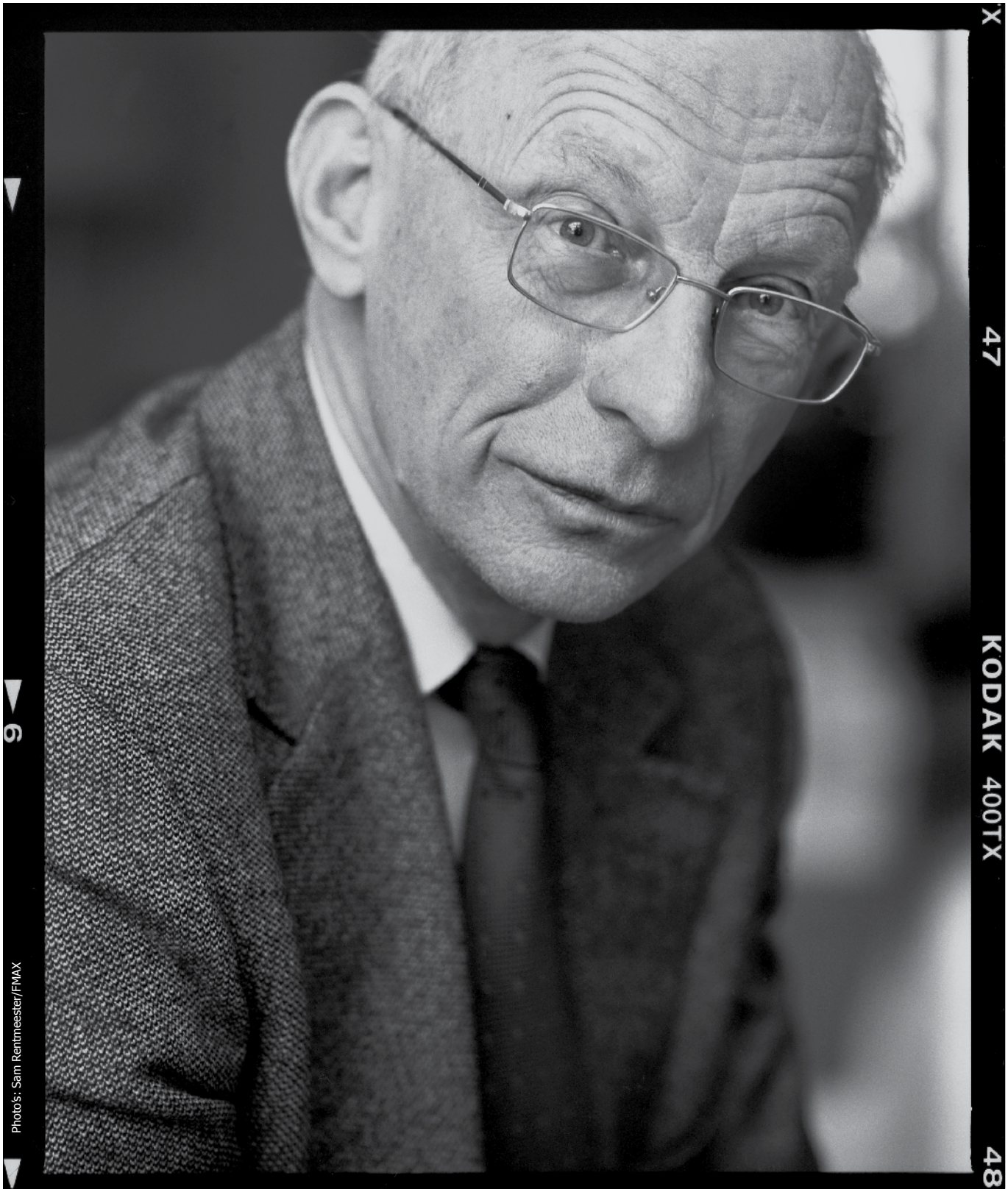
“Very soon after achieving my doctorate I was considered to be an expert in the housing market. But the housing market is an economic principle. As a discipline, architecture is capable of achieving a lot and modesty was never something that troubled me too much, but I was hardly an expert in economics. In order to save myself embarrassment, I took an evening course in economics at Erasmus University Rotterdam during the 1970s. I was keen to avoid whistling in the wind. Even now I still always ask myself: what evidence do I have for making this claim? I want to be able to express my ideas in soundbites. This approach may seem very similar to politics, but everything is always based on my own or others’ research.”

*Do you still often find yourself in The Hague?*

“Yes, I do. There are regular roundtable meetings of the permanent Parliamentary committees for Housing, Communities and Integration, Spatial Planning and Environmental Management or Transport, Public Works and Water Management. My input is often needed for those. The OTB has become extremely experienced in all this. Although there may be other similar institutes, we are reasonably unique in the successes we have achieved. We may not have developed any fantastic new theories, but we are able to make a contribution to political and social decision-making by providing input at the right time and in the right forum.”

*Have you never had any Parliamentary ambitions of your own?*

“I’m happy to leave that burden to others. Personally, I was born to be an advisor. I do not believe that researchers need to be overly secretive about their voting preferences, but you must remain independent. You need to have no qualms about questioning the ideas of the party of which you’re a member. Why the Dutch Labour Party (PvdA)? I have no time for religious inspiration in politics. And slavishly following the market, like the Liberal party (VVD), is something I find too simplistic. The more effectively the housing market works, the more people actually need to sleep under bridges. It is necessary to correct the market in a number of ways in order to ensure that minimum opportunities >




*'The more* **effectively** *the housing market works, the* **more** *people actually need to* **sleep under bridges'**

are guaranteed. That way of thinking soon places you on the centre-left."

*Social Economic Council (SER). You were a member of the committee of socio-economic experts that published a report about reforms in the housing market in April 2010. This included a proposed revision of mortgage interest tax relief. The new Cabinet, headed by Prime Minister Mark Rutte, has failed to take your ideas on board.*

"It's actually a waiting game. The new coalition agreement is very much wanting, so certain problems will only worsen in the years to come. Mr Donner (Minister of the Interior, responsible for public housing, ed.) has intimated that he is open to suggestions from the field for the establishment of a National Accord on Housing. You only need to ask the Homeowners Association *(Vereniging Eigen Huis)*, property investors, the Aedes Federation of Social Housing Institutions, the Netherlands Union of Tenants *(Woonbond)* or the construction industry trade organisation *(Bouwend Nederland)* whether they are happy with the current housing market. None of them have a good word to say about it. If Donner is listening to them and preparing reforms, some good things could still emerge from this dismal period."

*But surely Donner is committed to the coalition agreement?*

"A high-ranking civil servant who addressed the OTB anniversary event said that it is important not only to consider the contents of the coalition agreement itself, but more especially what it omits. It's in these areas that ministers have room to manoeuvre. Nowhere in the coalition agreement is there a prohibition on considering changes to the housing market."

*In your view, what is the problem with the market?*

"The basic problem lies in the fact that home buyers and tenants are treated as completely different categories. Consequently, making the leap from renting to buying or vice-versa is a risky undertaking. In the owner-occupied housing sector, there are built-in incentives to enter into debt. Thanks to such fiscal measures as mortgage interest tax relief, the average house price is about 20% higher than it otherwise would be. All of this needs to be subjected to gradual and consistent changes during the period from 2015 to 2040. But you will need the time between now and 2015 to create the social and political will and establish the necessary legal conditions. The United Kingdom has shown that it is possible."

*You have been an emeritus professor for three years now and still remain extremely active.*

"Dying on the job doesn't seem too bad an idea to me. I enjoy flying the TU Delft flag, carrying that badge of neutrality. I work full-time but adopt a very flexible approach, because I'm no longer directly responsible for anything. I choose to do the things that I enjoy and notice that I'm becoming increasingly selfish in this. I don't plan ahead too much. A lot will depend on my health. I don't want to revisit old ground, but I am keen to link up different areas with each other."

*Why didn't you become an architect?*

"When I started studying architecture in 1960, I was beset by serious doubts. It all seemed so arbitrary. I thought: this will get you nowhere, is this really academic education? However, later in the first year of my studies I had my first housing assignment. In those days, the idea was to cover housing in the first year, because later you would be too advanced for the subject. Yet this was the area that I found especially interesting. A lot was already known about housing preferences, the construction costs of housing and how to calculate rent levels, and about the incomes of the people who would live there. Technically it was also quite straightforward; system-building was the approach generally adopted at that time. It presented a puzzle with a series of different dilemmas that needed solving. That grabbed my attention. I was able to focus the rest of my studies on housing construction."

*If you had the opportunity to re-plan the Netherlands, what would it look like?*

"I do not have an ideal image of how the Netherlands should be. Rather, it's more about decision-making regarding the challenges you face. In the old days, people would just reclaim more land if it was needed. We now know that this damages the flora and fauna. The Netherlands is finite. You cannot want it all. In order to accommodate the needs of all our citizens, we need an area fourteen times the size of the Netherlands. The ideal Netherlands for me is a country in which we cut our coat to fit the cloth. We need to look not only at economic growth and demographic dynamism but also at how you can accommodate this in a way that enables everyone to develop to the full."

## *Who is* Hugo Priemus?

Professor Hugo Priemus studied architecture in the 1960s at what was then known as TH Delft. He then became a (head) scientific staff member at the faculty of Architecture. From 1969, he was also director of the RIW Institute for Research in Public Housing. In 1977 he became Professor of Public Housing at TU Delft and remained in that position until 2003. During that period he served as Dean of the faculty of Architecture. From 1985 to 2003 he served as director of research at the OTB Research Institute. From 2003 until his retirement in 2007, Prof. Priemus was the Dean of the faculty of Technology, Policy and Management. He also has countless other ancillary positions and publications to his name. Prof. Priemus has been awarded various distinctions and awards. In 1989, he was appointed Knight in the Order of the Dutch Lion and in 2008 he received the Golden Medal from TU Delft. In November 2010, he received the Hudig Award, which has been presented thirteen times since 1935 for services in the field of public housing and spatial planning.

# ‘Scrapping? That’s not what we call it’

*Tomas van Dijk*

Engineers love tinkering with just about anything. Some however prefer to spend their time dismantling and recycling things. With his business, Aircraft End of Life Solutions, Derk Jan van Heerden is one of them.

Next to the faculty of Aerospace Engineering’s hangar, the cockpit of a 35-year-old Fokker F27 lies between an F16 and a helicopter.
Two years ago, Derk Jan van Heerden bought eight of these aircraft from WDL, a German airline. They had been left to waste away at Cologne airport. Van Heerden cut the Fockers into pieces and sold the parts to training centres across Europe, including TU Delft.
Like many aerospace engineering students, Van Heerden’s choice of study was sparked by his interest in aircraft construction. But during an internship at KLM he came across a completely different aspect of aviation: what to do with old aircraft? For KLM, he calculated that it makes economic sense to dismantle an old Boeing and re-use the components.
Van Heerden had identified a hole in the market. Immediately upon graduating in 2005 he set up Aircraft End of Life Solutions, a company specialising in scrapping old aircraft.
“Pardon me, but *scrapping*? That’s not what we call it,” chides Van Heerden, who now employs five people and has already processed 25 aircraft. “Scrapping has negative connotations, and makes what we do sound simple, which it certainly isn’t. We do two things: we disassemble and then dismantle the aircraft.”
His company brings in heavy machinery to cut the old aircraft into pieces. Components like the cockpit, landing gear and engines sometimes end up at training centres. It is however often more lucrative to remove the meters, actuators and other components from the aircraft and resell them once they’ve been recertified.
“It depends on the individual requirements of the buyers and sellers,” Van Heerden explains. “Some of them do not want us to market their aircraft equipment because that would reduce the value of the components they still have in stock. In such cases we must then cut all the small meters in half.”
Anything that cannot be re-used is shredded. Van Heerden: “We start by using enormous machinery to cut the aircraft into large pieces. The rearmost part of the aircraft simply disappears like snow melting in the sun. We cut the tail into pieces measuring 10 x 10 cm. That’s the end of the process for us. We sell the scrap to metal smelters, who then separate all the metals.”
Van Heerden is about to face a major challenge, though. He has just begun work on a Boeing 747, the largest aircraft in his career thus far, for which he’ll need to hire some large-scale equipment: “We’ll have to watch out that the heavy cutting machines do not destroy the asphalt.”



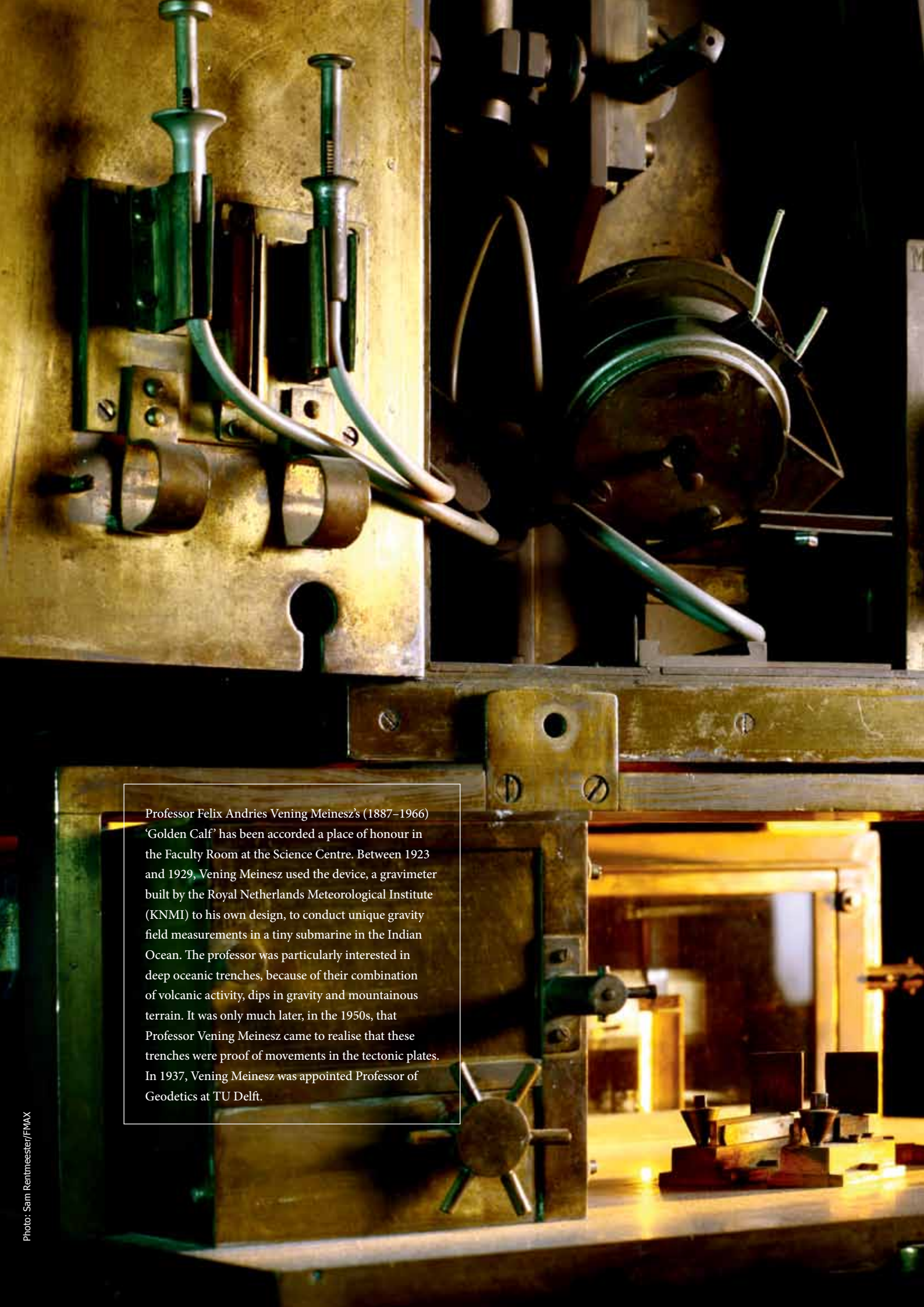
# What happened to the nuclear power plants?

*Jos Wassink*

‘An expected nuclear renaissance has failed to materialise as plans for new plants are scrapped or delayed’, reports *Technology Review*.

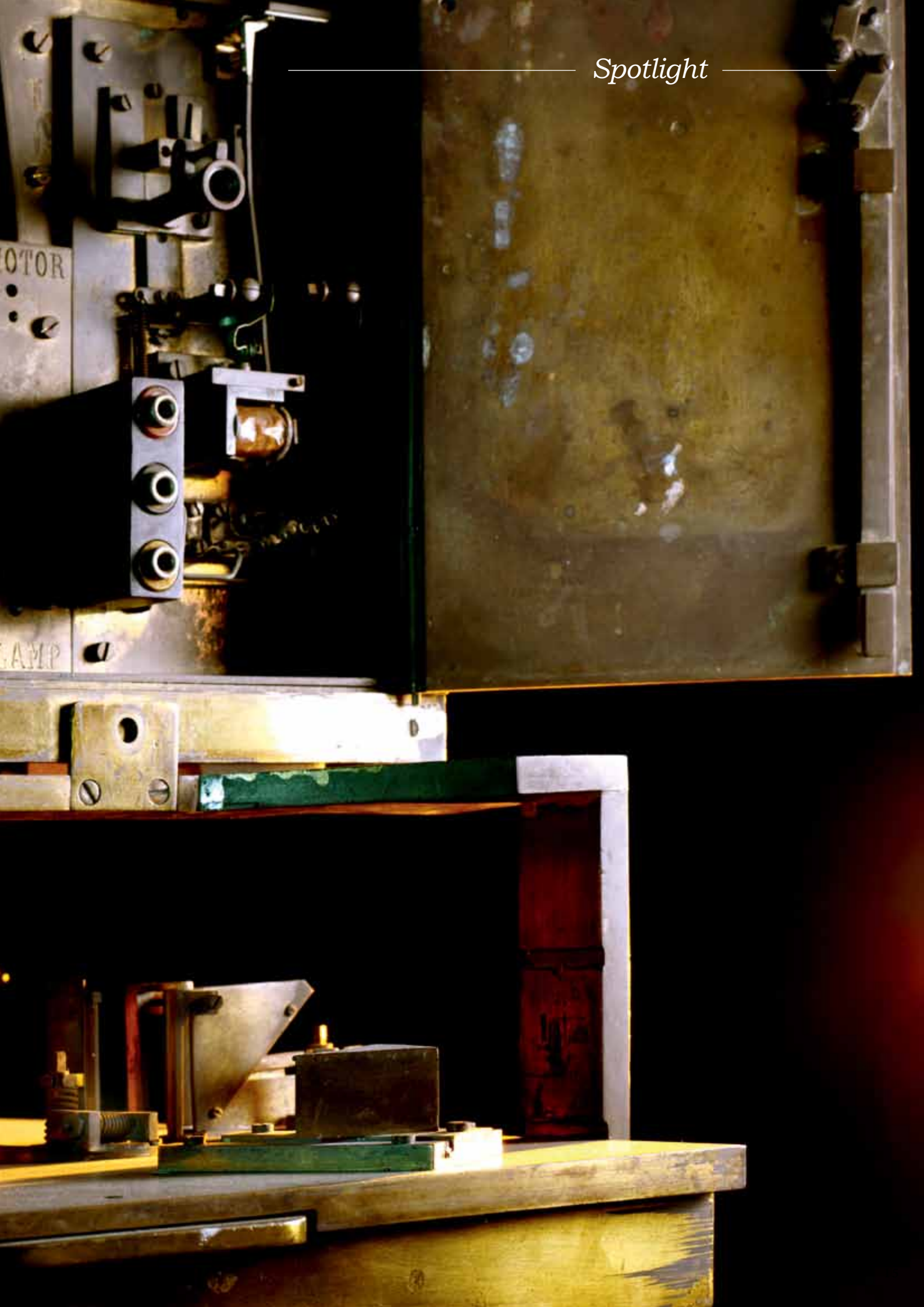
MIT technology magazine *Technology Review* reports that the construction of nuclear reactors in the United States and in many other places has virtually ground to a halt. This is despite government credits guaranteeing up to 80% of construction costs, political support from President Barack Obama, and high-level advocacy from such influential figures as Bill Gates and environmental activist Stewart Brand. Obstacles, delays, postponements and problems are emerging all over the place. Except, of course, in China, where at least 24 new nuclear power plants are under construction. So what is the West’s problem? In a word, money.
Dr Aad Correlje (Technology, Policy and Management) explains why. In the 1970s, when today’s reactors were first built, the market economy was in a much earlier stage of development. In those days, the energy companies agreed an acceptable energy price with governments, based on the repayment of construction costs during the estimated life cycles of the power plants. This was supplemented, of course, by a profit margin for the energy companies. The main advantage of this approach was that the energy companies avoided any financial risks.
In the United States, a similar system, known as ‘cost of service regulation’, was applied. According to *Technology Review*, this system is still in use in a number of southern US states, but these are the only states in which the industry is still showing any signs of life.
As in Europe, other US states have switched to the auction model for the energy market. *Technology Review* explains: ‘All power companies get the same price for their electricity. That price is usually determined by the cost of natural gas, making the construction of a new nuclear plant unthinkable.’ Dr Correlje adds that natural gas prices in the United States were relatively high after the country’s natural gas production peaked. But the recent extraction of new shale gas has led to increased production and a reduction in the price of natural gas. Consequently, energy prices dropped and enthusiasm for nuclear energy waned.
‘Carbon pricing alone is all that can save nuclear energy’, claims the MIT journal. ‘An amount in the region of $10 per tonne of $C0_2$ could make all the difference.’ Industry analysts projected a price of $60 to $80 per tonne, but that never happened because the US Climate Bill was never passed. “There is a lot of uncertainty as to whether it ever will be enacted,” Jay Apt from Carnegie Melon University told *Technology Review*.
Against this backdrop, is it likely that the Netherlands will build one or two more nuclear plants, as the government has announced? Correlje thinks not. The costs and financial risks are too high and prices of energy and emission rights too uncertain.

**Technology Review, ‘Giant holes in the Ground’, 12 November 2010**



Professor Felix Andries Vening Meinesz's (1887–1966) 'Golden Calf' has been accorded a place of honour in the Faculty Room at the Science Centre. Between 1923 and 1929, Vening Meinesz used the device, a gravimeter built by the Royal Netherlands Meteorological Institute (KNMI) to his own design, to conduct unique gravity field measurements in a tiny submarine in the Indian Ocean. The professor was particularly interested in deep oceanic trenches, because of their combination of volcanic activity, dips in gravity and mountainous terrain. It was only much later, in the 1950s, that Professor Vening Meinesz came to realise that these trenches were proof of movements in the tectonic plates. In 1937, Vening Meinesz was appointed Professor of Geodetics at TU Delft.

Photo: Sam Rentmeester/FMAX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# Atlas of the cell

*The cell is a miniscule universe of proteins that combine to form macromolecular machines. Peter Peters, a professor of nanobiology, plans to unlock the secrets of this world.*

*Tomas van Dijk*

*Chop, chop, chop...* a ribbon of transparently-thin slices of deep-frozen cancer tissue emerges from a microtome. "This machine's diamond knife can cut sections just 40 nanometres thick," says Peter Peters, a professor of nanobiology at the faculty of Applied Sciences and project manager in the Cell Biology department of the Netherlands Cancer Institute-Antoni van Leeuwenhoek Hospital (NKI-AVL).
"We view those sections in a transmission electron microscope (TEM). We examine cells from the whole body - breast, ovary, lungs and so on - which are sent to us from around the world. My own partner also sends us samples. She's the head of Pathology and works a couple of floors down from here.

*'The function of a protein depends mainly on its 3D shape'*

"In this room we culture the cancer cells at 37 °C. We add human serum, plus a range of growth factors and nutrients. Maintaining a viable culture of primary cancer cells isn't easy."
Professor Peters' tour of NKI-AVL is suddenly rudely interrupted. A member of staff walks through the department, loudly banging on a cooking pan - *bong*! The echoes fill the corridor. Researchers engaged in culturing cancer cells or cutting sections briefly stop work. Everyone is asked to gather near the coffee machine to toast the acceptance of a paper for publication in the scientific journal Cell.

## Rapid progress

For Prof. Peters, this is a familiar sound. In recent years his team of nine researchers has published three articles in *Nature* and *Cell*, both highly prestigious scientific journals. These articles deal with the three-dimensional imaging of proteins in cells and cell organelles.

"A protein's function depends mainly on its 3D shape, rather like a cog in an engine," the professor says, while occasionally sipping from his glass of champagne. "By investigating these shapes, we hope to gain a better understanding of various types of cancer, and of infectious diseases, such as tuberculosis."
The availability of greatly improved image processing techniques and better electron microscopes has led to rapid progress in the visualisation of proteins in recent years. The number of publications is growing exponentially.
"The concept of cells as simple bags of protoplasm, containing a nucleus and various organelles, has given way to an entirely new vision," Prof. Peters explains. "We now see cells as minute universes in which proteins work together and combine to form hundreds of macromolecular machines, of which each has a highly specialised task."
According to Prof. Peters, if the Netherlands is to keep up with other countries in this booming world of nanoscopy, it will need to set up a new research institute with three advanced transmission electron microscopes. To that end, he and a group of colleagues established the Netherlands Centre for Electron Nanoscopy (NeCEN), a collaborative venture involving ten universities and research institutes. Aside from NKI-AVL, the venture includes Leiden University Medical Center, Erasmus MC, and the universities of Delft, Leiden, and Utrecht.
The plan is for NeCEN to become an independent institution whose facilities are freely available to each of the participating organisations, as well as to any biotechnology companies wishing to hire microscopy time.
In June of last year it was announced that the still incomplete institute would receive government funding to the tune of 38 million euros. However, the political climate has since changed. "I'm holding my breath," Prof. Peters remarks, before returning to this point a few minutes later. "I'm still confident that the research institute is coming."
The article in *Cell* is a big boost, he believes. "Publications like this are worth millions."
By last summer, NeCEN had already received the first


Peters: "Proteins are so small that if we try focusing on them, we see nothing."

12 million euros of its government grant. The first two microscopes have been purchased and will soon be assembled in their temporary quarters at Leiden University's Gorlaeus Laboratory. A dedicated facility for NeCEN will be built on the same site within the next few years.

### Nano-sized atom bombs

Towering several metres above one's head, the steel-panelled Titan electron microscope is a veritable colossus. Housed in the Van Leeuwenhoek laboratory (a facility shared by TU Delft and the Netherlands Organisation for Applied Scientific Research (TNO)), this instrument is capable of observing details at the atomic scale. NeCEN will soon have three such transmission electron microscopes at its disposal.

Researchers use transmission electron microscopy to bombard specially prepared specimens with electrons. After these particles have passed through a specimen, the microscopists reconstruct the image based on measurements of electron scattering and absorption. Using this technique to examine biological samples presents particular challenges, however. The number of electrons in the beam must be kept to a minimum; otherwise, everything disintegrates into a formless mush. "These electrons are like nano-sized atom bombs," Prof. Peters says. "You must not exceed a dose of 80 electrons per square ångström [an ångström is 0.1 nanometres, ed.]." Another problem is that, until recently, it was impossible to detect the electrons directly. After passing through the specimen, the "nano-bombs" impact with a small, electron-sensitive screen, which emits light whenever it detects one of these particles. A CCD chip (charge-coupled device) then translates that electromagnetic radiation into a digital image. "A great deal of detail is lost during the conversion of electrons into light," Prof. Peters confirms. In TU Delft's high resolution electron microscopy research group, headed by Professor Henny Zandbergen (Applied Sciences), researchers are currently working on ways to improve this situation, using the Van Leeuwenhoek laboratory's Titan for this purpose. Together with FEI

*'Publications like this are worth millions'*

(which manufactures the microscope), the researchers have developed a sensor in which the CCD detector is directly linked to a phosphorescent layer. "This reduces information losses to one quarter of present levels," says Prof. Peters. Both groups are part of NeCEN.

The research partners are also planning to develop better lenses. With current equipment, viewing proteins is a compromise between sharpness and contrast, but "proteins are so small that if we try focusing on them, we see nothing," Prof. Peters explains. This problem arises owing >

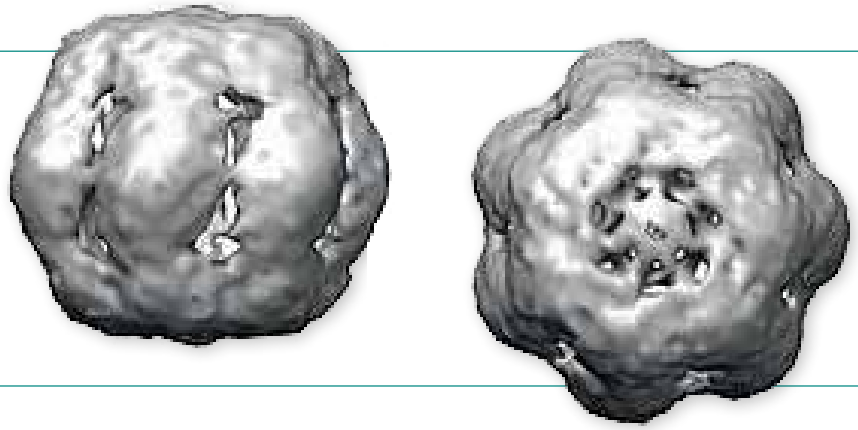


Illustration: Peter Peters

*Tubercles bacullus*, the bacteria that causes tuberculosis, perhaps draws its virulence from this small protein that comprises part of the pumping system in the membrane of the micro-organism. Prof. Peters reconstructs the structure of this particle using a technique called single particle analysis.

to the diffraction of electrons as they pass through a lens, which produces a small lens error.
A similar problem is encountered in light microscopy, but the solution there is to combine two lenses with equal and opposite aberrations that cancel each other out. "Within the world of electron microscopy, the race is now on to find an effective solution for the TEM," the professor says.

## Fuzzy beads

Prof. Peters aims to use the first of the three microscopes to explore a technique known as Single Particle Analysis (SPA), which involves using a TEM to take thousands of photographs of a certain type of protein. These images contain vast numbers of two-dimensional 'fuzzy beads' - nothing more. However, because the protein molecules are randomly positioned throughout the sample, each molecule is viewed at a slightly different angle. A computer then crunches its way through this huge mass of fuzzy images to resolve the protein's three-dimensional structure.
Prof. Peters has harnessed this technique for some pioneering research into tuberculosis, and he now wants to pursue this research in NeCEN.
In a PowerPoint presentation, he shows images he has made, using SPA, of a protein from the cell membrane of *Tubercles bacillus*, the bacterium that causes tuberculosis. The process involved taking 250,000 photographs of the protein in question. He conducted this research using a TEM at the University of Groningen.
The protein – known as EspB - is a ten-nanometre cog in a major pumping system inside the cell membrane. In appearance, the protein's shape resembles two plastic funnels with their large, open ends placed together. The protein moreover has thin, elongated openings along its sides, as well as minute holes on the top and bottom.
A few years ago, Prof. Peters and his colleagues discovered that EspB may be the key to *Tubercles bacillus*' remarkable survival skills. The professor suspects that certain substances released through the small holes in EspB enable the pathogen to undermine its host's immune system. Cells attack bacteria by engulfing them in a membrane, isolating and then destroying them. It had always been thought that *Tubercles bacillus* had evolved a way of surviving this encapsulation. In 2007, however, this team of researchers published a paper in *Cell* showing that the bacterium manages to escape from this 'tiny jail' by releasing certain substances that dissolve the encapsulating membrane.
Prof. Peters's suspicion that EspB is part of this escape mechanism is based on a genetic experiment. He inserted the genes encoding the pump system into a weakened strain of *Mycobacterium bovis*, a bacterium that causes tuberculosis in cows. This bacillus was isolated from cows 100 years ago, and has been maintained in culture ever since. Over the years the bacterium became increasingly primitive, shedding various genes from its genome that were not needed under culture conditions, including 14 genes encoding the membrane pump.
This weakened tuberculosis bacterium, known as Bacillus Calmette-Guérin (BCG), which has been widely used in human vaccines since the 1940s, has lost the ability to escape from phagocytes. But Prof. Peters' genetically modified variant was able to break out, indicating that the pump plays a crucial role in the escape mechanism.
Researchers believe that it may possible to convert the tuberculosis vaccine into a vaccine against many other pathogens, including the hepatitis B and C viruses and human papillomavirus, which cause liver cancer and cervical cancer, respectively. These micro-organisms also produce proteins that help them evade their host's immune system. Prof. Peters reasons that if the genes encoding these proteins were to be inserted into the Bacillus Calmette-Guérin genome, then the bacterium would synthesise these proteins and, perhaps, release them via EspB.

Peters: "Maintaining a viable culture of primary cancer cells isn't easy."

## Preserving cellular structures

Before this can be achieved, however, researchers must gain a better understanding of how the pump works. This, in turn, will require a detailed knowledge of the pumps' locations within the cell, which is where cryo-electron tomography comes in. This is the second major TEM technique that NeCEN plans to use in the next few years.
Cryo-electron tomography involves photographing parts of the cell at differing angles, which is achieved by slightly rotating the specimen repeatedly within the TEM. The photographs are then used to construct a 3D image.
The cells meanwhile are instantaneously frozen in place

using -186 °C liquid nitrogen. Such rapid freezing is essential for keeping the cell structures intact; otherwise, many of these structures would be lost when the cell dies, which is inevitable when specimens are examined in the TEM.

If the liquid in the cells was to crystallise, these delicate structures would be ripped to shreds. The researchers prevent this from happening by culturing the cells in a medium containing a cryoprotectant. The researchers however have only been able to successfully culture bacteria and yeasts in this medium, not animal cells.

Prof. Peters and his team are now working on ways to make human cells so thin that they freeze even faster, giving ice crystals no time to form. They have designed a special device for this purpose, consisting of two miniscule chambers in a piece of clear plastic. These two tiny chambers are connected by a slit, measuring just 25 microns high and 200 nanometres wide, which the cells must squeeze through.

"Some types of cell can manage that," Prof. Peters explains. "White blood cells, for example, which must be

*'These electrons are like nano-sized atom bombs'*

able to pass through the walls of blood vessels and into the surrounding tissue. To do this, the cells must make themselves very thin. I've actually photographed this process on numerous occasions. It's like a person sliding through the crack under a door." A white blood cell in one chamber is attracted by chemoattractants leaking from the other chamber. These are proteins that, under natural conditions, alert white blood cells to the presence of an infection. When the cell is halfway through the slit it is frozen.

"In theory, it should work," Prof. Peters says, peering through a nanochamber he holds between his thumb and index finger. "All we must do now is find a better way of removing the surrounding plastic, so that we can examine the specimen from every angle in the electron microscope."

Using cryo-electron tomography, the scientists can achieve a resolution of a few nanometres, which is a factor of ten less than with Single Particle Analysis. But this also means that no proteins can be seen in the photographs – or at least not by the naked eye. There is however a computer program capable of identifying traces of proteins, and these minute structures are then compared to the shapes of proteins derived from Single Particle Analysis. Professor Peters: "We use this 'template matching' process to create a sort of atlas of the cell, in which all parts are imaged clearly in 3D."

# Knowing where to find top quality

At the end of 2010, Associate Professor Homayoun Nikookar was named TU Delft's very first 'supervisor of the year'. He had been nominated by his PhD student, Madan Kumar Lakshmanan, who, in nominating Dr Nikookar, described him as a patient listener, an empathic guide, inspirational mentor and a sympathetic father figure.

*What is the difference between a supervisor and a good supervisor?*

"Master's and PhD students are very different from each other. Their supervision calls for different specialisms. A Master's student has subjects, elective subjects and a thesis, whereas the PhD student doesn't actually have individual subjects at all. He or she has much more freedom and must conduct independent research. It's up to a good supervisor to drive that research. The PhD student bears the responsibility, while the supervisor provides direction."

*How do you provide direction?*

"It's the supervisor's job to monitor and provide feedback to the PhD student. It depends on the student as to how often this feedback is required. If there is insufficient progress, the supervisor will provide a timely warning, and point out the need for more intensive or far-reaching research. It's even more important to introduce PhD candidates to good conferences and academic journals, because it's difficult to assess their quality for oneself at that stage. The supervisor knows where to find top quality."

*Supervisors are often criticised for leaving their PhD students too much to their own devices.*

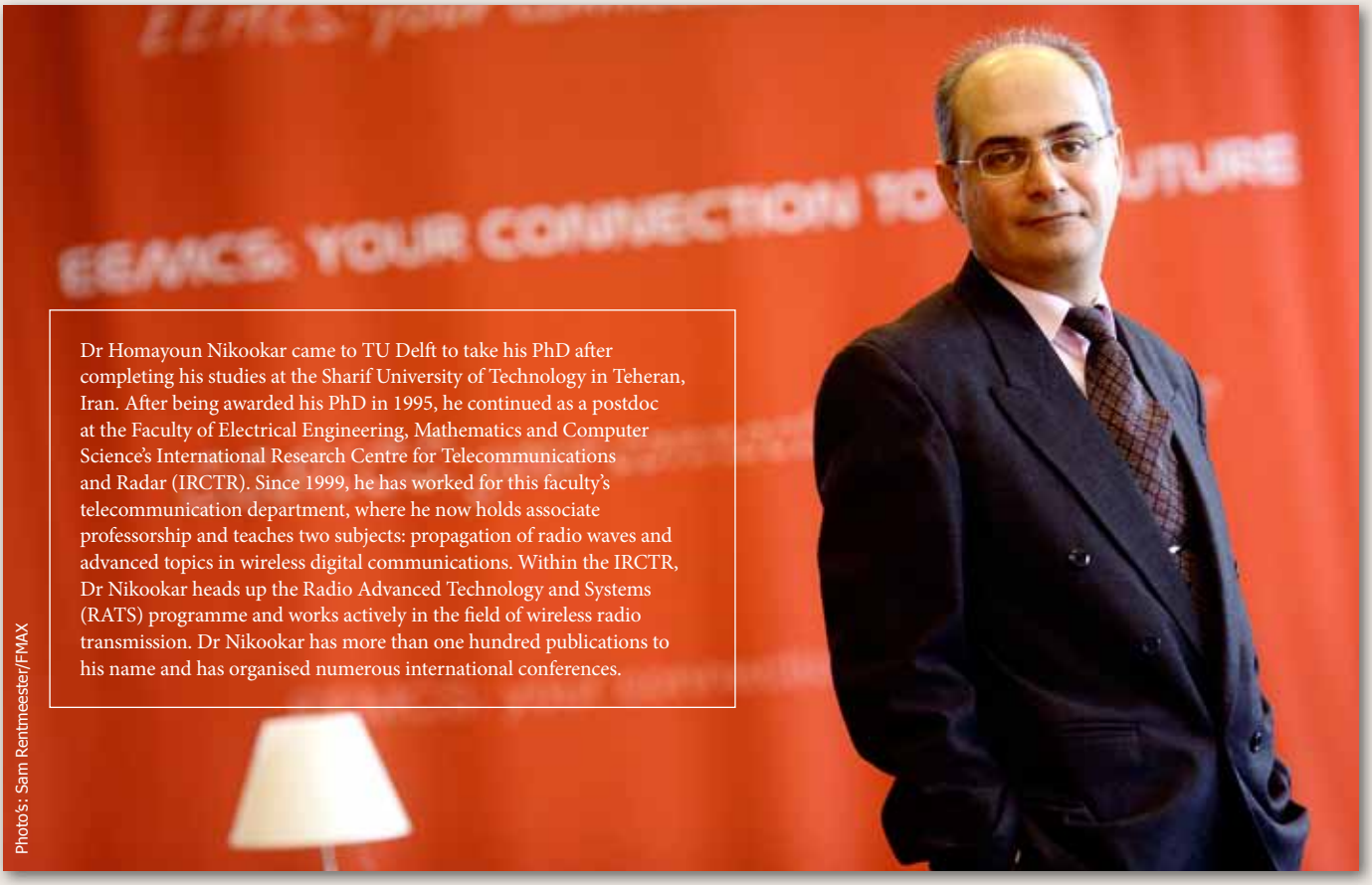
"It's important to provide lots of support, especially in the first year. After that, the need for supervision gradually decreases. But even then, the supervisor always needs to be able to free up time and be open to his or her PhD students. This can make it quite a challenging job. My work supervising students often extends into the evenings and weekends. But that's the secret of it: it has to be something you enjoy doing. For me, it's interesting to talk to my PhD students about their new ideas. I even occasionally benefit from them myself."

*What kind of PhD student is Lakshmanan?*

"He's talented and performs well. He works hard, is intelligent, affable, friendly and open. We have excellent discussions with each other. A good PhD student takes the initiative, shows enthusiasm and is willing to apply intellectual rigour. If he or she makes it through the first year, success is more or less guaranteed."

*There are lots of different cultures in your department. How do you handle that?*

"We have people from everywhere. That gives us a real mix of talents. The Chinese can tend to be extremely theoretical while the Austrians take a more technical approach to tackling problems. We also do a lot of great things together, going sailing for example. That's when you often see the cultural differences and similarities."



Dr Homayoun Nikookar came to TU Delft to take his PhD after completing his studies at the Sharif University of Technology in Teheran, Iran. After being awarded his PhD in 1995, he continued as a postdoc at the Faculty of Electrical Engineering, Mathematics and Computer Science's International Research Centre for Telecommunications and Radar (IRCTR). Since 1999, he has worked for this faculty's telecommunication department, where he now holds associate professorship and teaches two subjects: propagation of radio waves and advanced topics in wireless digital communications. Within the IRCTR, Dr Nikookar heads up the Radio Advanced Technology and Systems (RATS) programme and works actively in the field of wireless radio transmission. Dr Nikookar has more than one hundred publications to his name and has organised numerous international conferences.

Photo's: Sam Rentmeester/FMAX

# The ability to think logically

*Saskia Bonger*

*What gave you the idea of nominating Homayoun Nikookar for the title of 'supervisor of the year'?*

"When I saw the call for nominations, I wondered what I would write in the acknowledgements to my thesis. That's a good sign. TU Delft is an international institution. When you come here from far away, it's nice to have someone with whom you can share your concerns and who can provide support. That's what Nikookar is for me. But it's not only him: the telecommunication department is a very friendly place, like a family."

*What do you aim to achieve with your research?*

"I hope to make a contribution to highly developed mathematical principles for telecommunication. Take the mobile telephone, for example. With video and internet, mobiles have increasing numbers of different functions. In the future, we will try to incorporate more and more things into these tiny devices. But current mathematical principles have their limits. My aim is to leave my work in such a state that someone else can take it on and progress it further."

*What are you learning from Dr Nikookar?*

"He has taught me to remain patient. Sometimes you spend months working on tiny details that will only make up a small part of your thesis. It's not something you should get frustrated about."

*How often do you have discussions?*

"His door is always open. He also believes that we should publish regularly. That means that you always have to be able to clearly express in words what you are working on. Dr Nikookar teaches me to think while I'm writing about what people will understand based on their backgrounds. The ability to think logically is essential for that."

*Did you know from the outset what you wanted to achieve with your research?*

"I've been working on the mathematical principles of wireless telecommunication since my Master's. So I was quite familiar with the field when I started my PhD research. But it was only in the second year that I was able to set boundaries and fully focus my research. During the first year, I delved enthusiastically into all kinds of publications, but realised later that I needed to take it easier. It's not only Dr Nikookar who ensures I keep my eye on the ball, the Master's students working on my research also help. Their questions make me re-evaluate my approach."

*What is important about Dr Nikookar's work?*

"There are many experts in the mathematical principles that underlie wireless technology. But Dr Nikookar is the authority when it comes to translating these principles into practice."

Madan Kumar Lakshmanan (1979) completed his Bachelor's degree programme cum laude in Electrical Engineering at the University of Madras in India in 2000. He then spent three years working as a programmer for international companies that outsourced work to India. In 2003 Lakshmanan moved to the Indian Institute of Technology in Madras, where he led a team of young researchers designing a wireless communication network across agricultural areas. Although Lakshmanan actually wanted to stay in India, he felt that his prospects there were limited. Studying abroad seemed the logical next step. In 2004 he received a Shell scholarship to do his Master's in telecommunications at TU Delft. Two years later, he graduated cum laude and started his PhD research.

**Dr Maaike Kroon** (29) was appointed professor of chemical engineering at TU Eindhoven, as of 1 March 2011. With this appointment, TU Delft loses one of its outstanding young research talents. Kroon departs with pain in her heart: "I learned everything here". But she could not pass on the opportunity to set up her own research group in Eindhoven. Her appointment to a professorship is remarkable, given that she is just 29 years old, making her the youngest professor in the Netherlands.

On 29 November, Cabaret duo **Maartje & Kine** narrowly failed to win the Groningen Students' Cabaret Festival. In the final, Kine Handlykken (sixth-year student in industrial design engineering) and conservatory student Maartje de Boer competed against Dara Faizi from Amsterdam. The duos venture into the world of cabaret is set to continue: on Febuary 1 they will begin filming for HumorTV, a program of Vara, a Dutch broadcating network.

Three TU Delft researchers have been awarded Vici grants worth €1.5 million each by the Netherlands Organisation for Scientific Research (NWO) on February 1, 2010. Philosopher **Ibo van de Poel** will conduct research into the advantages and dangers that new technologies, such as biotechnology and nanotechnology, present to society. Van de Poel sees technological developments as social experiments and intends to investigate whether these kinds of experiments are admissible. **Professor Paul Hekkert**, of the faculty of Industrial Design Engineering, will use his Vici grant to study the aesthetic experience of everyday products. His hypothesis is that product aesthetics appeal to two extremes: the human need for security and the desire for change. The third Vici grant was awarded to **Dr Erik Bakkers**, a researcher at TU Eindhoven and part-time professor at TU Delft's quantum transport section (Applied Sciences). His research will focus on semiconducting nanowires that might one day be used in quantum computers.

Professor of educational technology, **Dr Sugata Mitra**, of the University of Newcastle (UK), received an honorary doctorate from TU Delft during the 169th Dies Natalis celebration of the university's foundation day. Professor Mitra was nominated from this honour by Professor Wim Veen of the faculty of Technology, Policy and Management. Prof. Mitra has helped teach 300,000 poor children in India how to use computers.

In late November **Dr Akke Suiker**, of the faculty of Aerospace Engineering, was awarded TU Delft's 'Best Teacher' award for the 2009-2010 academic year. His winning formula: he captures the essence of the subject matter and uses exciting practical examples in order to allow students to understand the theory involved in challenging subjects For winning this award, Dr Suiker recieves €7,000, of which €5,000 will be used to further improve teaching.

On Saturday, 28 November, **Jasper van Kuijk**, a PhD student at TU Delft, won the Cameretten cabaret festival. Van Kuijk, an industral design engineer, won both the public and the jury prize. The jury said that Van Kuijk's winning act, titled 't Kan nie op' was "an exciting and credible plea against simplification and animation".

**Dr Rob Fastenau** has been appointed the new Dean of the faculty of Electrical Engineering, Mathematics and Computer Science, as of 1 January 2011. For the past ten years he held a top-level management position with FEI, an American company. During his distinguished professional career, Fastenau has also been involved with the Netherlands Centre for Nanoscopy (NeCEN), the High Tech Systems, the strategic innovation program's Point-One, and the Center for Translational Molecular Medicine.

**Karin Laglas** (1959) has been appointed the new Dean of the faculty of Architecture, as of 1 January 2011. She succeeds Dean Wytze Patijn, who has been appointed to the position of 'TU Delft campus supervisor' and city architect of Delft. Dean Laglas is TU Delft's first ever female dean. She studied civil engineering at TU Delft, but had difficulty deciding between pursuing an architecure or civil enginerering degree. Her preference for stastics and her doubts as to whether she was suited for the artistic side of design ultimately made her choose civil engineering. However, upon graduation, her career path was closely involved with architecture.
She has held management positions with property development companies MAB and OVG and property investment company Rodamco Europe. During the past year she has served as acting director of the Royal Institute of Dutch Architects (BNA) and as a board member of the Forum for Urban Renewal. Laglas finds it "great" that she is TU Delft's first-ever female dean. She believes she was appointed to this position primarily because of her knowledge, experience and the fact that she fit the profile for what is expected of the new dean.

# Reborn


Photo: Sam Rentmeester/FMAX

Michiel Cramwinckel (49) manages an office for international patents firm, Haseltine Lake.

*Erik Huisman*

In 2009 Shell announced it would reduce Cramwinckel's department by 20 percent. He had been working there as a patent attorney for 30 years. "I didn't have to leave," Cramwinckel stresses, but he felt uncomfortable with the situation. "I believed that the work we were doing was of strategic importance for a technical company like Shell," he told *Het Financieele Dagblad* in March. "But obviously Shell had other ideas."
In that situation, something had to give. "I made it clear that I wanted to leave," he explains. "Being a patent attorney tends to limit one's career options. You spend four years studying and taking exams, then work for nearly twenty years as a patent attorney, ultimately ruling yourself out of the market for other positions."
Haseltine Lake proved the answer. All of which is completely different from the career that Cramwinckel had his eye on when he graduated as a chemical technologist in 1987. "I initially started studying industrial design engineering at TU Delft because of my specific blend of creativity and good exam results in science subjects, but industrial design didn't offer the scientific challenge I was looking for. So I decided to focus on science for my studies and leave the creative aspects for my leisure time," he explains.
His first job was as an engineer, spending two years on research at DSM. It was there that patents became his speciality. After six years at DSM he moved to Shell. Cramwinckel is passionate about patents, partly because they demand creativity. "At Shell, my work often involved major projects, like gas-to-liquids technology," he says. "The competitors had strong patent portfolios in this field, so it was my job to strengthen Shell's position, partly by challenging other companies' patents at the European Patent Office. Today I deal with a range of different technologies, from solar cells to fire extinguishers. With patents, in order to put together a claim, you must consider complex issues at the interface between technology and law. The aim is to word your patent application in such a way that clever competitors cannot use the invention. It always involves new, groundbreaking subjects."
At Haseltine Lake Cramwinckel was made responsible for his part of the business. "There were no orders and no income. You have to search out clients for yourself – but with patents, there is a problem with visibility. Your customer network grows very gradually," he concedes. "Despite that, I feel as if I'm reborn here. Starting small, from the bottom, with a single office." But matters will not stay that way for long, if Cramwinckel has anything to do about it. "We aim to become a partner of Haseltine Lake and greatly expand this office. And then I plan to retire at age 60."



# Traffic jams in 2030

*This winter's early snow nearly led a new record being set for the greatest number of traffic jams in the Netherlands - 975 km in 1999. Will we still be stuck in traffic jams in the year 2030? Professor of Transport and Logistics, Bert van Wee (Technology, Policy and Management), says yes, but believes some improvements are possible.*

*Jos Wassink*

"If the economy continues to grow and there are no extreme events, like oil running out or far-reaching changes in climate policy, we can expect rates of car ownership and use in the Netherlands to increase by tens of percentage points in future. Problems with traffic jams will increase still further, because traffic tailbacks are just the tip of the iceberg: if traffic on a busy road increases by just 1%, this results in traffic jams increasing from between 2 and 5%.
"What can we do about it? There is no single measure that would be more effective than the use of sharply variable road-pricing applied according to time and place. In essence, the plan proposed by former Dutch Transport Minister, Camiel Eurlings. According to calculations, this could result in a 50 percent reduction in traffic jams. But I do not consider the likelihood of this kind of regulation being introduced by 2030 to be very high, if only because the debate about different types of road-pricing has been raging for the last twenty years and every single plan proposed has met with failure.
I believe it is most likely that road-pricing would be introduced if other, preferably neighbouring, countries take that step and it proves effective. In that case, the Netherlands will probably follow suit. We have a reputation for being very good at developing innovative plans but being less successful at actually realising them.
"All of this still leaves the other 50 percent of traffic jams. These can be halved by means of a package of measures, including the selective expansion of the capacity of the road infrastructure. One example might include finding a cheap way of removing a bottleneck while ensuring that another one that replaces it is not created. But even if that works, you have to be aware that it will enable people to reach the cities more quickly, where they will face even further congestion. The bicycle also has a modest role to play in the process; for example, if it is made more attractive to store your bike in the city, offering an alternative for those who leave their cars at home.
"This leaves just a quarter of all traffic jams, which we will have to learn to live with, because the cost of removing this final quarter exceeds the benefit it offers. Currently, problems with traffic congestion cost us around 3 billion euro per year. If only a quarter of that remains, you can hardly expect society to incur enormous costs simply to save 750 million euro. Aiming to achieve zero traffic jams is simply not cost-effective."


Photo: Sam Rentmeester/FMAX

## Propositions

It is impossible to finish PhD research. You can only stop doing it.
**Tetyana Atamanenko**,
**materials engineer**

The cuteness of a cat is a monotonically function of the amount of love it receives.
**Fang Fang**,
**mathematical engineer**

Objectivity is so 20th century.
**Daniël Schuurbiers**,
**biotechnological engineer**

Bi-phasic enzymatic reactions can be a blessing for the enzymes but are a nightmare for the chemist.
**Andrzej Chmura**,
**chemical engineer**

The Dutch did not colonize Indonesia for three centuries, but it took them that long to unite Indonesia, and Indonesia still occasionally struggles to keep its unity.
**Widya Nugraha Budhysutanto**,
**materials engineer**

In The Netherlands the only non pensioners attending a classical concert are the musicians themselves. If things do not change, they will not have the opportunity to attend as pensioners.
**Ana Abel Tortosa Masiá,**
**energy technological engineer**

## Proposition

In contrast to what modern people want to believe, we still behave like predators. This prevents us from developing good relationships with prey animals, such as horses.
**Heleen Vreugdenhil , engineer in public administration**

## Defence

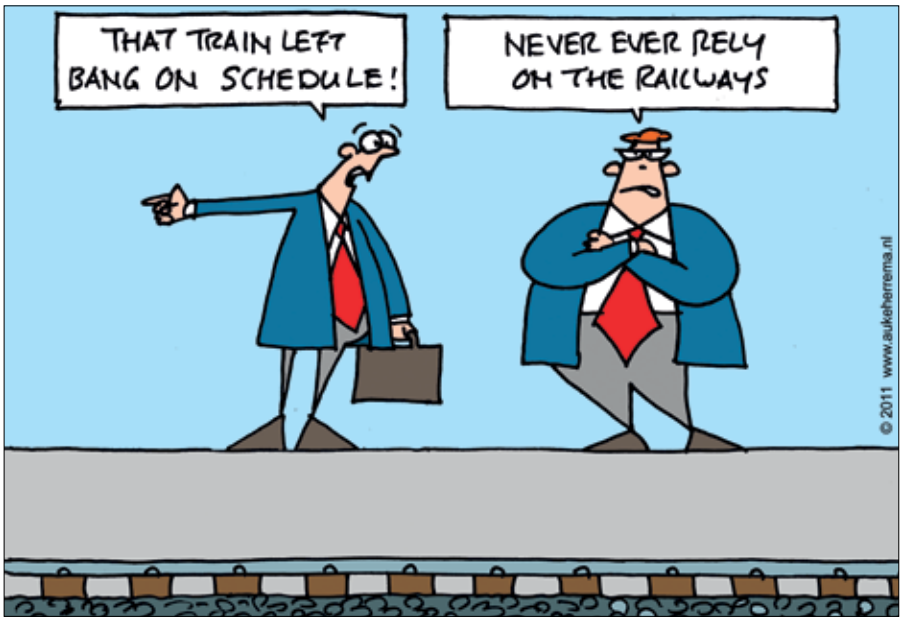
"As humans, we are forever disadvantaged in terms of developing our relationships with horses. We appear as predators, with our eyes in the front of our heads, we 'stink' of meat, just like a predator, and we behave like predators by proceeding straight to our goal (the horse) and 'capturing' it. Instinctively, these animals want to run away from us or at least stay away from us. We do not give horses the chance to be inquisitive and come to us. A horse will only ever want to be around us if we change our predator-like behaviour and offer the horse a sense of security and challenge."

## Sound Bites

"At the end of the 1980s, we excelled in this area. But all the companies from those days have gone bankrupt or disappeared from the Netherlands, because the market for wind turbines never materialised. Denmark and Germany are a different story altogether – such companies are flourishing there."
*Director of Research at the Wind Energy Research Institute, DuWind Prof. Gijs van Kuik on regenerating the wind turbine industry, in Trouw.*

"The old computers are stored in a depot in the Electrical Engineering faculty. It is below sea level, so they are under water if it floods. There is also a room where everyone walks in and out. I would prefer to have them in a safer location."
*Former Director of the Technology Museum (now Science Centre Delft), Dr Han Heijmans on early computers from the pioneering days of computing, in de Volkskrant.*

"People with solar panels have something to talk about in the pub. It gives your life meaning. People spend 10% of their income on their primary needs and use the rest to give their lives meaning. On things that they enjoy. In the Calvinistic Netherlands, we expect things to be cheap. But that's not the case: good things should actually be more expensive."
*Professor in Sustainability, Wubbo Ockels in NRC Handelsblad.*




*'People complain about a railway system no matter of its performance'*

**Francesco Corman, civil engineer**

## Column

# Oracle

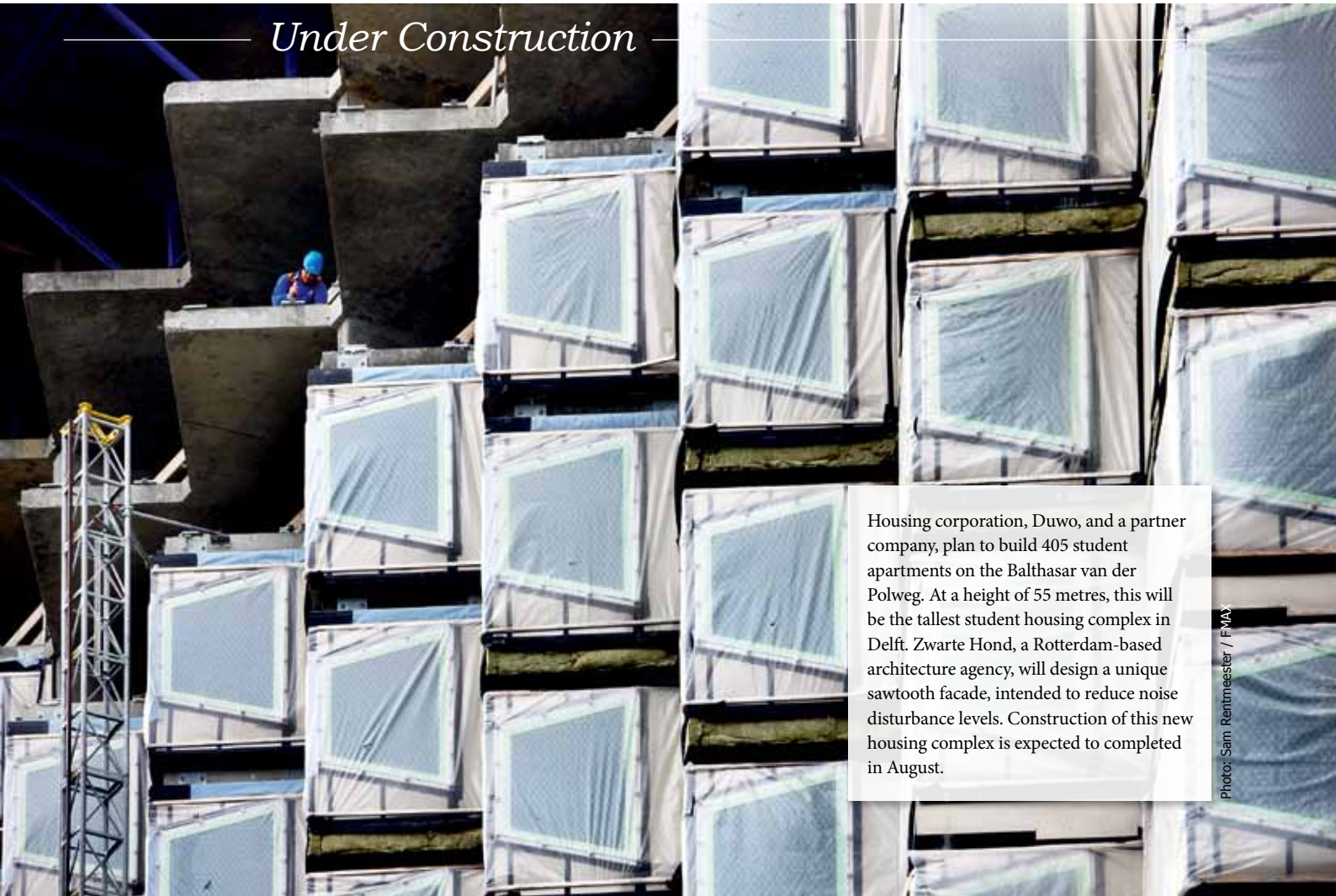
**Tonie Mudde** (1978) studied aerospace engineering and is a science journalist and writer. His work has been published in *Quest, nrc.next,* and *Het Parool* newspaper and elsewhere. In 2009 he was awarded a Tegel, the annual prize for journalism. Last year saw the publication of his debut novel, *Spaghetti Spoetnik* (Spaghetti Sputnik).

During a meal with friends recently, the conversation turned to the subject of a fly. One of my fellow diners had spent the entire car journey there wondering what would happen to the fly in the car in the event of a head-on collision. Would the fly crash against the windscreen or continue flying in the same place?
Silence filled the room, as everyone turned towards me, four pairs of eyes staring at me fixedly, convinced I'd know the answer. I was, after all, not only an engineer, but an engineer in aerospace engineering, so surely also an expert on the subject of insect aeronautics.
I suspect I'm probably not the only former TU Delft student to face this kind of situation.

Photo: Sam Rentmeester / FMAX

I generally handle these scenarios with a quip or an evasive answer, but the issue of the fly quickly became a matter of honour. It was first-year material: surely I'd know the answer? As long as the car drove at a constant speed with the windows closed, the air inside would be still. For the fly hitching a lift, the conditions of flight would be the same as they would be in a garden on a windless day. But what if the driver were to brake? That was where the doubts kicked in.
Later that evening I had a look at some of my old textbooks. I stared at the formulae-filled pages, hardly believing that I'd once known so much. Use it or lose it, the brain experts say, and indeed, after ten years in journalism my powers of calculation seemed to have completely evaporated.
I then enlisted the help of an engineer who has remained true to his calling. He reminded me of Newton's first law of motion: mass is inert. A fly weighs very little, but still more than the air in which it flies. This means that the fly shoots forward during a head-on collision. Further evidence can be found in Youtube videos of cars filled with balloons. If the balloon is filled with air, making it slightly heavier than air when you include the plastic, it will move in a forward direction on braking. If the balloon is filled with helium, however, making it lighter than air, then it actually shoots backwards when the brakes are applied.
I emailed this reputation-saving answer to my dining partners. Later that evening I put my old textbooks back in the cupboard. The fact that all that knowledge had become diluted suddenly didn't seem to matter so much. As long as you keep your Delft contacts up-to-date, you can be sure of quickly finding the answer to any question. Even when it's just about a fly.

## Under Construction



Housing corporation, Duwo, and a partner company, plan to build 405 student apartments on the Balthasar van der Polweg. At a height of 55 metres, this will be the tallest student housing complex in Delft. Zwarte Hond, a Rotterdam-based architecture agency, will design a unique sawtooth facade, intended to reduce noise disturbance levels. Construction of this new housing complex is expected to completed in August.

Photo: Sam Rentmeester / FMAX

# Alumni world

Searching for old student colleagues or networking with alumni in the Netherlands and abroad is possible thanks to the website www.worldofalumni.tudelft.nl. A total of nearly 250 alumni in more than 40 different countries have now registered on this interactive world map. These alumni act as contacts for school and university students interested in studying at TU Delft. The website also provides a picture of the worldwide alumni population. The more people who sign up, the more useful this world map will be for TU Delft alumni. Registering is easy on the website. If you have any questions or comments, please e-mail alumnibureau@tudelft.nl.


# Women of talent

**On Thursday 24 February 2011, the Delft University Fund presented the eighth 'Marina van Damme' grant to a talented and enterprising young female graduate of TU Delft. Entrants have the chance of being awarded the sum of €9000 for a study programme, internship or project. There is also a special incentive award. The winner of the grant must spend their prize money within two to three years, extending or intensifying their university programme or gaining wider international experience.**

Of the eleven entrants, four were ultimately short-listed.

**Adriana Diaz Arias** studied Systems Engineering, Policy Analysis and Management. She is working on a Master's in Engineering and Policy Analysis. She wants to use the grant for an internship at the World Bank, focusing on environmental policy in developing countries and its influence on the production and introduction of innovative energy sources.

**Sonell Shroff** studied Aerospace Engineering and is a PhD student in the Aerospace Engineering MSc programme. There are two universities in her discipline where she would like to develop her knowledge further: Stanford University and the National Institute of Aerospace, Langley.

**Jenny de Boer** studied Industrial Design Engineering and currently works for TNO. She would like to take a Master's in Cultural Anthropology in order to move on to a position in international development. She also hopes to spend three months engaged in fieldwork in Africa.

**Marjon Ruijter** graduated in Applied Mathematics and since October has been a trainee research assistant at the Centre of Mathematics and Computer Science in Amsterdam. She hopes to go to Bern to follow programmes at the Graduate School of Climate Sciences. She also wants to take an internship in Bern at one of the two leading institutes for climate research. In addition, she plans to take part in the NCCR Climate Summer School.


Already chosen as the best Industrial Design Engineering graduate, **Maarten Kamphuis** was also selected as the overall 'Best TU Delft Graduate' on 25 November 2010. Kamphuis is fascinated by European sword-fighting. He therefore completed his Master's in Integrated Product Design by designing a safe competition sword. The sword is made from steel and rubber and has a blade that retracts 10 cm into the handle when it is used.

Kamphuis' competitors for the 'UfD Mecanoo prize of Delft Graduate' were:

**Bart de Keijzer**, best EEMCS graduate, conducted research into weighted voting, as used at shareholders' meetings and by the European Union's Council of Ministers. His work involved designing a precise algorithm for this voting system.

**Tim van Oijen**, best 3mE graduate, compared the running performances of models with different centres of gravity and investigated the role of the torso during running. The results of his research can be applied in robotics.

**Anneleen Oyen**, best AE graduate, used satellite radar data to investigate the splitting apart of Africa into two sections.

**Diego Risté**, best AS graduate, investigated how the magnetic moment of individual electrons in diamonds can be controlled. This is useful for the development of super-fast quantum computers and ultra-sensitive magnetic field meters.

**Hadi Ashgari**, best TPM graduate, revealed patterns in the distribution of botnets across the networks of internet service providers (ISPs). Botnets are networks of end-users' computers infected by malicious software.

**Harmen van der Laan**, best CEG graduate, investigated how small scale technology can be used to remove arsenic from groundwater. The research offers hope to people in Bangladesh where much of the groundwater is polluted.

**Shirin Jaffri**, best Architecture graduate, has proposed a series of alternative intervention instruments based on detailed theoretical research in order to improve the quality of life of residents in the slum district of La Victoria in Santiago.

# Crossing borders

On 8 October 2010, more than 600 alumni attended the Alumni symposium on 'Cross-border Cooperation'. According to TU Delft's rector magnificus, Professor Karel Luyben, 'Cross-border Cooperation' is a key theme that is reflected across the whole of TU Delft. "Collaboration between the different disciplines in the development of technologies and products is increasingly becoming the rule rather than the exception. But TU Delft also literally crosses borders since we work with many universities abroad. This is something we must actively continue to pursue. Knowledge is the only renewable raw material that a university has. It is vital to continually innovate and the practical knowledge of our alumni plays an indispensable role in this regard." The afternoon session took place at the various faculties, where the alumni were given presentations on recent developments. A buffet was followed by an evening programme, featuring a speech by Professor Francine Houben. She is a professor in the faculty of Architecture and co-owner of Mecanoo Architecten architects firm. She presented an impression of her projects, including a library in Birmingham (UK) and theatre buildings in Spain and Taiwan. Regulations and conditions vary in each different country, which is why she is keen to come into contact with TU Delft alumni in other countries. "The knowledge that they have of these countries can be extremely useful for me. I can also get them or their company involved in my projects." Houben works with engineers from all types of disciplines. The importance she attaches to multidisciplinary and cross-border cooperation also influenced the design of the TU Delft campus. "I designed the area in such a way that students and academics from different specialisms couldn't help but meet up with each other."


More than 600 alumni payed a visit to the Alumni symposium.

## Ideas on sustainability

Cofely is challenging TU Delft Master's students to devise innovative solutions to reduce energy consumption. The most innovative idea will receive €7,500 from the Delft University Fund. There are also two prizes of €2500 for the runners-up. The nominees are:

**Douglas T. Gilding** studied Mining and also gained experience on the Delft geothermal project. He investigated the composition of the soil beneath Delft and its geothermal storage capacity.

**Michael K. Promodou** studied Civil Engineering, conducted an energy analysis of the Architecture building and provided recommendations on improving its energy efficiency.

**Victor Velez** studied Electrical Engineering and conducted research into the most effective management system for the energy network in neighbourhoods where people generate their own electricity.

The Delft University Fund Cofely Energy Efficiency Awards will be awarded on 24 February.

## Friends of TU Delft

Alumni who wish to support TU Delft students and academics and strengthen their professional and personal bond with the university can now become a 'Friend' of the University Fund. 'Friends of the Delft University Fund' will continue many of the activities of the former TU Delft Alumni Association and has the same objectives for the three Ts: Technology, Talent and TU Delft. Funds provided by Delft alumni have been used for a variety of purposes, including: promising research via *Daden voor Delft* (In Action for Delft), network activities such as the Alumni symposium, and supporting talented students from the Talent Teams. TU Delft and the Friends of the Delft University Fund are currently in the process of developing their strategy and publicity for the coming period. The University Fund is keen to welcome all Alumni as Friends. Further information about the Friends and the public benefit organisation status (ANBI) of the University Fund is available at www.universiteitsfonds.tudelft.nl.


## Janneke van Kilsdonk wins Delft University Fund's Strukton Master Awards

**Janneke van Kilsdonk** was awarded the Delft University Fund's Strukton Master Awards on 26 January. Three female Architecture students were nominated for the €5000 prize. The other two short-listed candidates each received €2500. Janneke van Kilsdonk devised a method for combining glass walls in buildings with solar cells. **Vera Kreuwels** developed the idea of the Hometown temp, a temporary residence for homeless people in Seattle that enables them to work on becoming integrated with other citizens. **Dena Kasraian** developed an instrument to measure urban capacity. She focuses primarily on urbanisation in the western Netherlands.

# 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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## Disciplines

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**Applied Earth Sciences**
Mijnbouwst raat 120
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Telephone +31 15 278 1423

**Applied Physics**
Lorentzweg 1
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Telephone +31 15 278 7774

**Architecture**
Berlageweg 1
nl-2628 CR Delft
Telephone +31 15 278 4184

**Chemical Technology & Bioprocess Technology**
Julianalaan 136
nl-2628 BL Delft
Telephone +31 15 278 2667

**Civil Engineering**
Stevinweg 1
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Telephone +31 15 278 5440

**electrical engineering**
Mekelweg 4
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**Geodetic Engineering**
Kluyverweg 1
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**Industrial Design Engineering**
Landbergstraat 15
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**Life Science & Technology**
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**Marine Technology**
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**Materials Science**
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**Mechanical Engineering**
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**Computer Science**
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**Applied Mathematics**
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**Technology, Policy & Management**
Jaffalaan 5
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Telephone +31 15 278 7100

## Multidisciplinary Centres

**Adhesion Institute**
Kluyverweg 1
nl-2629 HS Delft
Telephone +31 15 278 5353

**Biotechnological Sciences Delft Leiden (bsdl)**
Julianalaan 67
nl-2628 BC Delft
Telephone +31 15 278 5140/2342

**Centre for International Co-operation and Appropriate Technology (cicat)**
Mekelweg 2
nl-2628 CD Delft
Telephone +31 15 278 3612

**Centre for Transportation Engineering**
Stevinweg 1
nl-2628 CN Delft
Telephone +31 15 278 6634

**Dutch Institute of Systems & Control (DISC)**
Mekelweg 2
nl-2628 CD Delft
Telephone +31 15 278 7884

**Koiter Institute Delft (Institute for Engineering Mechanics)**
Kluyverweg 1
nl-2629 HS Delft
Telephone +31 15 278 5460

**Netherlands Institute for Metals Research (NIMR)**
Mekelweg 2
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Fax +31 15 278 2591

**Wind Energy Research Group**
Kluyverweg 1
nl-2629 HS Delft
Telephone +31 15 278 5170

**Reactor Institute Delft**
Mekelweg 15
nl-2629 JB Delft
Telephone +31 15 278 5052

**OTB Research Institute for Housing, Urban and Mobility Studies**
Jaffalaan 9
nl-2628 BX Delft
Telephone +31 15 278 3005

**Open Building Working group (obom)**
Berlageweg 1
nl-2628 CR Delft
Telephone +31 15 278 5400

**Delft Institute for Microelectronics and Submicron-technology (dimes)**
Feldmannweg 17
nl-2628 CT Delft
Telephone +31 15 278 3868

**Interduct Delft University Clean Technology Institute**
Rotterdamseweg 145
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Telephone +31 15 278 7233

**J.M. Burgerscentrum Centre for Fluid Mechanics**
Mekelweg 2
nl-2628 CD Delft
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**Netherlands Schools for Advanced Studies in Construction**
Stevinweg 1
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**Advanced School for Computing & Imaging**
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Telephone +31 15 278 8032

**Trail Research School**
Kluyverweg 4
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Telephone +31 15 278 6046

## 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.

*For further information:*
**Delft University Central Library**
Prometheusplein 1
p.o. box 98
nl-2600 MG Delft
Telephone +31 15 278 5678

**Delft University Press**
**IOS Press**
Nieuwe Hemweg 6B
nl-1013 bg Amsterdam
www.iospress.nl
Telephone +31 20 688 33 55
Fax +31 20 620 34 19
E-mail order@iospress.nl

## Information

*General information:*
**Information office**
p.o. box 5
nl-2600 AA Delft
Telephone +31 15 278 5404

*Information on facilities for foreign students:*
**Student Advisory Office**
Jaffalaan 9a
nl-2628 BX Delft
Telephone +31 15 278 4670

*Liaison between business and research:*
**Liaison Office**
Mekelweg 2
nl-2628 BX Delft
Telephone +31 15 278 1500

*Information on research fellowships:*
Mrs. M.Y.M. Spiekerman-Middelplaats
Stevinweg 1
nl-2628 CN Delft
Telephone +31 15 278 3773

*General information on university education in the Netherlands:*
**Min. of Education, Science & Culture**
**Central Information Dpt.**
p.o. box 16375
nl-2500 BJ Den Haag
Telephone +31 70 412 3456

## (Post Graduate) Courses

**Delft TopTech**
*(vocational courses)*
Mekelweg 2
p.o. box 612
nl–2600 AP Delft
Telephone +31 15 278 8019
Fax +31 15 278 1009
www.delft-toptech.nl

**Institute for Biotechnology Studies Delft Leiden (bsdl)**
Julianalaan 67
nl-2628 BC Delft
Telephone +31 15 278 2355

**For information on courses in the Dutch language:**
**Language Laboratory**
Jaffalaan 5
nl-2628 BZ Delft
Telephone +31 15 278 4124