2010.1

Research and education at
Delft University of Technology

# Delft Outlook

## Campus as testing ground

**Counting raindrops and scanning clouds**

**Satellites measure the climate** • **Guest writer Herman Koch**
• Nuclear bombs to cure cancer • Delta Committee • Atomic pencil • Flying toilets

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2010.1 DO



Delft Outlook

## [Edit] DO

Perspective is a key aspect of scientific endeavour. Take climate change, for example, an issue on which people have sharply contrasting opinions. Weather forecasts are based on averages taken across a huge area. Yet when it comes to the influence of the urban environment on the weather, we know precious little. That's why we have decided to launch a climate project close to home this year, on our very own campus. Meanwhile other scientists are operating at distances far beyond our planet in order to obtain climate measurements. They include Professor Ramon Hanssen, who is using satellites to collect his data.
The battle against cancer is also a field which can be approached from various viewpoints. It may turn out to be more effective to irradiate tumours from inside the body rather than from outside. By sending in radioactive metal nanospheres made of holmium to seek out tumours, researchers from Delft and Utrecht hope to be able to develop an internal form of radiation therapy. And what about the perspective of the TU Delft student? Guest writer Herman Koch is looking for students with original ideas for his Secret Project in which he plans to subject them to a 'Pop Idol style' selection process. Cruel? Exciting? Clichéd? Creative? It all depends on how you look at it.

Frank Nuijens
Editor-in-Chief of Delft Outlook




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# COLOPHON

**cover photo**
Sam Rentmeester/FMAX

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# Fire? Do the conga!

Forming a conga line is the most efficient way to evacuate a building. This is the conclusion reached by Dr Winnie Daamen of Civil Engineering and Geosciences. She was commissioned by the Ministry of Housing, Spatial Planning and the Environment to find out how wide exits need to be in order to evacuate a building safely. "We spent the whole day experimenting with the help of 250 people," Dr Daamen explains. "We reconstructed evacuations in schools, old people's homes and offices. By the end of the day, everyone was tired and people started messing around. Some of them formed a conga line." Instead of telling them to behave themselves, Dr Daamen decided to examine it as a serious alternative.

In the middle of the Netherlands' Carnival celebrations, the study was gladly picked up by the national media, with popular daily De Telegraaf at the head of the queue. "Is the building in flames? Play a party tune!" wrote the newspaper on 16 February. However, the finding that a conga line works most efficiently makes no difference to the safety regulations. "When determining how wide the exits should be, you can't base your findings on the best possible evacuation scenario," reveals Dr Daamen, who does not expect people to break into the conga as soon as the fire alarm goes off. And playing a party tune isn't likely to help matters.

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# Atomic pencil

Dr Willem van Dorp of Applied Sciences is delighted that his Veni grant is giving him the opportunity to expand his specialist field. Five years ago, in the scientific journal Nano Letters, he published patterns that were smaller than anyone had ever produced using electron beams. The lines, which measured one nanometre across, were ten times finer than had been achieved using electron beam lithography until that point. In the meantime, Van Dorp has further developed his expertise in electron-beam induced deposition (EBID) during a one-year residency with Professor Ted Madey at Rutgers University, and another year's work in Delft.

Dr Van Dorp will use his research grant to further refine his technique. His aim is to use an electron microscope beam both to deposit a number of atoms (from gas molecules) onto a surface and to inspect the results. Dr Van Dorp will conduct his research at the Technical University of Denmark near Copenhagen, but he will continue his affiliation with TU Delft as a guest researcher.

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# Cargo bike

The next time IDE students Louis Pierre Geerinckx and Onno Sminia set out for ikea to buy themselves some furniture, they won't have to rely on their parents to bring it home. They have designed a cargo bike capable of transporting up to 400 kilos. Two sets of pedals and an electric auxiliary motor provide the staying power. Delft city councillor for sustainability Lian Merkx was on hand to present the prototype at the beginning of February. The city subsidised the bike's development.

PHOTO: HANS STAKELBEEK/FMAX

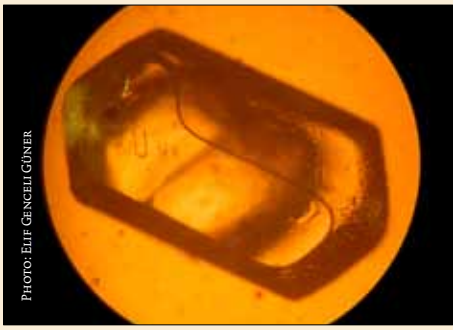
Photo: Elif Genceli Güner

# Freezing salt

From starch factories to mining operations, many industries produce waste from which salts could be extracted if an effective method were available. Professor Elif Genceli-Güner has developed a technique for separating salt from liquid by freezing it. This saves vast amounts of energy and water. The Eutectic Freeze Crystallization (EFC) technique cools a liquid until a temperature known as the eutectic point, at which water and salt crystallise simultaneously. It works like a sorbet machine in which a substance scrapes along a cooling element, forming an emulsion of ice and crystallised salt. Gravity does the rest: the smaller ice remnants and the salt sink to the bottom, creating a perfect separation into layers. Mining company Nedmag is already interested in the development and Professor Genceli-Güner has plans to collaborate with researchers from South Africa, where water is scarce. Freezing methods are already used on a large scale in industry but these consume a great deal of energy. The EFC technique uses 90% less energy than existing methods and, in theory at least, produces a yield of 100%.

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# Plastic plague

Plastic has become an environmental plague, both on land and at sea. The time is ripe for biologically degradable plastic that can be made from renewable materials. Possible raw materials for bioplastics include starch, cellulose, lactic acid or PHA (polyhydroxyl-alkanoate) – a polymer made of fatty acids that bacteria produce as a food store, in the same way that humans produce fat. Dr Katja Johnson of the Biotechnology Department of the Faculty of Applied Sciences has succeeded in getting bacteria to produce up to 90% PHA in an open and mixed bioreactor. The bacteria came from a waste water treatment plant in Rotterdam. "It's an important step forward," says Dr Johnson. "We are able to obtain the same yield as industry but without a sterile environment and without having to genetically engineer the bacteria."

Dr Johnson selected her bacteria from a wild culture by exposing them to an alternating regime of famine and feast. In the feast period, the microbes were able to thrive and grow but, in the long period of famine that followed, only the bacteria that had produced large amounts of PHA were able to survive.
Supervisor Dr Robert Kleerebezem is mainly struck by the fact that Katja Johnson has succeeded in achieving such a high rate of production with her alternative approach: "Up to 90% of the biomass consists of PHA. The other 10% probably consists of a stretched cell membrane and some flattened proteins."

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Photo: Nout Steenkamp/FMAX

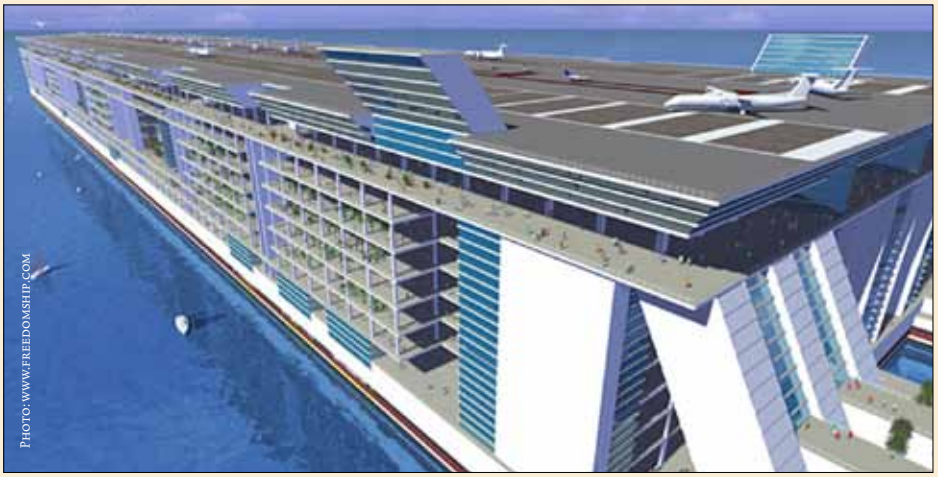
# 'You'll do just fine, Karel'


Photo: Sam Rentmeester/FMAX

At the 168th Dies Natalis (Foundation Day), Rector Magnificus Jacob Fokkema bestowed the chain of office on his successor Professor Karel Luyben. In December, Professor Fokkema bade a fond farewell to TU Delft, culminating in the grand midwinter party at Lijm & Cultuur in true Frisian style. At the festivities, it became very clear just how attached the university had become to Jacob Fokkema and his own inimitable style and character. At the solemn moment on 8 January when the insignia of office were being handed over, Professor Fokkema, in that distinctive way of his, lightened the mood with a well-timed "You'll do just fine, Karel".

# A shoe box at sea

Floating airports or sailing villages can best be built on a bottomless container. That's the conclusion of Dr Jan van Kessel, who recently obtained his doctorate at the 3mE faculty. Building projects such as the floating runways constructed near Tokyo ten years ago, always have to be protected by dams from the waves at sea. Dr Van Kessel has calculated that it is possible to dispense with the bottom of the supporting container and to have the whole construction float like an upturned shoe box on a large pocket of air. This roughly halves the forces acting on the construction, since the waves can move under the container more or less unobstructed. If a megafloater of this kind is to be constructed in future, A good option would be off the coast of Singapore, a busy, densely populated and wealthy country.




The Freedom Ship is the most ambitious design for a megafloater to date.


# Lecture on your iPod

How about giving a lecture that can be heard across the globe? At TU Delft, this has been reality since February. TU Delft and the Dutch Open University are the first two universities in the Netherlands to make free lectures available through iTunes U, the section of Apple's world famous digital media player that is reserved for podcasts from knowledge centres. This puts the two universities in the distinguished company of internationally renowned institutions such as the universities of Stanford, Harvard and Oxford, UC Berkeley and MIT, all of which publish on iTunes U. Approximately 80 lectures on water management can now be downloaded.

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IN·BRIEF

# Silent spy

It can cross the world's oceans for months on end without having to break the surface or adjust its ballast. This unmanned two-metre NATO submarine has no need for a propeller: gravity and the law of Archimedes help it on its way. This makes it ideal for espionage: it's quiet as a mouse and hardly uses any energy at all. Nevertheless, NATO's Underwater Research Centre (NURC) sought the help of TU Delft in order to improve the sub's performance. In its current form, it cannot navigate in shallow waters. Might it be possible to equip the sub with a propeller for use in the shallows so that it can head out to sea from a bay? Prof. Daniel Rixen of Mechanical, Maritime and Materials Engineering (3mE) passed this question on to students in 3mE's top-track programme, a track designed to challenge the top five percent of the faculty's Bachelor's students. The computer programme they developed shows that a propeller with a diameter of five centimetres equipped with a five-watt motor should fit the bill. They received top marks (9 out of 10) for their research.

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# ‘We mustn’t rush things’

**Satellites can make observations that are crucial for creating good climate models. The current uncertainty surrounding these models however can lead to the wrong political decisions being taken. The Faculty of Aerospace Engineering is therefore calling for an expansion of satellite-based Earth observations.**

Desiree Hoving

More snow has fallen in the Netherlands this winter than at any time during the past thirty years. Does this mean global warming isn’t as serious as it is claimed to be? That would be a decidedly simple-minded conclusion, says Professor Ramon Hanssen, of the Faculty of Aerospace Engineering: “This white winter has no implications whatsoever in terms of global warming. Our problem is that we tend to take a rather blinkered view of things. People are unaccustomed to thinking back beyond the period spanned by their own individual memories. Our perception is out of step with the time-scales of Earth’s processes.”
Roughly 20,000 years ago there was a real ice age, when large parts of Europe, Asia and North America were covered by ice year round, yet the Earth’s average temperature at that time was only 5 °C lower than it is today. Then, between 1600 and 1850, there occurred a little ice age, during which the average temperature was only half a degree lower than it is now. In 1780, soldiers were even able to drag cannons ten kilometres across the frozen ocean from Manhattan to Staten Island. Current climate models forecast a temperature rise of between 2 and 6 °C by the year 2100. Is that significant in this historical perspective? According to Prof. Hanssen, it certainly is: “This is at least double the temperature difference between the little ice age and what we see today. The effects of global warming are being seriously underestimated.”

*‘The effects of global warming are being seriously underestimated’*

The problem with the current climate debate is that there are such large inconsistencies between climate models, which reduce the accuracy of scientists’ predictions.
The professor feels that this is partly because too few observations have been made, with the direct result being that we still do not fully understand the significance of many variables. Yet these observations have nevertheless been encapsulated in climate models, which in turn are translated into political policy. “Accordingly, the climate-related options that we will spend our tax money on in years to come are highly dependent on good observational data. We mustn’t rush things in this debate,” says the professor of Earth Observation, who is therefore not only calling for more evidence to be gathered, but also firmly believes that he can obtain such evidence using smarter and better Earth observations by satellites.

## Noise

One such approach is a new, improved Earth observation method that Dr Bert Wouters developed to accurately map the melting of Greenland’s ice cap. On 19 January, Dr Wouters was awarded a PhD for his research on this topic. His research also involved using the two Grace (Gravity Recovery And Climate Experiment) satellites, which have been measuring changes in the Earth’s gravitational field since their launch in 2002. “Everything that has mass also has a gravitational field,” Dr Wouters explains, “so changes in the amount of ice in a given location also change the strength of the local gravitational field. If you know the strength of this gravitational field, you can therefore also calculate the degree of change in mass.” As a PhD student, he calculated that Greenland loses an average of 220 gigatons of ice per year. One truly innovative aspect of his research is that he can also accurately identify the exact areas from which this ice is disappearing.
The main problem encountered when attempting to analyse satellite data is the amount of noise contained in the data. When measuring gravitational changes, the melting of ice is not the only factor involved. Ocean tides and variations in air pressure also produce local fluctuations in the Earth’s gravitational field. Dr Wouters developed a statistical filtering method to reduce noise levels, thus enabling him to accurately map the areas of Greenland’s ice sheet that are melting. He then combined this data with a climate model developed at Utrecht University. Wouters and his counterparts at Utrecht collected data over a period of six years, before concluding that not only is melting occurring both on the ice cap’s surface and edges (i.e. in the glaciers), but that the ice has also started to melt even faster over the past two years. “The Utrecht model shows that less snow is falling on Greenland, while the melting of surface ice continues unabated,” says Wouters, who is currently developing climate models for the KNMI (Royal Netherlands Meteorological Institute).
The melting of ice sheets, like those in Greenland and ▸▸

Photo: Science Photo Library

Antarctica, will have repercussions in terms of sea level. Sea ice, like the ice around the North Pole, is already floating on water, so does not affect global sea levels when it melts. According to Wouters, the ice mass lost by Greenland caused sea levels to rise by 0.4 millimetres during the first four years of his six-year project, and by 0.75 millimetres during the final two years. Antarctica is also losing mass, a total of 150 gigatons per year, resulting in a further 0.5 mm rise in sea levels. If Greenland's entire ice sheet were to melt – a process that at this rate would take about 10,000 years – global sea levels would rise by an average of seven metres. Is this something that people in the Netherlands should already be worrying about?

"Yes," says Hanssen, "although local effects could diverge markedly from the global trend, for better or worse." In 2008, the Delta Commission started incorporating data on this presumed rise in sea levels (ranging from 0.65 metres to 1.30 meters in 2100) into policy. "However," the professor notes critically, "Veerman [the chairman of the Delta Commission – ed.] failed to take account of gravitational effects and the variable stiffness of the Earth's crust. How does an elastic crust respond to the disappearance of this ice? This varies considerably from place to place. The structure and composition of oceanic crust, for example, is completely different from that of continental crust." Hanssen is also aware that the committee ignored the impact of self-gravitation: "The Greenland ice cap attracts water molecules in the sea, which means that sea levels at more distant places actually fall. This will also have an impact on the Netherlands, given its coastal location. Unfortunately, our present understanding of the mechanisms involved leaves much to be desired. Rather than ignoring these effects, we should be intensifying our research activities in this field."

The Faculty of Aerospace Engineering uses a wide range of techniques to conduct all manner of Earth observations. One of these was previously mentioned: the gravity measurements performed by the Grace satellites. The Goce satellite, launched in 2009, is making similar measurements. Goce is the brain-child of Reiner Rummel, a former TU Delft professor. Whereas Grace primarily measures changes over time, Goce makes very precise measurements of the current mass distribution of the entire planet. "The Earth is a bit like a potato – it has more mass in some places than in others," says Prof. Hanssen. "Goce determines what the sea level would be like if there were no continents and if the Earth's dynamic processes were in complete stasis. This is a sort of reference surface against which you can map out any changes, such as those created by ocean currents."

Ramon Hanssen with a accurate gps-receiver.

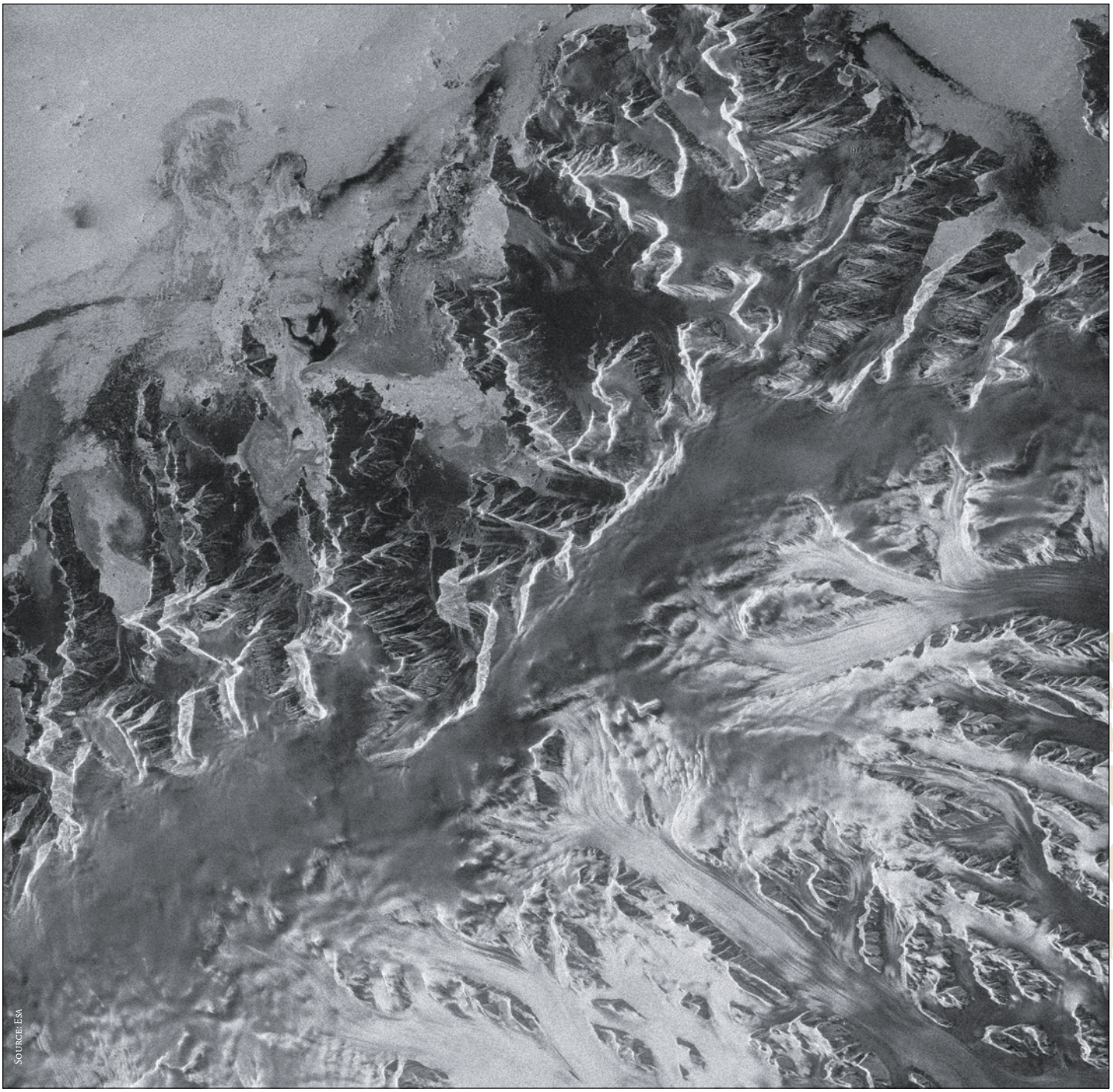
Foto: Sam Rentmeester/fmax

## Elevation

Gravity measurements are often combined with data on elevation. Such data can be obtained using a radar or laser, like those carried by Envisat and Icesat respectively. High up in the corner of Prof. Hanssen's office hangs a gold-coloured model of the Envisat satellite. "It helps give people a more tangible impression of what we do here," he says. "The instruments it carries measure the distance between the satellite and the top of the ice. But there's a problem: the Earth's deeper, liquid zones are displaced by the sheer weight of the ice above, causing the ice to sink. As the ice melts, the surface of the Earth rebounds. It's a bit like a crust of ice on water in a ditch. When you push down on the ice with your foot, it gives way, sinking slightly into the water below. When you lift your foot up again, the ice rises too. Accordingly, you need more than a simple measurement of the ice cap's elevation to determine whether the amount of ice that it contains is increasing or decreasing."

*'Greenland's ice is melting both at the ice cap's surface and its edges'*

For this reason, measurements of elevation are combined with gravity measurements. A third element is GNSS (global navigation satellite systems), the collective term for all GPS-like positioning systems. These GNSS receivers are placed on nunataks, which are mountain peaks that project up through the ice cap, thus enabling the satellite to obtain an accurate fix on the position of these peaks. In




The Antarctic Peninsula seen from SAR satellite.

places where this is not possible, SAR (synthetic aperture radar) satellites are also used to monitor the nunataks' movements. Research in this area is currently in full swing, particularly on the Antarctic Peninsula. The satellites must monitor movements of just a few millimetres per month. The radar images themselves are beautiful, detailed summaries of the distribution of ice sheets and sea ice. Earth observation is sexy again. The first measurements of the Earth were made using land-based instruments like theodolites, but since the 1970s this work has been done using space-based technology. Earth observation satellites orbit the planet at an altitude of several hundred kilometres. From this vantage point they can monitor changes in the size of ice sheets, in sea level, in $CO_2$ levels in the atmosphere, and in the thickness of the cloud cover, as well as the movements of volcanoes and landslides. In future, scientists will need more specific measurements and long-term observations in order to make more reliable climate forecasts; however, this will require budgets that are large enough to fund the launching of new satellites. But as Hanssen ruefully admits, politicians at the national and international level accord space technologies of this kind a very limited priority: "The really big budgets go to space travel, such as manned space flights to the Moon and Mars, which, among other benefits, serve to enhance people's interest in technology in general. But if we are to understand how our planet is changing, then Earth observation satellites are crucial. Many decisions about the climate are dependent on the data they collect." ◂◂

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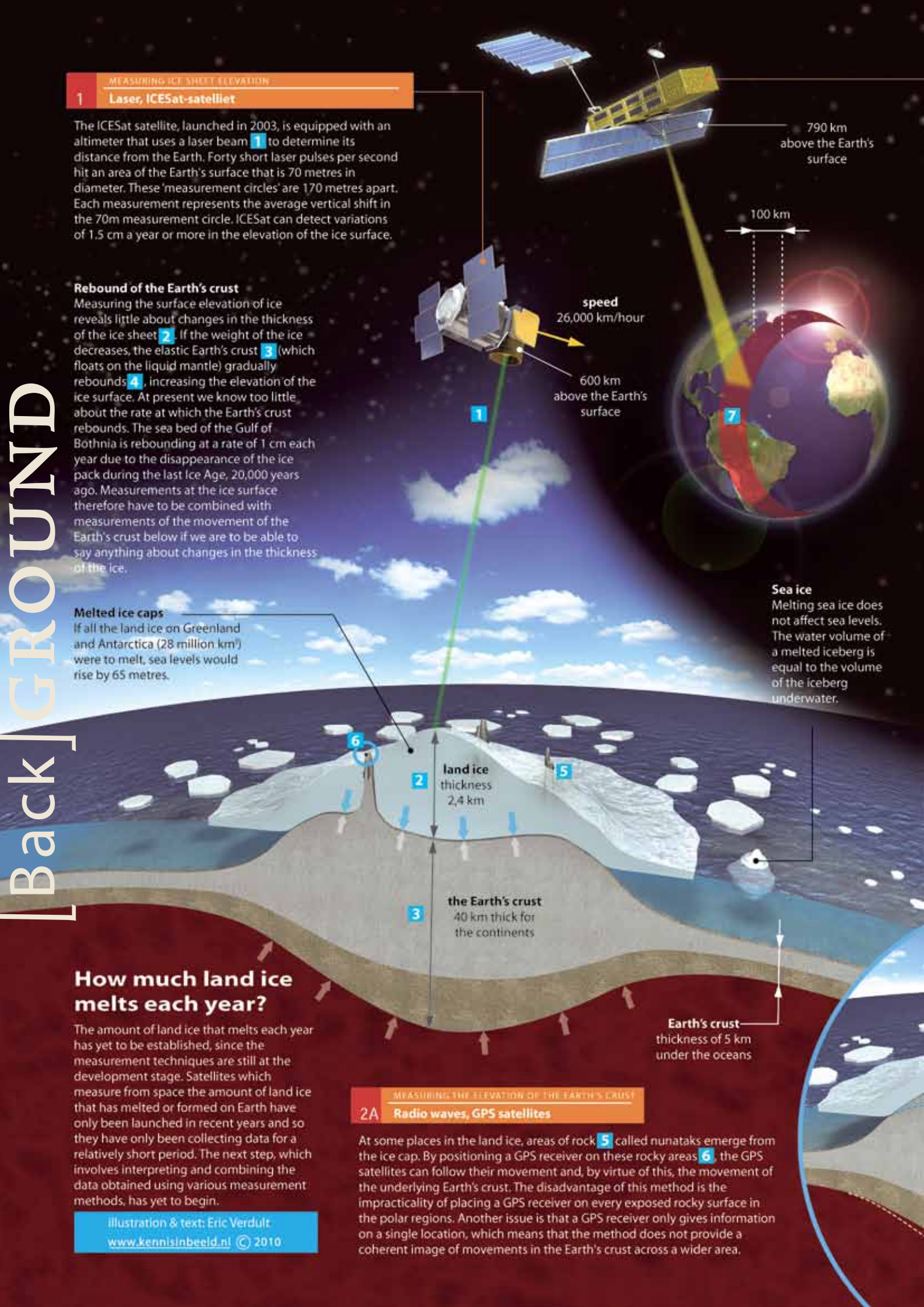


MEASURING ICE SHEET ELEVATION

## 1 Laser, ICESat-satelliet

The ICESat satellite, launched in 2003, is equipped with an altimeter that uses a laser beam 1 to determine its distance from the Earth. Forty short laser pulses per second hit an area of the Earth's surface that is 70 metres in diameter. These 'measurement circles' are 170 metres apart. Each measurement represents the average vertical shift in the 70m measurement circle. ICESat can detect variations of 1.5 cm a year or more in the elevation of the ice surface.

**Rebound of the Earth's crust**
Measuring the surface elevation of ice reveals little about changes in the thickness of the ice sheet 2. If the weight of the ice decreases, the elastic Earth's crust 3 (which floats on the liquid mantle) gradually rebounds 4, increasing the elevation of the ice surface. At present we know too little about the rate at which the Earth's crust rebounds. The sea bed of the Gulf of Bothnia is rebounding at a rate of 1 cm each year due to the disappearance of the ice pack during the last Ice Age, 20,000 years ago. Measurements at the ice surface therefore have to be combined with measurements of the movement of the Earth's crust below if we are to be able to say anything about changes in the thickness of the ice.

**Melted ice caps**
If all the land ice on Greenland and Antarctica (28 million km³) were to melt, sea levels would rise by 65 metres.

**Sea ice**
Melting sea ice does not affect sea levels. The water volume of a melted iceberg is equal to the volume of the iceberg underwater.

## How much land ice melts each year?

The amount of land ice that melts each year has yet to be established, since the measurement techniques are still at the development stage. Satellites which measure from space the amount of land ice that has melted or formed on Earth have only been launched in recent years and so they have only been collecting data for a relatively short period. The next step, which involves interpreting and combining the data obtained using various measurement methods, has yet to begin.

illustration & text: Eric Verdult
www.kennisinbeeld.nl 

MEASURING THE ELEVATION OF THE EARTH'S CRUST

## 2A Radio waves, GPS satellites

At some places in the land ice, areas of rock 5 called nunataks emerge from the ice cap. By positioning a GPS receiver on these rocky areas 6 the GPS satellites can follow their movement and, by virtue of this, the movement of the underlying Earth's crust. The disadvantage of this method is the impracticality of placing a GPS receiver on every exposed rocky surface in the polar regions. Another issue is that a GPS receiver only gives information on a single location, which means that the method does not provide a coherent image of movements in the Earth's crust across a wider area.

MEASURING ELEVATION OF THE EARTH'S CRUST

## 2B Radar, Envisat-satellite

The Envisat satellite, launched in 2002, is equipped with the latest radar equipment (SAR), which can track any changes in the elevation of entire areas, land ice and even rocky peaks. SAR does not simply measure elevation but yields a high-resolution image that produces a map of a 100 km wide strip 7 of the Earth's surface.

But it is difficult to assess the relationship between successive measurements of the same area, taken at 35-day intervals. Snow and ice change the geometry of an area, making it difficult to recognise which measurements relate to the same points and therefore to establish any changes in elevation that have taken place. SAR can detect vertical movements of only a few millimetres in an area that measures 20 x 4 metres (=resolution).

**Gravitational field is not homogenous**
The Earth is not a smooth homogenous globe but a flattened potato 8 with lumps and dents (including a 100m-deep pit near India). The gravitational pull that the Earth exerts on an object is not constant but varies according to location as a result of density variations in the mantle and on the Earth's surface. Measuring variations in the gravitational field offers the opportunity to map the melting of the ice caps. But in order to do so, we need to know the extent to which the ice caps contribute to the gravitational field as opposed to other factors (lumps, pits, tides etc.).
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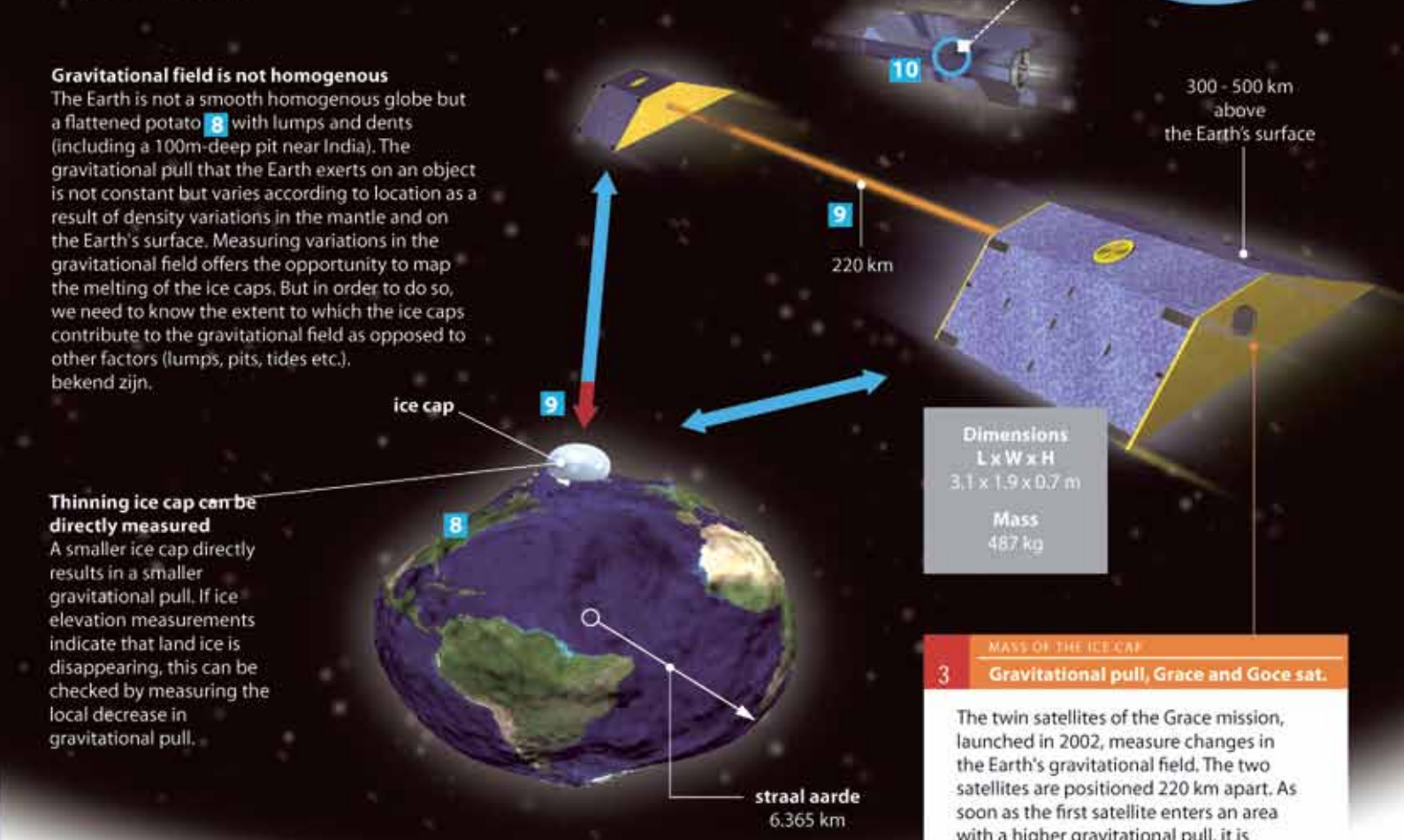



**Thinning ice cap can be directly measured**
A smaller ice cap directly results in a smaller gravitational pull. If ice elevation measurements indicate that land ice is disappearing, this can be checked by measuring the local decrease in gravitational pull.

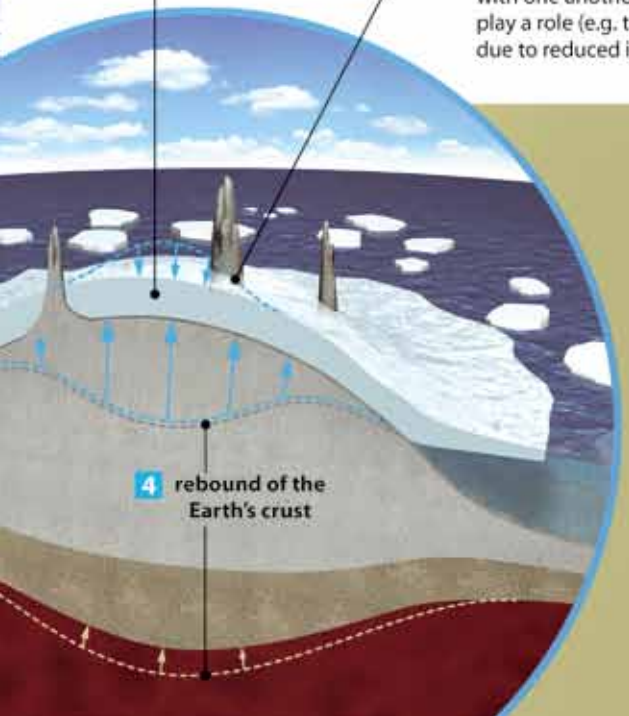
MASS OF THE ICE CAP

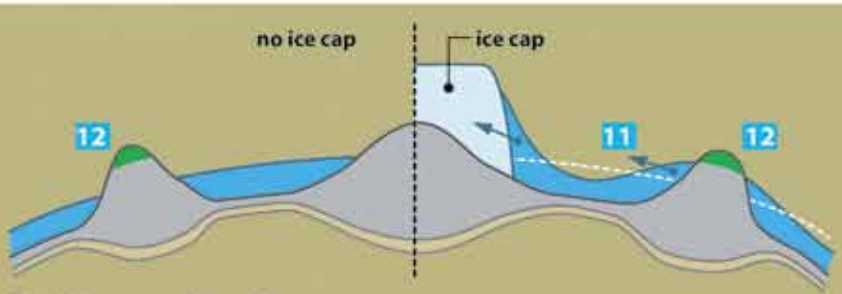
## 3 Gravitational pull, Grace and Goce sat.

The twin satellites of the Grace mission, launched in 2002, measure changes in the Earth's gravitational field. The two satellites are positioned 220 km apart. As soon as the first satellite enters an area with a higher gravitational pull, it is dragged further away from the second satellite. A laser beam 9 measures variations in this distance with high precision (0.01 mm) and derives information on variations in the gravitational field. The Goce satellite 10 contains finely tuned instruments which measure the stretch of a spring to determine the Earth's gravitational field.

**Measuring elevation and ice thickness**
The thickness of the ice is decreasing much more rapidly than the shrinking surface area suggests.

**Ice mass balance**
If the measurement of the elevation of the ice surface and the measurement of gravity do not correspond with one another, this means that other factors must play a role (e.g. the rebounding of the Earth's crust due to reduced ice load or tectonic plate movements).




## Self-gravitation

Higher gravity not only presses down directly on the Earth's surface but it also operates along the Earth's surface and has a major effect on sea levels. The extra pull exerted by Greenland's land ice attracts the surrounding water 11 causing the sea to rise and fall thousands of kilometres away. The melting of Greenland's ice could mean that sea levels in the Netherlands fall 12 instead of rise. The strength and scope of this self-gravitation is not yet known, but should be the subject of more intense research.


PHOTO & SAM RENTMEESTER/FMAX

# 'I do not work with formulas for success'

**Seated in a cafe on the edge of Amsterdam's Science Park, TU Delft guest writer Herman Koch is happy to talk about his novels, fame and family doctors. He does however remain anxiously discreet about his 'Secret Project'.**

Joost Panhuijsen

*About your post as guest writer: does it matter to you that this invitation came from a university of technology?*

"Yes, indeed it does. I would probably have rejected an invitation from a faculty of arts. However, this post as guest writer is quite new for me. It's not a writing course, but rather a project that requires me to be creative in other ways. It's more technology-oriented, and also gives me the opportunity to collaborate with young minds that are already accustomed to thinking along these lines."

**Who is Herman Koch?**

Before the debut of the series 'Jiskefet' on Dutch TV (VPRO channel), there was 'Save us, Maria Montanelli'(1989), a novel in which Herman Koch (born in Arnhem in 1953) explored his Montessori childhood in Amsterdam's Oud Zuid, while also paying homage to the writers Gerard Reve and J.D. Salinger. He wrote that debut novel in Barcelona, where he lived for five years. This period in his life emerges later in 'Dining with Emma' (2000), a book in which the juggling of fact and fiction is taken to such an extreme that a fake quote from a fictitious American writer is used as the book's epigraph. "Put it next to a real quote and nobody would notice the deception," Koch says.

Starting with 'Odessa Star' (2003), he has opted for tighter plots. His breakthrough came with 'The Dinner'. Once again his work received critical acclaim, but this time the sales figures were also spectacular. Koch, who lives in Amsterdam with his wife and son, is suddenly a bestselling author.

*In the week before your opening lecture, you and your students will visit an exhibition of Leonardo da Vinci's inventions at Clos Lucé, a chateau in Amboise, France. A man of such genius, isn't that intimidating?*

"Not at all, why would it be? My hope is that the first ideas will take shape there. I'm looking for people with original ideas. Accordingly, during the auditions for the master class, students will be given an opportunity to present little inventions of their own. It'll be a bit like the TV show 'Idols'."

*The project has been cloaked in secrecy for several months now. Why?*

"No comment!"

*You are working on a new novel. Do you feel any pressure to repeat the success of 'The Dinner'?*

"That is something one shouldn't think about too much. The only meaningful thing I can say about it is that the book that follows a bestseller usually sells well too - even if it isn't very good! But readers will then avoid buying the next book after that. I don't subscribe to that whole idea of being obliged to repeat your previous success. My only thought is that I should switch to something completely different, and make sure that it is good. In my career as a writer, I have of course explored many different areas. I'm not some young debutant who in 30 years' time will be told, 'Sadly, none of your other work lived up to the level of 'The Dinner'!' If anything, people are now starting to discover my earlier work."

*Which are your best books?*

"'Save us, Maria Montanelli' – my first novel – 'Odessa Star' and 'The Dinner'. Then there is 'Summer house with swimming pool', the book that I'm working on at the moment. I poured my heart and soul into these novels."

*To date 320,000 copies of 'The Dinner' have been sold. Is there a downside to that success? Are you, for instance, still able to quietly observe people?*

"My life is certainly a lot busier these days, yes. Yet it was the breakthrough of 'Jiskefet' [a popular TV comedy series, ed.] that first caused many people to start treating me a little differently. Total strangers seem to enjoy coming up to me in the street for a quick chat. Some people just want to impress others, by showing that they're acquainted with me. People also attach more importance to what you say. Even when it's utter nonsense." [He bursts out laughing.] "If I comment on an international issue about which I know as little as anybody else, some people still respond very seriously, saying 'Hmm, interesting!'"

*In 'The Dinner' you left some aspects unresolved. The narrator suffers from a mental disorder, but we never find out the real nature of his illness.*

"That character, Paul Lohman, the main protagonist, simply doesn't want to be pigeonholed on the basis of his condition. It is, of course, another way of clarifying the character of the main protagonist. He's someone who is very protective of his private life. It's certainly true that, in the first few chapters, he gives us very few clues about himself. He is already irritated enough by the fact that his brother Serge is a well-known politician. His brother's reputation makes it very difficult for Paul and his wife Claire to reach a decision about their son's future."

*What is the diagnosis? What's wrong with Paul?*

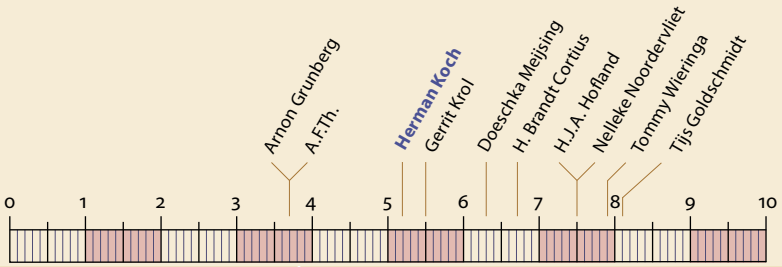
"I was deliberately vague about that. ▸▸

# Writers measured by the Technologist's Yardstick

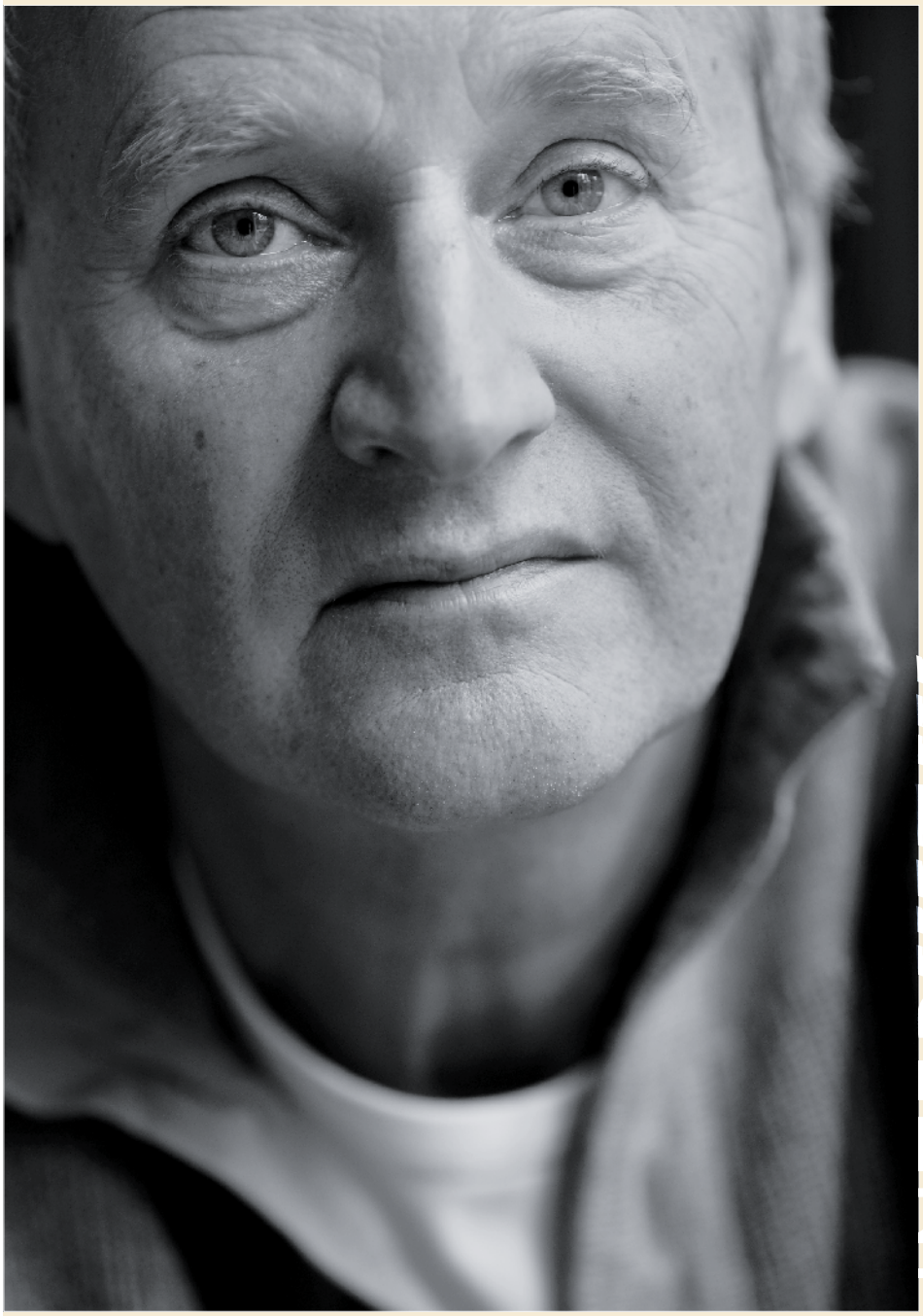
Final results for 2010:

## Koch doesn't make the grade

In recent years, ten writers-in-residence at TU Delft have been assessed to see how they measure up in a boffin's world. The greatest technological talent, without a doubt, is Tijs Goldschmidt. Self-confessed techno-illiterate Arnon Grunberg and A.F.Th. van der Heijden share last place. Best-selling author of the moment, Herman Koch, ends up with a distinctly average score.




| Question | Answer | Herman Koch | Doeschka Meijsing | A.F.Th. | Tommy Wieringa | Tijs Goldschmidt | Arnon Grunberg | Nelleke Noordervliet | H. Brandt Cortius | H.J.A. Hofland | Gerrit Krol |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2010 | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 | 2001 |
| Have you ever changed a light bulb? When did you last do so? | *"Yes. A few weeks ago."* | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Have you ever repaired a punctured bicycle tyre? | *"No."* | 0 | 1 | 0 | 2 | 2 | 0 | 2 | 2 | 1 | 1 |
| Do you know how to change the oil in your car? | *"No. But I can top it up."* | 0 | 1 | 0 | 2 | 2 | 0 | 1 | 0 | 1 | 0 |
| Can you change a car tyre? | *"I am a great car enthusiast, so I prefer not to do that myself."* | 0 | 1 | 0 | 0 | 2 | 0 | 1 | 2 | 1 | 1 |
| Have you ever used a drill? | *"Seldom."* | 1 | 2 | 1 | 2 | 2 | 1 | 2 | 2 | 1 | 2 |
| Can you assemble Ikea furniture with the help of their instruction manuals? | *"That is not something I ever want to do again. About eight years ago I decided never again to buy anything from Ikea. You always end up three screws short of what you need to finish the job."* | 0 | 1 | 1 | - | 1 | 0 | 1 | 1 | 0 | 1 |
| Can you assemble Ikea furniture without the help of their instruction manuals? | *"I've been cured of that too!"* | 0 | 0 | 1 | - | 0 | 1 | 0 | 0 | 0 | 1 |
| Can you find your way around the manuals provided with electronic goods? | *"Yes, but I'm someone who prefers to discover things by myself, using a process of trial and error. I just start pressing buttons on my new mobile phone and keep going until I have discovered all of its new features. I get quite a long way using that approach. I've got a new car, but I don't have the patience to read the manual. But when I do need to know something I tend to get it pretty quickly, I think. In that respect I do not consider myself to be technologically challenged."* | 2 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 |
| How many tool boxes do you own? | *"Just one."* | 1 | 1 | 1 | 2 | 1 | 0 | 2 | 1 | 1 | 2 |
| Do you write your books using a computer? | *"Yes. Mind you, I still jot ideas down in notebooks."* | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| Do you use the Internet? | *"Yes."* | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 0 |
| How many hours a day do you spend at the computer? | *"No more than three."* | 2 | 2 | 0 | 1 | 2 | 2 | 1 | 2 | 2 | 1 |
| If there are problems with the computer, can you solve them by yourself? | *"To a large extent, yes. My fifteen-year-old son is far from being computer illiterate, but sometimes even he asks me for help with computer-related problems. In these situations, I find that I can almost always get the PC up and running again after 45 minutes or so. That gives me quite a buzz, or at least it does when I'm able to crack the problem. This stems from the fact that I've analysed the issue in a logical, yet creative way."* | 1 | 1 | 0 | 2 | 0 | 0 | 2 | 2 | 2 | 0 |
| Is your computer protected by a virus scanner and/or a firewall? | *"Yes."* | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 |
| Do you install and maintain these yourself? | *"No."* | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| Are you able to communicate effectively with helpdesks, where such facilities are available? | *"I never phone helpdesks. On the few occasions that I can't deal with a computer-related issue myself, I call a friend of mine who installs PCs for a living."* | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 |
| Have you ever had an idea for an invention, or formulated a technical problem? | *"I believe I have. I'm currently writing a thriller-like story for a book of collected short stories. In the course of this work I have dreamt up some of the technology used by the police in that setting, and the technology strikes me as being quite plausible, which is the whole point of course. For example, by linking up separate databases in the right way, people are instantly able to see what the interior of any given house looks like. Oppressive? No, the less privacy enjoyed by others, the better! I once came up with the idea of a mobile phone that you could also use as a razor."* | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| Have you ever come up with a real invention or committed such matters to paper? | *"No."* | 0 | 1 | 1 | | | | | | | |
| Have you ever followed up an idea for an invention and, if so, how often? | *"No. I think it's more fun to imagine something than to go through all that fuss and bother with patents and the like."* | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 |
| | **Total points:** | 14 | 17 | 10 | 19 | 22 | 10 | 20 | 18 | 20 | 15 |
| | **Final score:** | 5,2 | 6,3 | 3,7 | 7,9 | 8,1 | 3,7 | 7,5 | 6,7 | 7,5 | 5,5 |



# 'I don't need any rituals to help me write'

I considered certain autistic disorders, particularly Asperger's. After all, he is rather indifferent about what happens to other people. But if I had stated this explicitly in the book, people would have said, 'That's a very crude caricature, people with Asperger's don't behave as aggressively and unpredictably as this fictional character!' I had no wish to engage in discussions of that kind. However, I did consult an expert about whether someone's DNA might show clear evidence of such disorders. He told me that this is not yet possible, but that it will be in five years' time. So that's the only bit of sciencefiction in the whole book."

*Then Michel stepped forward, threw his arms around me and held me close.*
*"Dear Daddy," he said.*
*('The Dinner')*

*What made you decide to end the book in that way?*
"When writing this book I was constantly aware that the boy had decided very early on that it was his job to protect his father from himself. 'The Dinner' is about parents who wonder how they can best protect their child, but here the roles are reversed."

*At that point, rather than wanting to be protected himself, the son just wants to protect his father?*
"Yes. 'OK, I may have murdered a homeless woman, but I still have a much better understanding of the ways of the world than someone who finds this all oddly amusing.' Michel is less unstable and unpredictable than his father.
"In an earlier chapter, Paul recalls how his son once kicked a football through the window of a bicycle shop. The shop's owner continued to complain about it, even after Paul had offered to pay for the window to be replaced. At one point Paul almost attacked the man with a bicycle pump. That chapter too ends with Michel saying, 'Dear Daddy'. He was only eight at that time, but those words may well have the same connotation as they do in the final chapter."

*The father is the narrator. Did you ever consider shifting the perspective to the son?*
"Yes. Soon after starting work on the book, I began to wonder whether I should make Michel the narrator in some chapters, to help the reader understand the son as well. I finally decided against this, however, in order to emphasis the father's self-deception. The description of the homeless woman's murder is the only point at which the perspective really changes. That creates a sudden, very intimate connection between the reader and those two boys. You are aware of thinking, 'These events could never have been related to the father in such detail.'"

*As a writer, do you have set working hours, a permanent workplace, fixed rituals?*
"I always work continuously for a couple of hours in the morning, and this is almost always at the same time each day. It's a bit of a superstition, but also practical and useful. Happily, I don't need any rituals to help me write. It would be no problem for me to write at other times and in another place. I've always been able to shut myself off from the outside world fairly easily. I do however prefer to work at home."

*Do you listen to music when you're writing?*
"Yes, I make playlists on my iPod. These include the titles of my books: Dinner1, ▸▸

Dinner2, etc. It's all about conjuring up the right atmosphere. A soundtrack, yes. It can be something very new or something very traditional; it can even be music that I don't much like. Some R&B and hip-hop tracks put me in an appropriately aggressive mood. Right now, for instance, I'm listening to a song by Winne, a rapper from Rotterdam."

*Does that also affect the rhythm of the sentences?*

"Yes, that's how it works. The book that I'm working on at the moment is much more staccato than The Dinner, a sort of bam, bam, bam! Shorter sentences. I'm particularly fond of a song called 'Your Ex-Lover Is Dead' by the Canadian group, Stars. Right at the beginning you hear an actor saying, 'When there is nothing left to burn, you have to set yourself on fire.' That quote will be the epigraph for 'Summer house with swimming pool.'

*Writers are often reluctant to talk about the books they are still working on.*

"Me too. If you tell someone the story too soon, the urgency to get it all down on paper can suddenly disappear. But I've already written a good 200 pages. I'm now at a stage where I feel able to say something about it.

"'I am a GP.' That's the opening sentence. The main character talks about his practice. It then emerges that one of his patients has died, and that it's widely believed that this is the result of a medical blunder on his part. He is required to attend disciplinary hearings conducted by a medical tribunal. He thinks, 'Let's hope that I can get away with a six-month suspension.' He also thinks, 'I deliberately disguised my actions as a medical blunder, otherwise I would never have been able to do this. I've done something, and he deserved it.'"

*What had the deceased patient done to warrant this?*

"I can't comment on the doctor's motives. The readers will have to find out for themselves once the book has been published. All the time you're constantly being wrong-footed by the doctor. Just when you think that you're starting to understand his motives, a new piece of information emerges to turn everything on its head. Ultimately, of course, it's a matter of whether you can approve of his act."

*Where did you get the idea for this book?*

"At one point I found myself wondering what it would be like to be a GP, so maybe that was the beginning. You can easily imagine what it must be like to be a surgeon, someone who says, 'We're now going to make an incision to find out what the problem is.' But what must it be like to work in a profession where, for instance, someone can ask you to take a look at their toenail? That just doesn't feel right."

*GPs just get on with it.*

"For this man, that's no longer an option. He's interested in the human body as a fascinating machine, but its outer surface disgusts him. Fungal infections, sweaty places - he finds it all highly repulsive. His aversion to certain patients and diseases finally takes on gigantic proportions.

To top it all off, the group of patients under his care consists largely of actors, writers and artists. In that artistic environment, the doctor is not taken seriously – rather like Miriam, the main female character in 'Thinking of Bruce Kennedy', a previous book of mine. These artists all consider themselves to be very interesting people. They have a strong sense of entitlement, drink too much and tend to look down on the doctor. Whenever he warns them that they really should cut down on the vodka, they just think: good thing there's another doctor we can go to."

*And that attitude, in turn, reinforces his dislike of his patients?*

"Very much so, even though he admires some of them in a strange sort of way."

*In 'Thinking of Bruce Kennedy', Miriam is almost driven crazy by her husband Ben, a pretentious and eternally aggrieved film director. Despite all that, I still found myself sympathising with the man. Deep in his heart he knows that his films are no longer interesting to anyone. Do you ever find yourself sympathising with your characters?*

"Definitely. Without that I'd never be able to write. Ben is an asshole, but still he tries to do his best. Or take Serge, for example, the successful politician in 'The Dinner'. In the first few chapters of the book, his brother Paul constantly portrays him as an insensitive prick. But in the end he turns out to be more empathic than his brother gave him credit for. Possibly even smarter, too. Serge has far less of a hidden agenda than the other three people at the dinner table. Hardly something that you'd expect of a true politician."

*The critical acclaim accorded to 'Thinking of Bruce Kennedy' partly focused on the fact that Miriam's character was not a caricature. Did you find it difficult to write convincingly from a female perspective?*

"I wanted to give it a try, writing a novel about a woman who feels all bent out of shape in an inappropriate social circle. But I didn't want to make her a drunken slut, as some writers would do. Nevertheless she had to be a woman with certain weaknesses, someone who would be totally fascinated by a genuine international celebrity like the actor Bruce Kennedy.

'Thinking of Bruce Kennedy' is also somewhat based on a particular aspect of my own life. You're at a party and you notice that they all want to monopolise your attention. They're always far less interested in your wife, for after all she isn't famous. To her they say things like: 'Herman is coming tonight, isn't he?'

"The book is about just such an artist's wife. It's dedicated to my own wife and to the wife of Michiel Romeyn. They, too, will sometimes sigh and say: 'These people don't even know I exist!'"

*Did the wives like the book?*

"Yes indeed. It was - to use a hackneyed phrase - all horribly familiar to them."

*Are you, as a writer, keen to engage with a wider audience?*

"Yes. The best compliment is when people say to me: 'I'm not a great reader but I could hardly put this book down.' I don't write thrillers, nor do I make concessions in order to appeal to the tastes of those who are 'not great readers'. Nevertheless, my books do appear to be accessible to a wide audience.

"I'm not someone who uses formulas for success. Quite the opposite in fact. If I notice in my latest book that a moral dilemma has once again emerged, I immediately ask myself: is that a good idea? Although moral dilemmas do seem to be an interest of mine. There was also one in 'Odessa Star' ".

# Campus climate

**Rain gauges that count drops, mobile radars that scan clouds, and hundreds of wind vanes mounted on the windows of the EEMCS building. TU Delft researchers are busily transforming the campus into a laboratory for climate research in the urban environment.**

Tomas van Dijk

Photo: Nout Steenkamp/EMAX



All it takes is a light wind and starts again: cyclists are literally blown off their bikes as they pass the high-rise Electrical Engineering, Mathematics and Computer Science (EEMCS) faculty building on the Mekelweg. And strangely enough, this happens whatever direction the wind is blowing from. Winds blowing from the west collide with the building sixty meters up, then shoot straight down and blast around the corner at ground level. When the wind is blowing from the opposite direction, it also shoots straight down but then curves up again just above the ground. Regardless of whether the wind is blowing from the west or east, cyclists are usually blown towards the Applied Sciences faculty building. Weather forecasts always give average values over a large geographical area, but in urban environments such figures are not especially meaningful, because cities are dominated by microclimates.

Everyone has had first-hand experience of such microclimates, yet very little is known about this phenomenon. Nick van de Giesen, a professor of Water Management at the Faculty of Civil Engineering and Geosciences, and the head of the Delft Research Initiative Environment (DRI Environment), aims to change that. Together with colleagues from DRI Environment, a partnership involving all TU Delft faculties, he plans to transform the campus into one huge laboratory for studying climate in the urban environment, with the goal being to launch numerous studies within the Climate City Campus project before the end of the year. Most of these multidisciplinary studies will be student projects. The Climate City Campus project was officially launched on 24 February. One of its first sub-projects involves an experiment to measure rainfall. ▸▸

*'Cyclists are usually blown towards the Applied Sciences faculty building'*


Photo: Nout Steenkamp/FMAX

## Weeds

Stijn de Jong, an MSc student being supervised by Prof. Van de Giesen, is developing rain sensors that will enable him to very accurately measure rainfall in the vicinity of the EEMCS building. "We don't fully understand how buildings affect rainfall," he says, while standing on the roof of the low-rise section of the EEMCS building, which adjoins the high-rise block. Pointing at clumps of weeds, he notes: "Here, in the lee of the tall building, there are many plants growing on the roof. Windborne sand and seeds are deposited here, because it's usually less windy. Perhaps the same goes for raindrops?"
Just a hundred metres from this spot, the wind is often much stronger. How does that affect rainfall? Are the raindrops slammed against the building or are they instead blown back up into the air? Moreover, is this behaviour related to the size of the individual raindrops? In attempting to answer these questions, Stijn will install a hundred rain sensors on the building's roof this summer. Unlike traditional rain gauges, which are just glorified buckets that collect water, these devices are sensitive microphones that count raindrops (see box). This technique not only enables Stijn to monitor rainfall very accurately over time, but he can also use it to measure the size of the drops.
The researchers participating in the Climate City Campus project want to incorporate this raindrop data into various wind models. "It's very important to understand how buildings affect rainfall and wind," explains Prof. Van de Giesen. "We expect climate change to cause increased rainfall in the years ahead. Improved drainage facilities will be needed to handle that extra water. Many drainage systems need to be replaced. If we know exactly where we can expect this additional water, we can then modify the drainage systems accordingly. For instance, we could install wider pipes in some parts of the system."

## Chewing gum

The collection of wind data is the specialist field of flow expert, Professor Jerry Westerweel, of the Faculty of Mechanical, Maritime and Materials Engineering (3mE). The way in which wind flows past the building has already been modelled in detail, but Prof. Westerweel still wants to see for himself: "I want to see if the calculations are correct, and that's why I'm asking the window cleaners to stick wind vanes onto every window of the EEMCS building. Nothing high-tech, they could just stick them on with a piece of chewing gum." People working at their desks inside the building will then be asked to compile daily reports, simply stating the direction in which their vane is pointing.
The tall EEMCS building does however also have its good points, such as accounting for much of the


Photo: Sam Rentmeester/FMAX

Nick van de Giesen

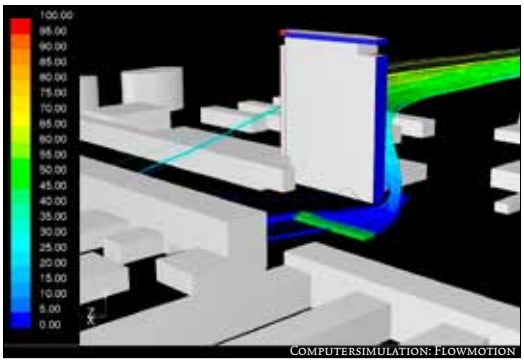
## Rain sensor

Professor Nick van de Giesen's room is filled with the mellifluous (if slightly tinny) tones of Diana Ross singing 'A Brand New Day'. "Hey, this one still works," shouts PhD student, Rolf Hut, in an attempt to make himself heard above the noise of the music blaring from the open greeting card he's holding. Most of the other musical cards scattered around Van de Giesen and Hut here in this room are broken.
The researchers cannot resist the lure of cheap consumer electronics. In fact, they are looking for sensors they can use to make measuring instruments for weather stations. Van de Giesen wants to install 20,000 weather stations across Africa, and then link them together using a wireless network. There is however one considerable restriction: these weather stations must cost no more than 100 euro each.
Together with Hut, TU Delft alumnus and engineer Coen Degen, and MSc student Stijn de Jong, Van de Giesen found a way to use the speakers from electronic greeting cards in the African weather stations. Indeed, these hydraulic engineers have a good track record in this area, having previously made an evaporation meter from a Wii controller.
"The speaker consists of a thin piezoelectric disc that deforms - thereby producing sound - when an electric current is passed through it," Hut explains. "But it also works just as well in reverse. If a raindrop strikes the disc, the material vibrates and creates an electrical signal."
The researchers have already made a prototype rain sensor that operates on this principle. All they need to do now is to calibrate the device, in order to work out the relationship between vibrations and droplet size. They must also 'strap on' various other electronic components, so that the data accumulated by the sensor (which is linked to a logger that keeps track of all the drops) can be easily read. When this work has been completed, De Jong will place around a hundred sensors on the roof of the low-rise section of the EEMCS building.

clean air on campus. "The building acts as a natural air freshener," Westerweel explains. "Depending on the wind direction, masses of polluted air from the nearby A13 motorway tend to drift in our direction. The high-rise building funnels clean air down from a higher altitude, ensuring that the Mekelweg receives blasts of clean air. Vertical mixing occurs."
Prof. Westerweel hopes to gain fundamental insights into how the 'roughness' of a cityscape (the extent to which high-rise and low-rise buildings alternate) affects the through-flow of air: "What is the best way to design a city so that it will blow pollution away? That's what this is about. There are all kinds of models capable of indicating the average concentrations of pollution, but they provide no details about peaks."
In addition to wind vanes stuck on with chewing gum, Westerweel wants to set up a large number of monitoring stations all across campus. Their instruments would be used to measure atmospheric concentrations of various oxides of nitrogen. The aim is to install these monitoring stations at sites that are situated ten to a hundred metres apart. The professor is now trying to recruit students who get a kick out of collecting and analyzing data.
The flow expert has a fun experiment in mind for those students. "We'll release a gas at a secret location on campus and then see how long it takes the students to figure out where the gas is coming from. The speed with which they can do this will depend on the number of sensors they use and whether they've placed these sensors intelligently."

## Parsax

The Parsax cloud radar, situated on the roof of the EEMCS building, is also being used for the Climate City Campus project. This radar installation, which became operational last year, can measure the composition of clouds at altitudes of up to fifteen kilometres, and at resolutions as fine as three meters. For comparative purposes, the KNMI (Royal Netherlands Meteorological Institute) weather radar's resolution is one kilometre.
"Parsax cannot monitor what happens to raindrops during the final hundred meters, because it only looks straight up," says remote-sensing researcher, Professor Herman Russchenberg (EEMCS), who will consequently use two small, mobile radars to study how the drops change during that last part of their descent.
"Raindrops also contain currents," the professor adds "and if they become too strong, through the action of the wind for instance, then the raindrops will shatter. This changes the intensity of the rainfall, as smaller drops fall more slowly."
According to Russchenberg, all major cities should have a radar network consisting of a few large cloud radars, like Parsax, situated on tall buildings, and a larger number of small radars on the ground. He is eager to use the campus as a testing ground, where his research will determine how far apart, and in which locations, the small radars should be placed in order to compile a reliable picture of raindrops on the neighbourhood level. The professor intends to use the data obtained from the rain sensors for this purpose: "This data also indicates what happens to raindrops during the last one hundred meters of their fall."



Winds collide with the building, shoot straight down and blast around the corner.

### Green facades

Cities and rural areas not only differ in terms of wind patterns and rainfall, but also in temperature. Concrete surfaces absorb more heat than grasslands, forests or bodies of water. In addition, plants cool themselves and their surroundings by allowing water to evaporate from their leaves. This cooling effect is less pronounced in cities than in the countryside.
Furnishing buildings with grass roofs and green walls can, to some extent, reduce outdoor and indoor heat. Researcher Marc Ottelé, of the Faculty of Civil Engineering and Geosciences (Microlab), is currently investigating the magnitude of this effect. In addition to building a section of cavity wall (in brick), he had a large wooden box made, the inside of which is lined with thick layers of polystyrene. He will soon start making measurements, which will involve sliding the wall section into the box, putting a plate that is overgrown with ferns in front of it, and using strong PAR (Parabolic Aluminised Reflector) floodlights to simulate the sun. The box, the fern-covered plate, and the wall section are all studded with temperature sensors that will measure the cooling effect of vegetation. As part of the City Campus Climate project, Ottelé plans to install panels of lush, green vegetation on an outside wall somewhere on campus.


Photo: Sam Rentmeester/FMAX
Mark Ottelé in his box of polystyrene, also called 'sarcophagus'.

### Delft Research Initiatives

The continuous incentive for research at TU Delft is to find solutions for society's present and future demands. That's why TU Delft pays extra attention to developing solutions on the major social issues environment, health, energy and infrastructure & mobility.

www.tudelft.nl/research

FOCUS

**The junction between tubes and castings has to contend with a fluctuating load of 500 tons. On and off, on and off, like the force exerted by juggernauts thundering over a bridge. In the Stevin Laboratory of the Structural and Building Engineering research group at the Faculty of Civil Engineering and Geosciences, PhD candidate Richard Pijpers is testing the combination of German very-high-strength steel with castings in a construction commonly used in the industry. "We measure the fatigue in the welded connectors and record how quickly a fault-line grows." These measurements form the basis for new design regulations. As long as they do not exist, very-high-strength steel cannot be used to its full potential. That would be a missed opportunity given that we already have the capacity to make bridges lighter and less bulky, and to speed up the construction process.**

Photo: Sam Rentmeester/pmax

# Nuclear bombs to cure cancer

**The first clinical trial of radiation therapy using minute radioactive microspheres has recently been launched in Utrecht. Once again, TU Delft researchers are thinking one step ahead.**

Jos Wassink

The future scenario goes something like this. Imagine that your doctor suspects you have cancer, yet is uncertain about the tumour's exact location and whether or not it has metastasised. An injection of microspheres and specific protein fragments could quickly clarify the situation. Owing to the nature of these microspheres, they are clearly visible by magnetic resonance imaging (MRI), while the protein fragments ensure that the microspheres only bind to cancerous cells. In this way, any metastases become visible almost immediately after the injection. More importantly, treatment can start immediately, because these same microspheres (which are made of the metal holmium) can be made radioactive by placing them for several hours in a neutron beam emitted by a nuclear reactor. A swarm of radioactive nanoparticles is then injected into the bloodstream, where, like guided missiles, the particles search for tumour cells. Once the particles locate their targets, it is only a matter of time before the holmium microsphere unleashes its deadly beta radiation in the surrounding tissue. This is, in effect, nuclear warfare combined with precision bombing. Two such injections will cause tumours to shrink.

Is this pure science fiction? Yes, of course it is. Yet Utrecht University's Faculty of Veterinary Medicine has recently demonstrated technology so amazing that it verges on science fiction. In his laboratory at the university, Professor Jolle Kirpensteijn treats tumours in cats and dogs with a syringe full of radioactive holmium microspheres, developed at the Radiology & Nuclear Medicine department of the University Medical Center Utrecht (UMCU). The microspheres are made radioactive at the Reactor Institute Delft (RID). The holmium microspheres are injected directly into the tumour. Writing about a cat named Lucky (what's in a name?), Prof. Kirpensteijn states: "We have achieved a CR (complete remission), something which had previously been considered impossible. There is currently no clinical evidence of tumours, and a swab that was made several weeks ago revealed no trace of any remaining tumour cells." As befits a good scientist, he qualifies his findings as follows: "N = 1 [just the one patient, ed.], so perhaps it is a good idea to publish an article in the Journal of Veterinary Medicine, in order to attract more patients with oral tumours?" In other words, people whose pets have been diagnosed with an oral tumour would be well advised to take them to Utrecht.

Radioactive holmium microspheres were first used to treat a human patient in a clinical trial late last year. Researchers from Delft and Utrecht regard this clinical trial as a first step towards a promising form of internal radiation therapy. "It's a very exciting time for us," says medical biologist Dr Frank Nijsen (UMCU). "We've been working on this project for the past fifteen years, and we've worked out all the details."

*The holmium microspheres can be made radioactive*

The current clinical trial is focused on the treatment of liver cancer, and there is a good reason for this: 80 percent of patients with liver tumours cannot be treated using available methods. This new and experimental radiotherapy involves bombarding liver tumours with radioactive holmium microspheres. At just 30 micrometers in diameter, 30 of these microspheres placed side-by-side would span a distance of less than 1 millimetre.

## Three-in-one

"Holmium is a really great element," says Professor Bert Wolterbeek (Applied Sciences). He walks over to a poster of the periodic table on the wall of his office and points a well-aimed finger at a black square marked 'Ho'. "The non-irradiated material is 100 percent holmium-165," he explains, "but if you bombard that with neutrons, a large proportion of the material is converted into the radioactive isotope holmium-166." This form of holmium disintegrates when subjected to emissions of electrons (beta radiation) and gamma rays, and after just one day the radioactivity is halved. ▸▸

Photo's: Sam Rentmeester/FMAX

The TU Delft section engaged in this holmium therapy study is part of the 3Binding project – imaging, investigation and treatment by means of innovations in nuclear diagnostics and therapy in healthcare. The 3Binding project is part of the Medical Delta interdisciplinary research plan, in which TU Delft is collaborating with the Erasmus Medical Center and Leiden University Medical Center. The study is partly funded by the Ministry of Economic Affairs.

Another advantage of holmium is that it 'lights up' beautifully on MRI images. Prof. Wolterbeek is very enthusiastic about it: "It's a case of 'three-in-one': you can see the particles flowing through the bloodstream in the MRI; the gamma radiation pinpoints sites of intense activity; and the beta radiation kills any tumour tissue in the immediate vicinity."
At 30 micrometers in diameter, the holmium microspheres are exactly the right size to become trapped in the liver, where they deliver their radiation from a blockage, or embolism. After being injected into the main artery carrying blood to the liver, the microspheres flow down ever narrower arteries, before eventually getting stuck and delivering a dose of deadly radiation to the tumour. Tumours are very good at rapidly creating a large network of blood vessels. With holmium therapy, however, this ability becomes their Achilles' heel. The extensive blood supply carries most of the radioactivity deep into the tumour. The diameter is critical. If the microspheres are too large, they will not penetrate into the tumour. If they are too small, they will pass right through the tumour and pose a hazard to other tissues.
In addition to holmium, the microspheres also contain poly(lactic acid); however, this does make them vulnerable to radiation. Prof. Wolterbeek says that the reactor institute has extended the exposure time to six hours, while reducing the intensity of the neutron beam and the gamma radiation, in an attempt to minimise any potential damage to the poly(lactic acid).
The current work is part of a Phase I clinical trial, in which the safety of the treatment itself must be demonstrated. In this context, it is expected that twenty patients will be treated in Utrecht. During the next stage, which the researchers say could easily take two to three years, the efficacy of holmium therapy must be demonstrated in a group of around eighty patients.
In the 'Building for Chemistry' on the Julianalaan in Delft, a group headed by Dr Kristina Djanashvili is attempting to transform Nijsen and Wolterbeek's 'holmium bomb' into a guided missile. Although this research is still at an early stage, the preliminary work has been completed. The plan is to create radioactive nanoparticles which, after being injected into the body, attach themselves to cancer cells and irradiate the tumour from within. In a room opening off one of the long corridors, Dr Djanashvili, Dr Joop Peters (recently retired, but of whom everyone says 'we simply can't manage without him'), and PhD student, Florian Maier, are seated around a table. On a sheet of paper, Djanashvili draws a picture that vaguely resembles a 'Smartie' candy, but is actually

Staff members measure the injected radiation after surgery.

a nanosphere encased in a couple of layers. This is what the group is working on: nano-sized holmium spheres that are resistant to radiation and capable of finding their way independently through the body. The drawing is of a spherule about 100 nanometres in diameter. Thirty of these would not be enough to span a distance of 1 millimetre; for that you would need 10,000 of them. These objects are so small that they can pass unhindered through even the narrowest of capillaries. The holmium particle itself is only 70 nanometres in diameter - the optimum size for an MRI signal. The particle is encased in a layer of silicon about 15 nanometres thick. While this may sound fairly straightforward, preparing holmium particles of exactly the right size from a solution is a complex process, according to Maier. The group has moreover opted to encase these particles in silicon, as this is more resistant to radiation than the poly(lactic acid) used for the microspheres.

On the outside of the Smartie, perpendicular to its surface, Dr Djanashvili then draws some sticks that represent polyethylene glycol molecules and act as a 'cloak of invisibility', hiding the particles from the immune system. This enables the nanospheres to drift along in the bloodstream, virtually unnoticed, until they reach their destination. Other molecules on the surface of the nanosphere must ensure that it binds to a tumour cell. "Tumour cells have specific receptors on their cell membrane," says Dr Djanashvili. "We use peptides [protein fragments, ed.] that bind to these specific receptors on tumour cells." The researchers hope that this binding process will allow the radioactive nanospheres in the bloodstream to independently attach themselves to tumours, thereby targeting their deadly radiation to best effect. "We want to keep the chemistry as simple as possible," Dr Peters adds. "Once the holmium nanospheres have been irradiated, we 'bolt on' the appropriate components and then the solution is ready for injection."

Dr Kristina Djanashvili draws a holmium sphere, enlarged two million times.

## Hurdles

There are however still quite a few hurdles to overcome before the researchers arrive at that stage. Dr Frank Nijsen (UMCU) still has his doubts about the specificity with which these microspheres bind to tumour cells: "Ever since monoclonal antibodies were first developed, about thirty years ago now, researchers have dreamt of designing proteins or antibodies capable of discriminating between normal cells and tumour cells." Dr Nijsen agrees that the science is indeed improving, but tumour cells and body cells are very much alike, so the distinction is never 100 percent. He estimates that only five to ten percent of the injected antibody-linked, radioactive material actually reaches its target, while 60 to 80 percent will be removed by the liver, and the remainder will go on to damage healthy tissue.

Dr Nijsen points out that antibody therapies often proceed no further than Phase I clinical trials, as they are either too toxic or induce an immune response in the body.

This is not the only approach to internal radiation therapy, however, and work is already progressing in other related areas. One example cited by Dr Djanashvili involved the use of holmium particles of a suitable diameter, yet without a peptide layer for specific binding. These particles are normally retained within blood vessels; however, the blood vessels in tumours are often very leaky, which allows the particles to penetrate into the surrounding tissue where they can do their work.

Dr Nijsen, in turn, is extremely interested in the work being carried out by his veterinary colleague, Prof. Kirpensteijn, and he is eager to repeat the success of the professor's single-shot therapy in humans. If microspheres could be developed with just the right diameter and level of radioactivity, then internal radiotherapy in humans should also be feasible. Encouraged by that early success, researchers are currently attempting to find the most effective form for what might eventually be known as 'Holmium Therapy'.


Bert Wolterbeek:
"Holmium is a really great element."

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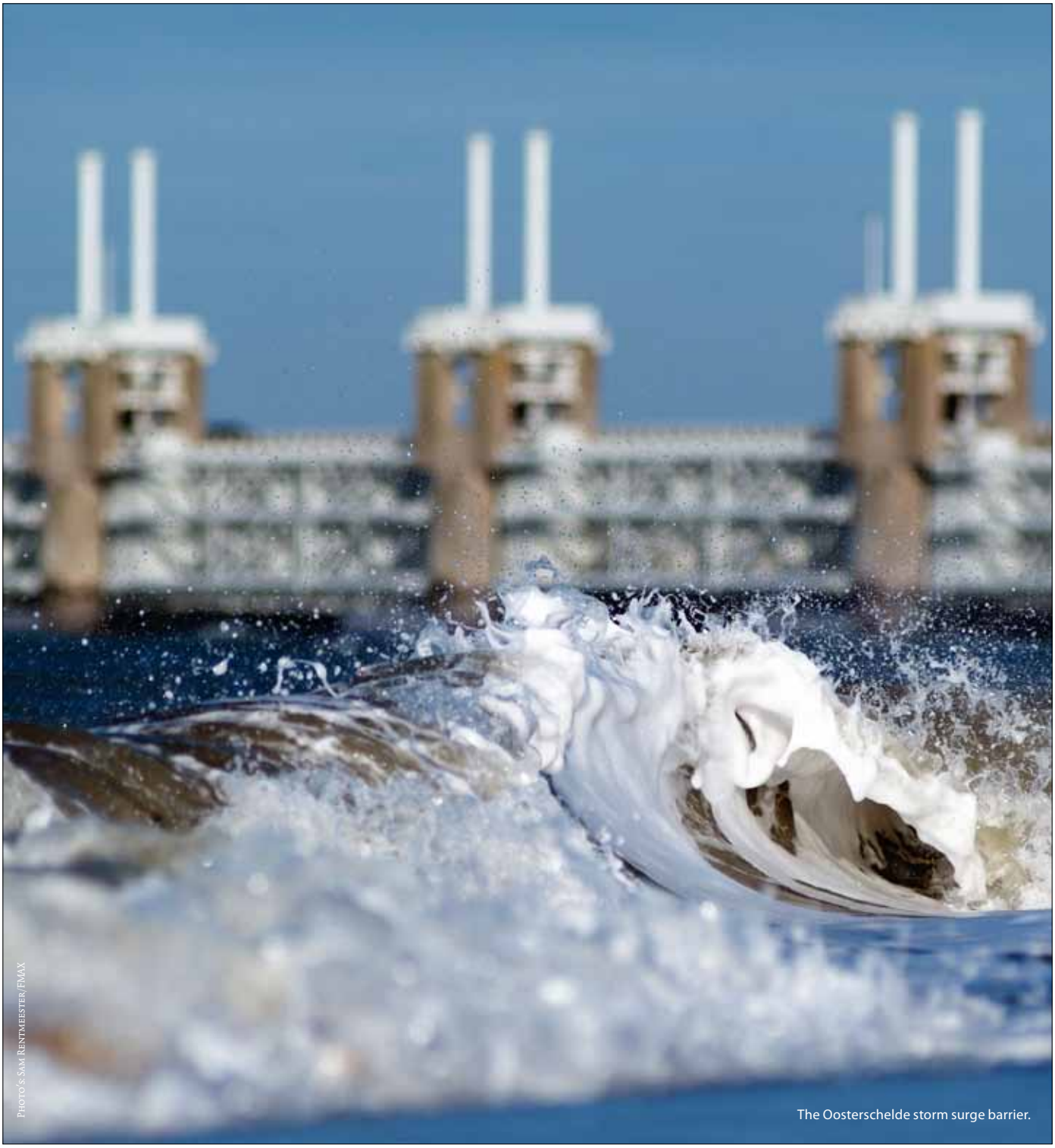
# Banishing the water



Photo's: Sam Rentmeester/FMAX

The Oosterschelde storm surge barrier.

**The Delta Commission issued its final report in 1960. At that time, construction of the Delta Works was already well under way. Nearly five decades later, in 2008, the "second Delta Commission" issued its report. There was a world of difference between these documents.**

Frans Godfroy

In the night of 31 January/1 February 1953, the dikes in southwestern the Netherlands burst. At the time, plans had already been laid for a "new Delta". Prior to the Second World War, an outline plan had been developed for taming the waters around the islands of the province of South Holland. Once the war ended, those plans were immediately put into action. Meanwhile, however, those responsible failed to closely monitor the existing dikes. The consequences were fatal.

The urgency of the situation was dramatically brought home to the entire country. Less than three weeks after the disaster, the Dutch Minister, Mr. J. Algera, installed the Delta Commission, which was tasked with drawing up both short term and long term measures. The commission's mandate clearly stated that they were to focus on closing off the estuaries, with the exception of the Westerschelde and the New Waterway. The Delta Commission was chaired by A.G. Maris, the Director-General of Rijkswaterstaat (the Directorate General for Public Works and Water Management). As might be expected, TU Delft (formerly called TH Delft) was well represented on the commission. Many of the commission members were already acquainted with one another through the course of their work as civil engineers. Professors Pieter Jansen and Johannes Thijsse were on the scientific staff at TU Delft, with each of them holding two posts. Prof. Jansen was also chief engineer at Rijkswaterstaat, while prof. Thijsse's second post was executive director of the independent Hydraulics Laboratory at Delft. In 1956, Prof. Jansen was also appointed head of the Delta Department.

The decision to close off the estuaries was an obvious one. It involved a significant reduction in the length of coastline, which constituted a major step forward in terms of coastal protection. An incidental benefit was that roads running along the top of the dams would make the islands of Zeeland much more accessible. A second primary objective of closing the estuaries was to push back the salt water: the salinisation of coastal areas - that other centuries-old threat from the sea - was now a thing of the past.

## Bureaucrats

Prof. Jansen was a leading light of the Delta Commission and of the Delta Department. He graduated from TU Delft in 1926 and was subsequently involved in the Zuiderzee Works, which led to the construction of the Afsluitdijk. In 1944, Prof. Jansen was appointed head of the Dienst Droogmaking Walcheren (Walcheren Drainage Division). During the WWII battle for the southern Netherlands and Belgium, large parts of Walcheren Island disappeared beneath the sea when the Allies bombed its dikes.

The author A. den Doolaard (the pseudonym used by C.J.G. Spoelstra) was appointed to the Walcheren Drainage Division in February 1945. Having recently returned from wartime exile in Great Britain he was now serving as an Information Officer to the Military Authority. In his autobiography, Den Doolaard describes Jansen as "a little man with friendly eyes, an ironic smile, and a voice adept at cutting sarcasm". Prof. Jansen and Den Doolaard got along very well, and the professor figures prominently in Den Doolaard's roman-à-clef, Het verjaagde water (The banished water), as the fictional engineer Van Hummel. In this story, which centres around the reclamation of Walcheren from the sea, Van Hummel works shoulder to shoulder with his contractor/supervisor Berend Bonkelaar (in real-life the legendary Kobus Kalis, the man behind the success of the dredging firm Boskalis), battling not only against the water but also against the bureaucrats:

'The mandarins hummed and hahhed, then put forward their objections again, starting at the beginning. Bonkelaar rolled a cigarette. When he'd finished, he lit his cigarette and threw the match to the floor, just in front of their feet. One of the mandarins had just launched into a stream of officialise, "Might possibly merit some consideration ..." or something like that. Bonkelaar snorted, emitting a cloud of smoke in the process, and interrupted the man: "Nonsense, gentlemen. I can see under the water, and you can't.'"

The scene refers to an actual conflict between Jansen and Theodoor Tromp, the new Minister of Water Management, who had been appointed one month before the Allied liberation of the northern Netherlands. Minister Tromp was dissatisfied with the way matters were proceeding. He suggested postponing the reclamation until further studies were completed, and appointed a naval officer (Van Houweninghe) as head of the Walcheren Drainage Division. Some say that Jansen then threatened to resign from Rijkswaterstaat, whereupon the status quo was restored. According to another version of this story, Van Houweninghe advised the minister to dismiss Jansen and Kalis from the organisation, at which point Bergansius sided with Jansen. Whatever the truth of the matter, the minister decided to make the best of a bad job, cancelled the appointment of Van Houweninghe, and allowed the reclamation work to proceed as planned. The work was completed in February 1946, only two months behind schedule. Experience gained in the construction of the Afsluitdijk came in very handy in the reclamation of Walcheren. This reclamation work, in turn, also proved to be very useful in the Delta Works project, which was launched in 1953, immediately after the flood disaster. As in 1944, there was no time for everything to be scientifically investigated and ▸▸

Prof. J.Th. Thijsse.

thoroughly tested in advance. Prof. Jansen had to solve many problems quickly, on site. Experimental investigations of these issues at the Delft Hydraulics Laboratory did not occur until much later. Prof. Jansen, in particular, had to pull out all the stops in order to deal with the complex tidal movements in the interconnecting holes.
Caissons were just one of the innovations that Jansen successfully introduced during the Walcheren project. Some of those involved were not exactly bowled over by this idea, however. Caissons could be difficult to handle; they tended to break loose in rough seas, and they also made it difficult to achieve a hermetic seal. The advantage of using caissons however was that the holes could be filled in faster than with stones and clay. Given Jansen's tight schedule, this was a very important consideration. Caissons made a significant contribution to the Delta Works. Prof. Thijsse, who was a member of the Delta Committee and Head of the Hydraulics Laboratory, supported Jansen in this. The Hydraulics Laboratory carried out a great deal of work on behalf of the Delta Department and the commission. The Walcheren Drainage Division had its own Hydraulics Department, for taking measurements and making observations. With a workforce of about 200 people, this department was charged with studying the movements of water and sand. The role of the Hydraulics Laboratory was to conduct experiments using scale models. The Delta Model, which was laid out on the roof of the laboratory and had been constructed prior to the calamitous floods of 1953, came in very handy for this purpose. At the same time, in the indoor pool, experiments were being conducted on scale-models of caisson structures. This made it possible to vastly improve the caissons during the course of the Delta Works project.
As he had done with the reclamation of Walcheren, here too Jansen was willing and able to defend his own methods. In the late 1950s, as head of the Delta Department, he had become involved in disputes with the director of the Port of Rotterdam and with the planners of the province of Zuid-Holland. The latter envisioned the creation of a new port city on the Haringvliet inlet. As Chairman of the Working Group on the development of Rhine Estuary Ports, Prof. Jansen incurred the planners' wrath by issuing an advisory report to the effect that the Haringvliet was unsuitable for port operations. The argument became really heated when the planners of the Government Agency for the National Plan informed Jansen that his working group should not get involved in planning issues. The professor however was not prepared to be brushed aside in this way, stating that "a good hydraulic engineer is also a planner, and is bold enough to act as one".

The Maeslant storm surge barrier at Hoek van Holland.

PHOTO: SMA RENTMEESTER/FMAX

## Ecological values

Yet times change. From the very outset, the security that the Delta Plan offered the southwest region of the Netherlands was virtually undisputed. There did however come a time in the age-old battle against salt water and salinisation when voices of dissent began to make themselves heard. The 1960s were marked by growing resistance to the planned closure of the Oosterschelde, a resistance that centred around one drawback of the plan; namely, that it would signal the end of all mussel and oyster farming in the area. Both the Delta Commission and the politicians of the time had simply accepted this as inevitable, with the farmers to be compensated for any financial losses incurred. Campaigners however raised a series of new objections: one was that the freshwater ponds that (according to the planners) were to be created by the closure of the estuary would actually be just a single, large pool of polluted river water. At the same time there was increasing concern for the ecological values inherent to the Oosterschelde's saltwater environment.
This issue remained unresolved for many years. Eventually, in 1974, an alternative plan for the Oosterschelde was developed. Instead of completely closing the estuary, as the original plan proposed, the new, much more expensive plan involved constructing a multiple buttress dam that could be closed in the event of a storm surge. Suddenly, the Delta Department had a lot of work on its hands. In addition to designing and building a multiple buttress dam, work was required in the area behind the storm surge barrier to prevent the salinisation of West-Brabant and to facilitate the passage of shipping.
The changing political and cultural environment of the time meant that, in a period of less than 20 years, the struggle against the encroaching sea had become much more complicated. But such was its momentum that this new development was now unstoppable. The multi-disciplinary approach favoured by Jansen back in the 1950s, when he stated that hydraulic engineers should also be able to act as planners, was as nothing compared to the principles adopted a half century later. A comprehensive "transdisciplinary" approach is the motto of the second Delta Commission. In 2007 and 2008, under the chairmanship of former minister

Cees Veerman, this commission set out its long-term plans for the future. Unlike the 1950s, there is no urgency to break ground today. However, before proceeding further, there was a clear need to set out a comprehensive vision. The government wants to use the Commission's findings "to formulate sustainable policy strategies for the coast". In its final report, the Commission explains that its mandate was broader in scope than security (and security against hazards posed by water) alone. "Accordingly, the vision also takes account of the involvement of such factors as housing and work, agriculture, the natural environment, recreation, the landscape, infrastructure and energy." This is reflected by the composition of the nine-member committee. Professor Marcel Stive, of TU Delft, occupies the only seat on the Commission reserved for the field of hydraulic engineering. The other seats are occupied by five members with connections to Wageningen University, one member with links to the Ministry of Agriculture, Nature and Food Quality, one member representing the offshore industry, and one member representing the investment world.
The Veerman Commission's task was limited to the development of a vision. Accordingly, it took just one year to produce a report consisting of 134 densely printed pages. The report contains no clear-cut, detailed plans; these will have to be developed by others, in future, based on this vision.

## Beach nourishment

There are many reasons why the two Delta Commissions cannot be compared to one another. Nevertheless, such comparisons are increasingly being made, even if only because the government has presented the Veerman Commission as successor to the first Delta Commission. This inevitably gives rise to certain expectations.
One key concept in the modern approach is 'soft coastal engineering', which mainly involves the 'support of natural processes' rather than simply closing off water connections. Priority is now given to 'beach nourishment' rather than to dams.
Han Vrijling, professor of hydraulic engineering at TU Delft, views this development with some suspicion. While he has no problem with the idea of widening coastlines as a means of keeping the sea at bay, he is concerned about hidden agendas: "A strip 100 meters wide is enough. However, some variants involve the reclamation of a 1kilometre-wide strip of land, for ecological reasons. If a given measure is only partly useful in the classic sense, and if the remainder of its effect involves an environmental component, then I think we should take a clear decision on whether or not this is what people really want. In other words, clearly identify the environmental part of the measure. I have no problem with that, provided it does not erode the funding of security measures. If it were to do so then we would be making a huge mistake. So rather than funding that extra 900 meters of beach from the scarce resources available for coastal defence, let's pay for it from the budget for nature and the environment."
To support his arguments, Vrijling points to a recent study that revealed that 24 percent of dikes are sub-standard and in urgent need of reinforcement. Furthermore, the professor notes, the Veerman Commission, for no apparent reason, neglected to address an important principle on which the work of the first Delta Commission was based; namely, the shortening of the coastline. After 2050, when the current Oosterschelde storm surge barrier reaches the end of its operational life, the Commission sees opening the Oosterschelde to the sea again as a viable option. This was prompted by the present-day restriction of the tides, which, from the perspective of nature conservation, is seen as a disadvantage of closing the estuary. Intertidal zones are increasingly disappearing under water, due to "sand starvation", for example.
Prof. Vrijling disputes the Veerman Commission's suggestion that there was a failure to recognise this problem until it was too late to do anything about it: "The initial calculations showed that if we were to build a storm surge barrier, those plates would erode. This work was carried out by Luc Kohsiek who, until recently, was the Deputy Director-General of Rijkswaterstaat, and who is now a dike inspector in the province of North Holland. On one occasion, early in his career, Kohsiek performed this calculation for the purposes of a memorandum. The current situation is entirely in accordance with his predictions. The underlying mechanism involves the movement of large volumes of water along the channels. If, at some point, this flow diminishes, then the channel has excess capacity, and sand is naturally drawn down into it, making it correspondingly smaller. That sand has to come from somewhere. Since sand cannot easily pass through the storm surge barrier, it is instead displaced from the plates. There is nothing surprising about this. All that has changed is our perception, for nowadays we are deeply troubled by the fact that the plates are eroding. But I'm not sure that this is so troubling."
Vrijling is also critical of the new plans for the Brouwersdam. The Veerman Commission wants to let water in through the Brouwersdam, thus restoring the tides to Lake Grevelingen. The commission believes this would improve water quality, which, in turn, would benefit the natural environment. "An important question to ask here is: how clean is the water that you are letting in?" Vrijling asks. "This issue should be studied before we proceed any further, because, after all, the incoming water will be a mixture of seawater and Rhine river water, and that is a far cry from the crystal clear seawater from the Bay of Biscay that they use in aquariums at Blijdorp Zoo in Rotterdam. If you're spending hundreds of millions of euro punching holes in the Brouwersdam, only to let in water polluted by chemicals, then you'd just be making a bad situation worse." ◂◂

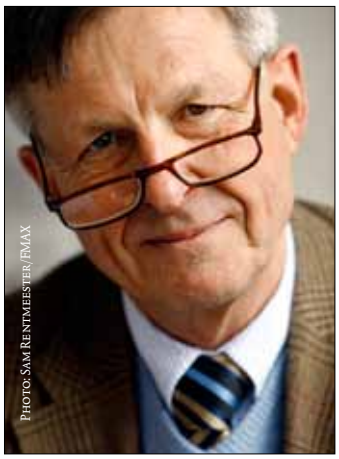


Photo: Sam Rentmeester/fmax

Prof.dr.ir. Han Vrijling.

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More information:
- Delta Commission, "Delta Commission Report", The Hague, 1960-1961
- Willem van der Ham, "Heersen en beheersen. Rijkswaterstaat in de twintigste eeuw" (Dominate and control. Rijkswaterstaat in the twentieth century), Zaltbommel 1999
- Hilde de Haan, Ids Haagsma, "De Deltawerken. Techniek, politiek, achtergronden" (The Delta Works project. Engineering, Politics, background), Delft 1984
- A. den Doolaard, "Het verjaagde water" (The banished water), Delft 2001
- www. deltacommissie. com
- j. k. vrijling@tudelft. nl

Photo's: Sam Rentmeester/FMAX

## Professor Patrick French

*'Just keep going'*

# Motivator and inspirer

Patrick (Paddy) French was born in Rochford, England, on 29 June 1960. In 1981, he obtained a Bachelor's degree in Mathematical Physics at Southampton University. A year later, he was awarded a Master's in Electronics at Southampton, on the basis of a study into the problem of growing single crystal layers on substrates after ion implantation. He obtained his PhD at Southampton in 1986, on the effect of pressure resistance in polycrystalline silicon. From 1986 to 1988, Professor French worked at TU Delft, conducting research into rocker switches in micro-electronic circuits. In 1991, he moved to Japan, where he conducted research into sensor systems for the car manufacturer Nissan. He subsequently took up a post at TU Delft's Faculty of Electrical Engineering, Mathematics and Computer Science. Since 2002, Patrick French has been professor in the Department of Micro-Electronics and Computer Engineering, and the head of the Electronic Instrumentation Laboratory.

Erik Huisman

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

**Explain, in just a few words, who or what the other person is**

French: "He can sometimes be a bit chaotic, but he's an enormously talented scientist. When he applied to do a PhD here, his academic supervisor in Germany wrote: 'I was briefly tempted to give him a bad reference, as I really don't want to lose him. He's the best.' He can also do unexpected things. In addition to the work that he was doing here, he suddenly decided to tackle a Master's in Economics, in Madrid.
Margallo Balbás: "He's a motivator and an inspirer, someone who helps people realise their full potential. He's also a very sociable person, witty, able to cheer people up. In addition, he gives people plenty of scope."

**What is distinctive about the other person?**

French: "Eduardo is creative and versatile, able to transcend the boundaries of different academic disciplines in the course of his research. One line of work, for instance, involves electronic warning systems for use when drilling into bone – that is, mechanical. Other fields include optical projects and photodynamic therapy."
Margallo Balbás: "Paddy is special in many ways. He's unconventional, but in a good way. He's not a radical, just different in practice. He's also very energetic in his role as head of department."

**What have you learned from the other person?**

French: "Modesty. Eduardo is not one to jump up on a table and shout, 'I'm the best!' He just gets on with it. Eduardo does much more than you might at first give him credit for. He has completed a fine dissertation here, in four years, and a degree in Spain. That has shown me that you can get a lot more from your work if you just get on with things. Just do it."
Margallo Balbás: "Many things. As a researcher, I now have a much stronger grounding in the methodology. More specifically, I've learned a great deal about microchips, both in terms of their manufacture and of the underlying technology. More generally, he taught me how important it is to give people sufficient space for personal development."

**What are the key aspects of a good teacher-student relationship?**

French: "That, as far as my students are concerned, my door is always open. Also, we can always pop into town together, dropping the teacher-student relationship for a while – except for the fact that I pay the bill. When relaxing in a pub, I don't want to hear the word 'professor'. It's important that they feel at ease, that I'm one of them yet still the boss."
Margallo Balbás: "Father-son is a bit over the top, but it's not too far wide of the mark. In Germany, PhD

# Eduardo Margallo Balbás

*'Given sufficient scope, you can learn a great deal'*

# Crème de la crème

Eduardo Margallo Balbás was born in Santander, Spain, on 12 May 1980. He earned top grades in the Spanish university entrance examination, and, in 2004, was awarded a Master's in Telecommunication at the Polytechnic University of Madrid. He combined that with a course of study in physics at the Spanish National Distance University, obtaining his Master's degree in 2005. On top of that, from 2002 and 2004, he studied for yet another Master's degree - this time in electrical engineering - at the University of Stuttgart (Germany). Since 2004, he has been conducting PhD research at the Faculty of Electrical Engineering, Mathematics and Computer Science, in the field of instruments fitted with biophotonic sensors. He expects to obtain his PhD in May.

supervisors are referred to as 'Doctor Father', and there is a grain of truth in that. For it is he who helps you develop into a researcher. I believe that there are two important things that a teacher must provide. First, focus on your subject and on your work as researcher. Then there are things like writing articles, attending conferences, and making new contacts. And secondly, provide feedback on how you are progressing."

**In formal terms, the relationship is one of subordinate/superior. Is that how you both see it?**

French: "My relationship with Eduardo feels more like a partnership. If he were to do something weird, then I would switch to the role of teacher, but that would be totally out of character for him. Soon I'll be required to sign for his thesis; then I'll be the teacher. However, he has delivered good work here, so in his case there's not really an issue of teacher-student."

Margallo Balbás: "Yes, that's generally how it has been. In technical terms, that relationship will change because there will come a time when you know as much or more about your own subject. But that's not the case regarding my career as a scientist. Paddy has been a scientist for so long, has so many contacts, so much experience, skills, ways of working. I'm just starting out."

**Is it possible, desirable or even logical that you could have a relationship outside the bounds of your scientific work?**

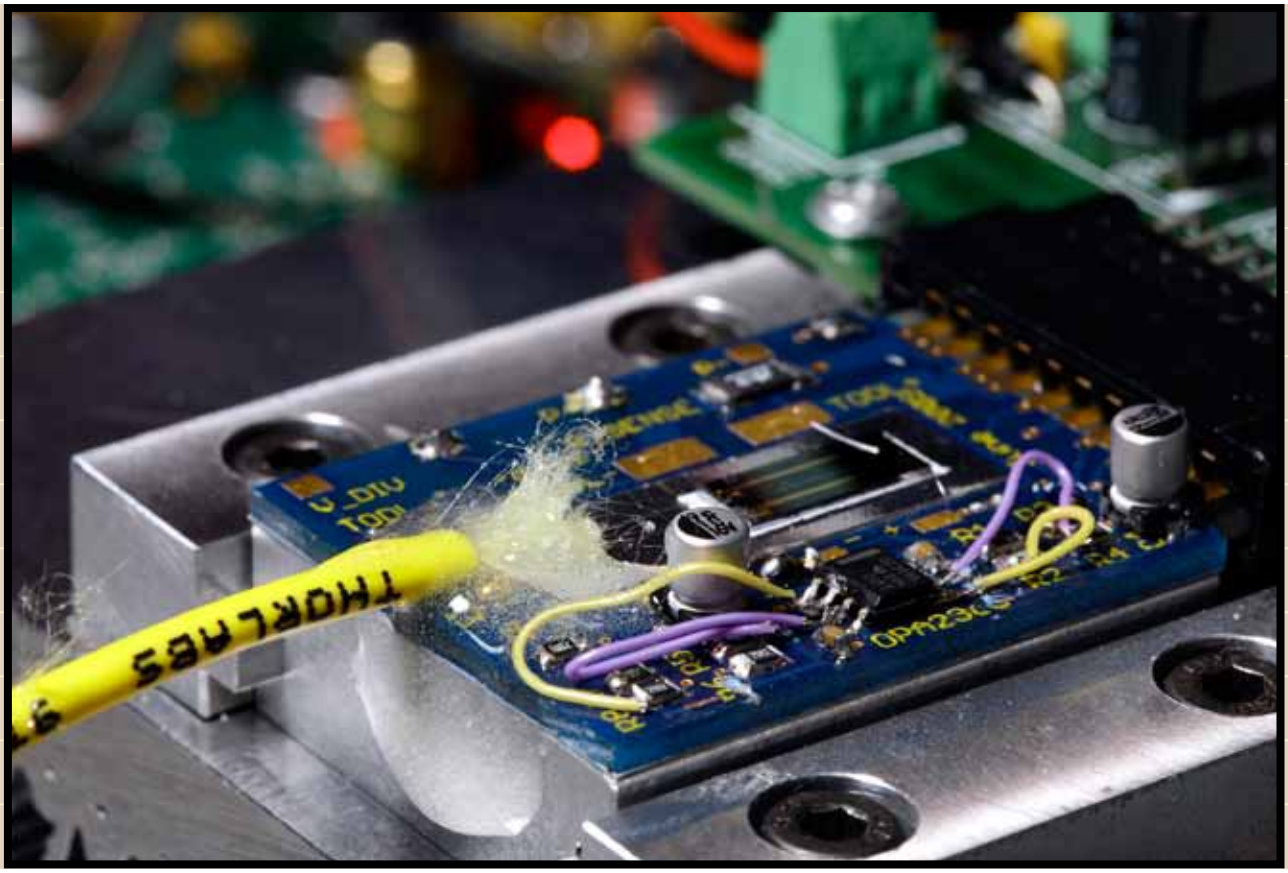
French: "Of course! I have worked with these people for years. I'm open to everything, whether or not it's work-related. Your PhD students are almost part of your family. I want them to do well, in all areas of their lives. When my PhD students give presentations, I'm often more nervous than they are."

Margallo Balbás: "Paddy sees to it we also do things outside of work. Pop out for drinks, go to conferences together.... And that is something I find both desirable and important, because, as a PhD student, I have lived in a foreign country for five years. In such a situation, a social life – with a circle of friends and colleagues – is important and inspiring. It's also good for your work, as you perform better when you're happy."

**Which of the other person's habits or characteristics would you like to adopt?**

French: "Less talk, more action. If you filled our university with Eduardos, then TU Delft would be best! And not just in scientific terms. He also knows how to party. It's a real shame that he'll soon be returning to Spain."

Margallo Balbás: "His mix of charisma, leadership and social skills, coupled with his ability to motivate without pushing. His personal discipline, too. He arrives here every morning between six and six-thirty. I could manage that once, but that would be an exception." ▸▸



*Married/Cohabiting*
French: Married
Margallo Balbás: Living together, engaged to to be married in June

*Favourite books*
French: "'Animal Farm' by George Orwell, which is still relevant today. That, and the books by Sartre."
Margallo Balbás: "'Brave New World' by Aldous Huxley."

*Favourite newspaper and magazine*
French: "When I do read a newspaper, then it is usually 'de Volkskrant'
Margallo Balbás: 'Der Spiegel' and 'The Economist'

*Discoveries that you would like to have made*
French: "The electric motor. It has so many applications."
Margallo Balbás: "X-rays and their medical applications; their importance cannot be overstated."

**And which habit or characteristic would you definitely not want?**
French (laughing): "Eduardo doesn't have a watch and usually has no idea what time it is, although I must say that he's often very punctual."
Margallo Balbás: "His chaotic streak. He's really very chaotic. I'm a bit like that too, and it really irritates me. You can fight chaos with discipline, but it really comes down to finding a good balance. In his job, if you don't allow for a little chaos, it means you're spending all your time organising, and then you can no longer do your work."

**What do you like most about the other person?**
French: "Besides the fact that he just gets on with things? The fact that he seldom gets angry. Furthermore, Eduardo's range of conversation is not limited to his field of research. He's very open to others and has a fine sense of humour. If you wander into his office and say, 'Good grief, you look awful', he usually replies, 'I do try!'"
Margallo Balbás: "The freedom that he gives to others. This meant that I always had to make choices, to think for myself and make judgements. You really learn a lot that way."

**How would you assess the other person's contribution to your field of research?**
French: "He's the only person in the world who can measure bone density using an optical system. This has the benefit of being fast and non-invasive. His PhD research centred around taking measurements in the course of drilling work for dental implants, but he didn't stop there. His projects have generated all kinds of spin-offs, such as bone-density measurement in the elderly, and in relation to spinal implants. Another example is the measurement and control of tissue growth in cases of brain cancer."
Margallo Balbás: "Working alone and with students, Paddy has developed numerous devices and instruments, such as accelerometers. He has also contributed greatly to the development of sensors, to the steps in that process, and to the associated knowledge of fundamental physics."

**With regard to your chosen field of study, or your own research, do you have any surprises up your sleeve?**
French: "In Eduardo's field – medical sensors – there will be new ways of making measurements, in the bowels, for example. Moreover, there will be improved sensors for pacemakers, and cochlear implants that will enable the deaf to hear again. Another line of work involves sensors for smart scalpels. And that's just in the area of medical applications."
Margallo Balbás: "In my case, that would be incorporating optical coherence tomography into a drill. When drilling in various materials, this technique can show you what is immediately in front of the drill tip. We are working together to develop a chip that will make devices based on this technology smaller and cheaper. We're also working on a technique that uses light to measure bone density. I had an idea for photodynamic therapy and did some of the initial work. A student is currently developing the concept further. This therapy kills cancer tissue using a substance that is activated by light. Here we are developing a light source for the treatment itself, and a sensor for the non-invasive monitoring of this process."

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


Microbiologist **Professor Jack Pronk** of the Faculty of Applied Sciences has won the 2009 Energy Prize awarded by chemical firm Dow Benelux for inserting a bacterial gene into yeast. This genetic modification makes the yeast better suited to produce ethanol from agricultural waste. Dow established the €25,000 prize for 'sustainable developments in the process industry'. Process technologist **Dr Elif Genceli** won one of two Dow Energy Dissertation Awards (worth €5000) for her PhD research into extraction of raw materials. Dr Genceli, who works at the Faculty of Mechanical, Maritime and Materials Engineering and who also won a VENI grant shortly before, developed a method for extracting salt from a mud flow by cooling it. At present the mining industry uses evaporation to carry out this process, a method which consumes ten times more energy. Professor Pronk and Dr Genceli received their awards on Wednesday 25 November from Maria van der Hoeven, the Minister of Economic Affairs.

Extremely thin and flexible solar cells are the energy source of the future. That was the view advocated by **Professor Miro Zeman** (of the Faculty of Electrical Engineering, Mathematics and Computer Science) on 11 December in his inaugural speech as Professor of Photovoltaic Materials and Devices. The thin, flexible solar cells his group is working on are cheaper to produce than traditional solar cells and are also more versatile thanks to their pliability. The most important challenge which Zeman will address in the years to come is raising the yield of the flexible cells from 10 to 15 percent.

Climate change, urbanisation and the ageing society will increase water pollution in urban areas. This will have an impact on our living environment but also on the quality of our drinking water. With his appointment on 1 January as Professor of Integration and Innovation in the Urban Water Cycle, **Professor Luuk Rietveld** of the Faculty of Civil Engineering and Geosciences wants to make a contribution to solving these problems. He argues that a solution to the lack of clean water lies in extracting and treating the salt water that is now seeping into our fields. He also wants to investigate how to prevent hormone disruptors and the residue of medicinal products finding their way into the environment through the water supply.

Former Rector Magnificus **Jacob Fokkema** was awarded the City of Delft's medal of honour by Mayor Bas Verkerk on Tuesday 5 January at the Delftse Kring meeting. Professor Fokkema was awarded the honour for his great dedication to Delft. The Mayor praised Professor Fokkema for not only enhancing the allure of TU Delft but also for contributing to the fame of Delft as a city. Jacob Fokkema was a driving force behind the Hippolytus Lecture, the aim of which is to acquaint the general public with the university's research.

**Professor Nynke Dekker** of the Kavli Institute of Nanoscience was awarded a VICI grant at the start of this year by the Netherlands Organisation for Scientific Research. A specialist in bionanotechnology, she received €1.5 million to develop techniques for examining individual molecules within the living cell. One of the future benefits of this study would be to improve our understanding of the DNA replication mechanism, which is relevant to cancer research.

Hospitals should take far greater care when using advanced technology, and technicians and medical staff need to learn to understand each other's language better. This is the argument put forward by gynaecologist **Professor Frank Willem Jansen** in his inaugural lecture 'Is there an engineer in the house?' on Monday, 11 January. His chair is funded jointly by TU Delft and Leiden University Medical Center (LUMC).

**Dr Susanne Rudolph** of the Faculty of Civil Engineering and Geosciences has won the title of TU Delft's best teacher for 2009. On 13 January, the €10,000 prize was presented to her by former Rector Magnificus Jacob Fokkema. Dr Rudolph, who also celebrated her birthday on the day of the ceremony, was completely overwhelmed by the news that she had been crowned best teacher. In her acceptance speech, she said even being nominated had come as a big surprise. "I am highly critical of myself and I don't think of myself as a good teacher." The jury – consisting of the rector, two members of the Student Council and one member of the Societies' Council – chose her from among seven nominees.

250 fewer traffic fatalities a year in ten years' time. That is the fervent wish of Professor Fred Wegman, the new Professor of Traffic Safety at Civil Engineering and Geosciences. In order to achieve this, he advocates a new "forgiving environment", which includes crash barriers with a gully on secondary roads and safer cars. **Professor Wegman** held his inaugural lecture at the end of January.


[HORA·EST]

# Propositions

The reduction of engineers in governmental positions costs the tax payer lots of money, as is shown by the budget overflows of most large infrastructural projects.
*Patricia P. Parlevliet,*
MATERIALS ENGINEER

The motivation of a PhD student is often proportional to the distance to the next conference location.
*Raf Theunissen,*
AEROSPACE ENGINEER

Graduate students are the blood cells of an organism called university.
*Wojciech Grzegorczyk,*
MATERIALS ENGINEER

The most relevant (and also exciting) interface is that between water and air.
*Katja Carola Nowack,*
PHYSICS ENGINEER

A welding joint between the bonnet and the body work of a car can save high garage costs.
*Guus van Gemert,*
MATERIALS ENGINEER

There is never a single right solution. There are always multiple wrong ones, though.
*Semen Grabarnik,*
PHYSICS ENGINEER


The miracle of life is no less extraordinary when it is explained through the theory of evolution.
*Koenraad Elewaut,* GEOLOGIST

## [Sound]BITES

"In the Netherlands, three ladies on a dike can bring everything to a grinding halt. I've literally had firsthand experience of this, with the new library in Spijkenisse. It was delayed for years. Construction is impossible in such situations."
*Professor of architecture and co-founder of the MVRDV architectural firm, Winy Maas, in NRC Handelsblad*

"Dutch designers have a strong sense of social involvement, which perhaps they also share with Scandinavians, but which you rarely find in architects elsewhere in the world. In America it's usually just about earning money. Preferably all wrapped up in a tempting package."
*Design historian, Dr Timo de Rijk, in the AD*

"At work I'm the only woman among my 40 male colleagues, but even so, I'm still just 'one of the guys'. The notion that science is a male bastion is a bit outdated now. If have good ideas, you'll be taken seriously."
*Mathematician and Antoni van Leeuwenhoek Professor, Hester Bijl, in De Volkskrant*

Photo: Sam Rentmeester/pMax

Proposition
It is a sad reflection of modern society that we take the car to the gym to run on a treadmill without making any progress.

Defence
"My proposition is open to two interpretations. There are lots of people who go for a five-minute run on a treadmill once a week. It doesn't get you anywhere, either literally or metaphorically, yet hordes of people do it. Many of them even take the car to go to the gym. It's something I've noticed at TU Delft's sports centre too. Another option might be to cycle to work. That's what I do, weather permitting. I cycle from Delft to Schiedam and back. Or if you'd rather run, why not do it in the woods? Not only are you keeping fit, but you're also using your time and resources more efficiently. But perhaps that's just my engineering mind at work. For instance, I still don't understand why they don't attach generators to all that gym equipment."
*Jan van Kessel,* NAVAL ENGINEER

# THE ALUMNUS

**A TU Delft alumnus first writes a personal column, then passes the baton to another alumnus of their own choosing.**

"To Italy?" my girlfriend asked. I had just told her about the "offer you cannot refuse" that I had received from a company that builds paper-processing machines in various countries throughout the world. Just four months after I had obtained my degree in mechanical engineering, we were on our way to northern Italy.

Before I started my engineering studies at Delft, I had studied art history in Florence. After this first taste of life in another country, I was convinced that I would live and work abroad again at some point in the future. It also instilled in me the belief that I should not restrict my wide range of interests. These two convictions have been constant factors in my life ever since.

After completing my course of study in the manufacture of equipment for the processing industry, I joined Beloit Italia in Turin, as a project manager. In that capacity, I have built paper-processing machines in various parts of the world, such as Italy, Slovakia, and Indonesia. The way in which these machines combine vast bulk with a delicate interplay of mechanics, electronics and chemistry is nothing short of breathtaking. Above all, my dealings with people from other cultures, and with Italians in particular, has left a lasting impression on me.

Sadly, Beloit's parent company in the United States went bankrupt. After taking a fairly circuitous route, I ended up in Great Britain.

I had became very interested in the financial and organisational aspects of my paper-processing machine projects, and wanted to explore the subject further. To this end, I completed a two-year MBA programme at the London Business School.

When I started this programme, however, I didn't know that I would never undertake purely engineering work again.

Indeed, I ended up at virtually the other end of the spectrum. I took up a post as a consultant with Roland Berger, a consultancy in Germany. I worked primarily for clients in the manufacturing industry, focusing on strategic – often non-technical – issues.

In the course of my work as a consultant, I have participated in some very interesting projects, picking up a range of skills in the fields of analysis, presentation and communication. In addition, dealing with some customers in south-western Germany presents cultural and linguistic challenges that should not be underestimated.

The highlight of this period was a project that involved a protracted stay in Tokyo, during which time I worked closely with various Japanese professionals. Bill Murray's experiences in the movie "Lost in Translation" almost perfectly mirror my own encounters with the Japanese and their culture during that time.

I am currently living and working in the Netherlands again, having returned home just over three years ago. My present post is as Director Corporate Strategy with Océ, in Venlo. The work itself involves supporting strategic projects and supervising the purchase and sale of business units. During the past year I have primarily been occupied with the ultimate sale ... that of Océ itself, to Canon. If all goes well, Canon will soon complete its take-over and my wife will be asking me "To Japan?".

Tys van Elk studied Mechanical Engineering in Delft. Van Elk passes the pen to Erik Roscam Abbing.

# EUREKA!

## Eradicating weeds

Photo: Hans Stakelbeek/FMAX

Robert Visscher

Weeds! In gardens they are generally just an annoyance, but in some places they can be downright dangerous. Take the Port of Rotterdam, for example. Safety considerations have made weeds a thorn in the flesh of oil companies there for many years. In the summer, weeds shoot up in no time at all. Next, they dry out, posing a fire risk. "The areas around the oil storage tanks must be clean and safe", says assistant professor Jan van der Tempel of Aerospace Engineering. However, getting rid of the weeds is no easy matter. "We're not allowed to use herbicides. Nor, of course, would it be a good idea to incinerate weeds with a flamethrower close to an oil storage tank. And manual weeding is way too expensive."

It was a friend who first mentioned the port's weed problem to Dr Van der Tempel. "Soon afterwards we came up with the idea of freezing weeds", he says. He and his co-workers collected a flask of liquid nitrogen from the Faculty of Applied Sciences. "We went out to the civil engineering car park, pulled up a weed, and sprayed it with liquid nitrogen. The plant became hard and brittle, I ground it under my shoe, and it was gone."

Following that first successful test, Van der Tempel dived into the patent archives. To his disappointment, he discovered that he was not the first to come up with this method. "But none of the weed-killing methods described were ever put into effect, as they required prohibitively large quantities of liquid nitrogen. Accordingly, these inventions were not financially viable."

This prompted him to look for more efficient ways of putting this principle into practice. He came up with a trolley that sprays nitrogen onto weeds. A brush is then applied to the frozen plants, shattering them into a thousand pieces. "Using a brush in this way enables us to cut the amount of liquid nitrogen needed by half", says Dr Van der Tempel. "Even so, our model is not yet financially viable. The initial design is quite rudimentary, so there is still plenty of scope for improvement. Our ultimate aim is to create a motorised trolley that can be driven, rather like a sweeping machine."

" To date, Dr Van der Tempel's main claim to fame has been an invention by the name of Ampelmann. This is a six-legged platform, supported on hydraulic cylinders, which enables people to transfer from ships to drilling platforms, for example. "I am still fully occupied with that project, so I don't know how much time I can devote to the development of this weed killer. However, if we go ahead and implement the necessary improvements, then we will be ready to place the trolley on the market in three years' time."

More information:
Dr Jan van der Tempel, j.vandertempel@tudelft.nl

# WHO & WHERE

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

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

*For further information:*
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*Information on research fellowships:*
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*General information on university education in the Netherlands:*
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**For information on courses in the Dutch language:**
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