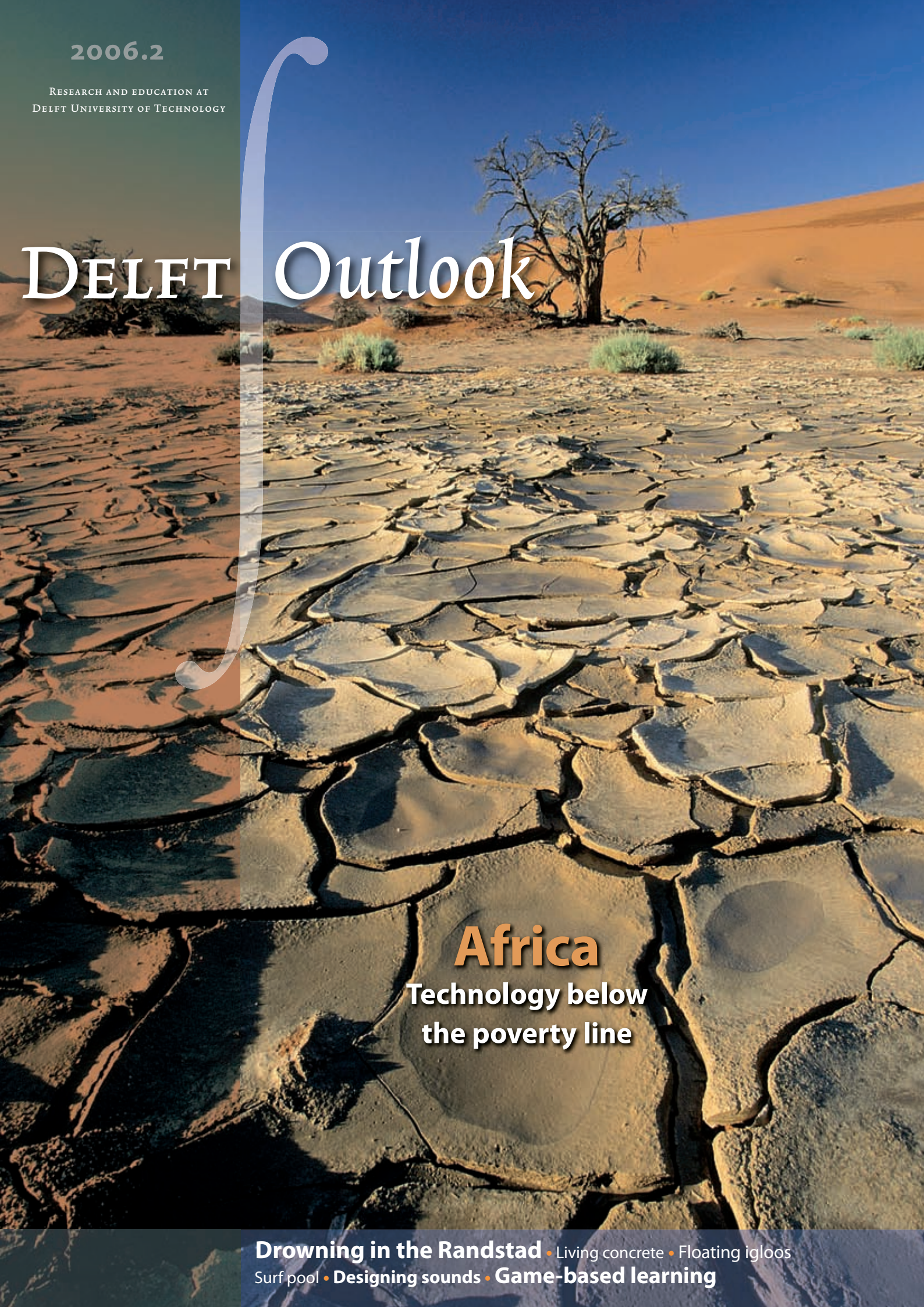
2006.2

Research and education at
Delft University of Technology

Delft Outlook



Africa
Technology below the poverty line

Drowning in the Randstad • Living concrete • Floating igloos
Surf pool • **Designing sounds** • **Game-based learning**

Contents

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Delft Outlook

[Edit]DO

Is Africa really 'the lost continent', as former Secretary General of the United Nations Boutros Boutros-Ghali labelled it ten years ago? A fresh new approach to developmental aid has inspired engineers to tackle Africa's problem with common sense and simple, inexpensive, low-tech applications. In this edition of our magazine, you can read about how Delft University of Technology (TU Delft) has accepted this challenge: it is no coincidence that the university has placed Africa at the forefront of its 165th anniversary celebrations. There is certainly no lack of creativity at TU Delft, as you will also discover in articles about a new method for predicting the casualties caused by floods; an axe-shaped-ship's bow; and a new thermal microactuator. The hope is that in the coming years developing countries will finally be able to really ride the wave of technological ideas.

Maarten Keulemans
Deputy editor-in-chief

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COLOPHON

coverphoto
Dryness in Namibia.
Photo: Nigel Dennis/ANP

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Concrete creatures

There is a lot of hard work being done in the experiments of microbiologist Dr. Henk Jonkers (Civil Engineering and Geosciences). But not only by the post-doc researcher: for the past two years billions of bacteria have been trying to prove that self-repairing concrete is a reality.

Construction bacteria still hard to feed

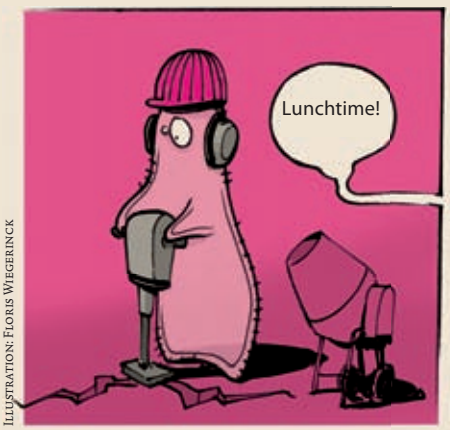


Illustration: Floris Wiegerinck

"A small crack in concrete doesn't significantly affect its overall strength. But water can seep in through that small crack and affect the metal reinforcements, causing them to rust." Concrete decay, as this is called, does weaken the concrete, however. Of course you can repair the cracks, but what could be better than having a billion bacteria do this work themselves? Jonkers has since found the appropriate bacteria. They leave spores – a kind of seed – that can survive for years in the inhospitably high acidic levels found in concrete. As soon as a crack appears, air and water ensure that the bacteria get to work closing the crack. The bacteria, which are found in every common backyard, do this work with limestone that they produce themselves. But first these bacterial builders want to eat. Jonkers has found a food source that satisfactorily hardens the concrete. Experiments will now be conducted to determine if the bacteria can also work well with it.

More information: Dr. Henk Jonkers, H.M.Jonkers@tudelft.nl.

Floating igloos

If the dikes are breached, residents of this futuristic city have nothing to fear. A research group led by Rutger de Graaf of the Faculty of Civil Engineering and Geosciences has won first prize in the Delta competition for their innovative plan to build a floating city on the IJmeer. The Delta competition was organised by Royal Haskoning engineering bureau. The 'igloflats' were not only designed to survive floods; their unique shape also allows for maximum energy use from solar rays.

More information: Rutger de Graaf, tel. (015)2784673, r.e.degraaf@tudelft.nl.

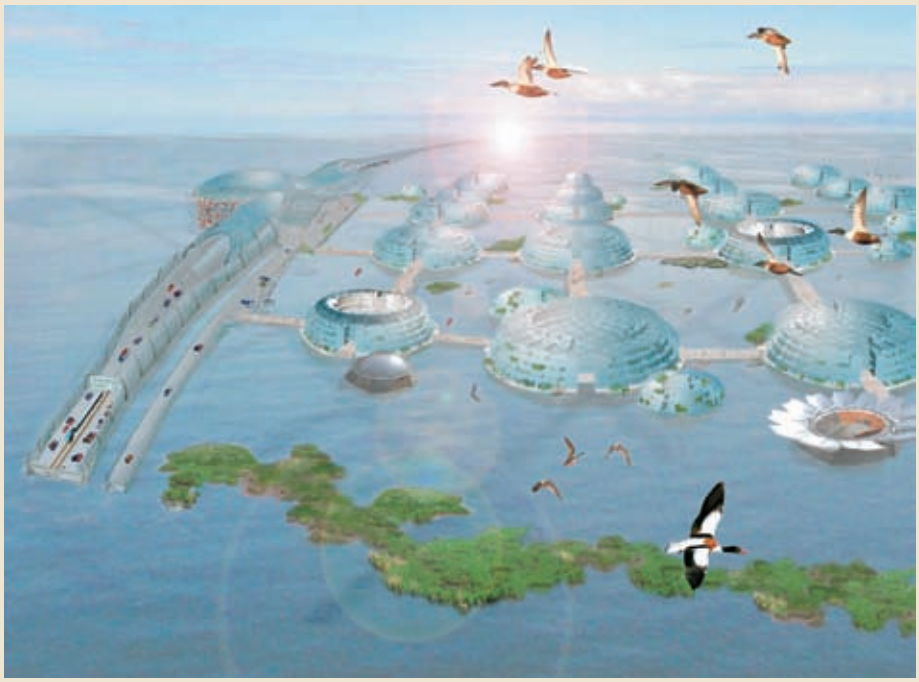


Illustration: Deltasync4

Axe Bow cuts through its first wave

A new ship's bow designed in Delft set sail on its maiden voyage on the deep blue sea. "A brilliant design," the shipbuilder declared.

The three ships that are nearing completion feature a so-called 'Axe Bow': a high, straight bow shaped like an axe, which was designed by maritime engineer Dr. Lex Keuning in the 1990s. The bow provides the vessel with superior seaworthiness. Vessels with axe bows pitch less heavily, their noses do not come out of the water and therefore they do not slam into the waves. The result: less seasickness and damage, and higher speeds. "Waves do not hurl this ship upwards; the ship just carries on cutting through such waves. Consequently, the captain can cut back on the throttle less quickly," says Jaap Gelling, product director for *High Speed & Naval Craft* at Damen Shipyards, in Gorinchem.

Photo: PR Damen Shipyards

The first axe bow vessels will be used for quickly transporting personnel and equipment to and from offshore oil rigs. "I envision them as the courier vehicles of the sea," Gelling says. The first two axe bow vessels are expected to be put into service in Mexico. The third vessel, which is a fast, 35-meter long transport ship, is currently being built for the Croatian offshore industry. In the coming years, another two longer axe bow vessels will be built. And there are also two designs for axe-bowed patrol boats currently on the drawing board.

It became clear during the first sea trial that the axe bow vessel performed exceptionally well. "It's a strange experience. You see a huge wave coming at you, but the bow just gradually rises, without extreme up and down accelerations." The vessels also proved to be easy to steer. Experts had initially feared that the axe bow might negatively affect the vessel's manoeuvrability and the ability to steer a fixed course. "But the captain complimented us on the vessel's ability to be tightly steered at all speeds."

More information: Damen Shipyards, www.damen.nl; Dr. Lex Keuning, 015-2781897, j.a.keuning@tudelft.nl

The Wad bogs down

Sand is disappearing from Texel and North Holland beaches and accumulating in the Wadden Sea. Experts theorise that this process will cease by itself, but TU Delft research undermines this theory.

"Five to six million cubic meters of sand per year has been added to the Wadden Sea over the past decades," says PhD candidate Edwin Elias, of TU Delft's Faculty of Civil Engineering and Geosciences. The culprit: the construction of the Helderse Zeewering, which already began around 1750, and the construction of the Afsluitdijk. The government must apply sand-water slurries to Texel's beaches and other North Holland beaches to prevent the land from disappearing into the sea.

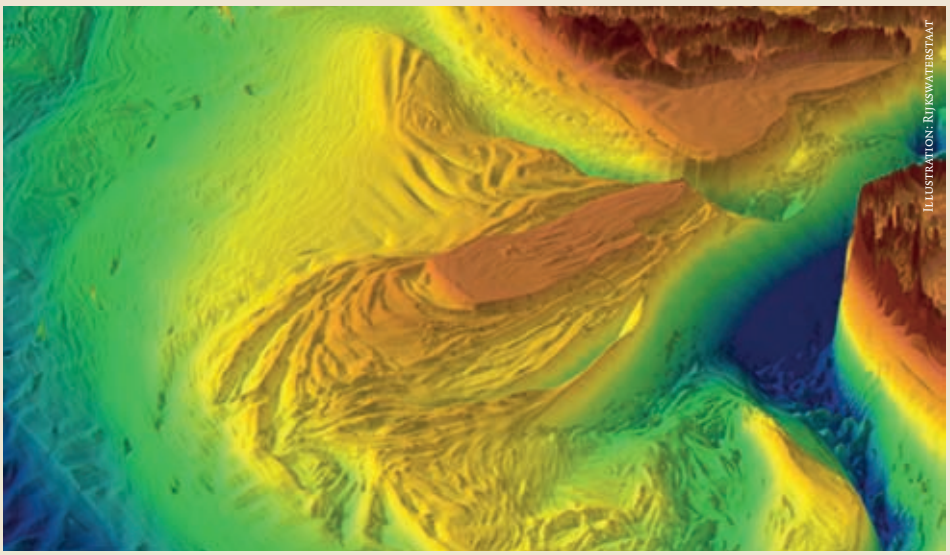


Illustration: Rijkswaterstaat

3D Computer images of the Razende Bol sandbar (centre) lying off the coast of Texel (upper right) and North Holland (centre right).

It may seem that the Wadden Sea is absorbing less sand, but Elias has discovered that the sand is in fact accumulating more eastwards, in a section of the Wadden Sea that until now was not included in the analyses. His doomsday scenario: "We must consider rises in sea levels and seabed subsidence due to natural gas extraction. The Wad will try to neutralise these changes, and this is likely to lead to even more displacement of sand."

Elias however is unconcerned. "The Netherlands has an enormous reserve of sand in the North Sea," he says. His research moreover has shown that this sand can be unloaded at the Razende Bol, a large sandbar located in front of Texel. The sand that is dumped there will flow straight back into the Wadden Sea. "The great advantage of this is that you will rarely need to use sand dredging vessels."

More information: Edwin Elias, eelias@usgs.gov

Photo: Sam Rentmeester/fMAX

Top story

Gloves are required for this top story. In the atlas of cartographer and merchant Georg Braun that dates from 1575, Rotterdam strangely enough is pictured as lying on a peninsula. This atlas can be admired in the new Map Room, where all the maps acquired by TU Delft since 1850 are collected under one roof. From Jacob van Deventer's impressive Atlas of Cities dating from the 16th century, to sparkling new digital aerial maps.

Computer coach

Photo: Jeroen Arendsen

The computer as a coach. The computer is an extremely helpful tool for children aged between three and five years old who are learning sign language. Two cameras film the children as they make a sign that has appeared in an image on the computer screen. The computer then 'judges' if they have made the correct sign. Three TU Delft PhD candidates will devise the best way for the computer to recognise and evaluate the signs.

More information: Gineke ten Holt, g.a.tenholt@tudelft.nl; Jeroen Lichtenauer, j.f.lichtenauer@tudelft.nl; Jeroen Arendsen, j.arendsen@tudelft.nl.

IN·BRIEF

Rococo under the x-ray

A great mystery has long surrounded the yellow flowers of rococo painter, Jan van Huysum (1682-1749). Some of the flowers Van Huysum painted have faded, while others have continued to shine down the centuries. Materials scientist Dr. Joris Dik has solved the mystery.

Last summer Dik (Faculty of Mechanical, Maritime & Materials Engineering) placed a yellow flake of paint from a Van Huysum flower under an x-ray diffractometer. This machine emits x-rays and, based on the reflections on the underlying object, determines the crystal structure. Dik concluded that Van Huysem used orpiment (arsenic sulphide). This pigment consists of strongly reflecting crystals. The only problem is that this pigment degrades when fully exposed to sunlight for too long. Oxidation occurs, creating a colourless arsenic oxide and corrosive sulphur dioxide. During his research, Dik also discovered small bits of plaster and chalk in the less effected sections of the paintings. From this, Dik surmised that Van Huysum, like many of his contemporaries, diluted his paint with chalk. There is less corrosive sulphur dioxide in such mixtures. The sulphur reacts with the chalk to create plaster.

Gaining insights into the stability of the orpiment's various compositions can be beneficial for restoration works, Dik believes: "If the paint only has a little chalk in it, the varnish should perhaps be removed more carefully." In order to be absolutely certain of his theory, Dik will begin conducting additional x-ray research next year, when he will place an entire painting in the diffractometer.

More information: Dr. Joris Dik, tel (015)2789571, j.dik@tudelft.nl.

Before (left) and after the restoration (centre and right).

The dream of every surfer

Surfers Paradise is regarded as heaven by Australian surfers. But the Gold Coast 'Down Under' now has a formidable competitor in Delft.

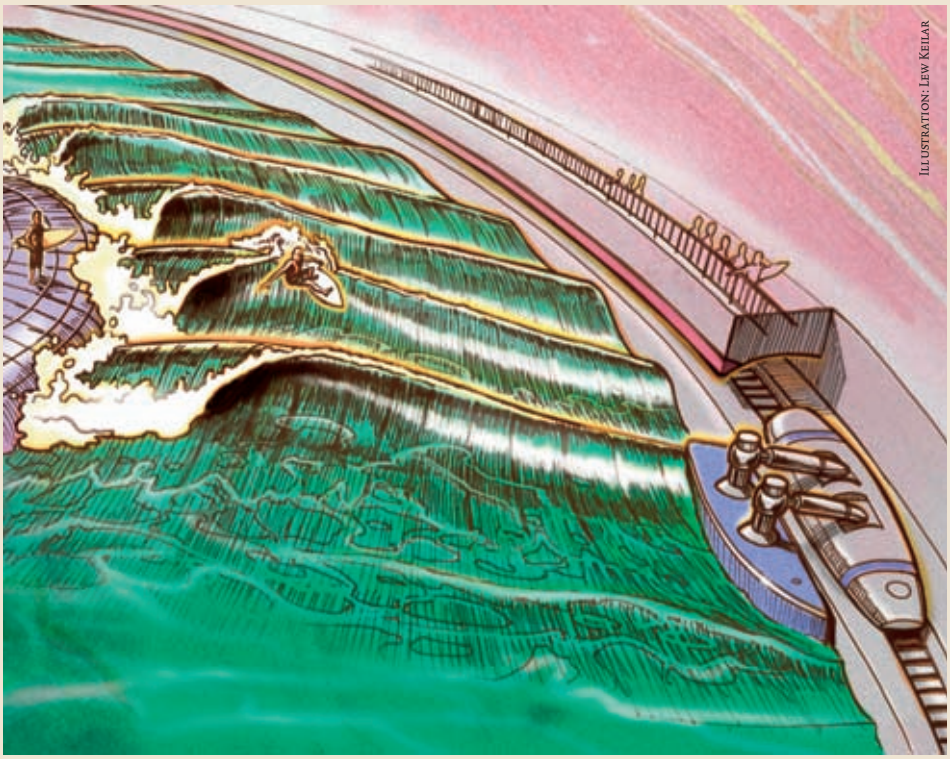


ILLUSTRATION: LEW KEILAR

Coastal engineering and fluid mechanics students Matthieu de Schipper (23) and Sierd de Vries (24) have designed a mobile surf pool that can be used anywhere – even in the barren outback, 4,000 km from the Australian coast. Their 'Liquid Time Wavepool' is a round, 200 meter in diameter swimming pool that has an island in the middle of it. A ship's hull rotates along the outer edge of the pool, leaving a series of 2-meter high waves in its wake. The waves 'break' – as they say in surfer speak – at the island, becoming uniform, curling masses of water. The dream of every surfer. The two students are planning to graduate this summer based on this research subject. They are currently using a numerical model to determine the ideal shape of the hull, which they will then test as a scale model in the Faculty of Mechanical, Maritime and Materials Engineering's tow tank. The original idea for this wave pool came from Australian surfboard designer Greg Webber, who patented the idea a few years ago. Webber was introduced to the two TU Delft students by fellow Australian, Andrew West, who had previously studied at TU Delft.

More information: Sierd de Vries: sierddevries@gmail.com; tel. (06)55808345 and Matthieu de Schipper: madeschipper@hotmail.com; tel. (06)44818331.

IN·BRIEF

Randstad to become 'Medical Delta'

In ten years time, anyone who needs to undergo a complex operation will come from far and wide to the medical facilities in South-Holland.

There will be lots of good business and employment opportunities in the region for companies directly or indirectly involved in the medical sector, like, for example, providing hotels for people visiting patients. This is the ambitious goal of the Health Science and Technology (HST) research institute, which was founded at the end of October. TU Delft has joined this venture in partnership with Rotterdam's Erasmus University and Erasmus Medical Centre, and the University of Leiden and Leiden University Medical Centre. The various doctors, technologists and researchers will pool their knowledge, in order to improve the health care service. This will involve everything from diagnosing, treating and recovering from illnesses, to caring for the chronically ill. Ultimately transforming the southern Randstad into a 'Medical Delta' is an ambitious project, but not too ambitious, according to Professor Ted Young, chairman of the HST taskforce. "We have a unique concentration of expertise within an 20-kilometer radius. Having the various disciplines working together means we can achieve a lot." Many TU Delft faculties develop interesting technologies for the medial sector. The Faculty of Applied Sciences has developed methods to help chemotherapy treatments focus more effectively on the 'sick', cancerous cells. The fluid dynamics developed at the Faculty of Mechanical, Maritime and Materials Engineering can also be applied to blood streams. And Industrial Design Engineering can design more efficient and ergonomic operating rooms.

More information:
Professor Ted Young, i.t.young@tudelft.nl;
www.hstresearch.nl.

Elif Ozcan Vieira, designer of product sounds

Sound isn't noise

Designers devote too little attention to the sounds a product makes, according to Elif Ozcan Vieira (Industrial Design Engineering). She researched product sound perceptions and has developed a method for designing sounds for household appliances.

Maaike Muller

Why should a designer design the sound of a household appliance?

"The sound a product makes when you use it or place it somewhere must fit the product. It must generate a positive experience. Users find this important at a time when the sound must match well with the product's functionality. A coffee machine for instance must have a pleasant sound, because people associate drinking a cup of coffee with relaxing."

But don't designers consider sound at all?

"Not nearly enough. They are slightly concerned with sound, such as the beeping of an alarm clock. But the sounds you hear when using a vacuum cleaner, like the click of the knob when you turn it on or the sound the motor makes are given very little attention. The only exception is the auto industry, where lots of creative energy and money are spent on designing the perfect sound for the engine or the closing of the doors. I think that designers need to be more aware of the fact that the sound of a product changes if the design - the material, for example - changes."

Photo: Sam Rentmeester/FMAX

In addition to studying industrial design in Turkey, Elif Ozcan Vieira also created jingles and sound-effects for a local radio station. "I discovered that designing sound is really not so very different from visual design." After having worked for a few years as a multimedia designer in Lisbon, she came to Delft to pursue the relatively new research field of sound design. Her PhD research is focused on developing a method for designing the sound of a product.

That makes sense, but how do you design sound?

"During my research, I developed a method for designing product sounds. The sound design process follows the same steps and runs parallel to the product design process. But there are two steps in the method that are really new and specifically for sound design. One of them involves making sound sketches. To do this, the designer collects objects that make sounds and then analyses how well the sound fits the particular product. This agrees with the visual sketches the designer makes to determine the product's shape in the beginning of the process. Then, to better visualize the design, the designer often makes a 3D computer model. Analogous to this, the designer makes a model of the sound. We've developed software that allows the designer to choose from a sort of library of sounds for all the various product parts. The motor, a lid that closes or a knob. The computer can be used to simulate the product's *soundscape*, which is all the various sounds the entire product makes."

How has your method been received?

"The students who I've let work with it found it really good and useful. And the academic world and industry are also very interested in it. Large product design companies realise that they don't know how to design sound, so they simply ignored it. Theories for color and form have existed for centuries, but not for sound. I'm one of the few who have researched sound design. A lot more knowledge must be developed, for example about our emotional responses to a product's sounds. Sound must fit with the product. It's obviously not my intention to regard sound as noise and therefore design a product in such as way that it makes as little noise as possible. My research group is thinking about the sound a hydrogen-powered car makes, for example. These cars can be very quiet, which is fine, but you also want to be able to hear if the engine is running and when you accelerate."

More information: E. Ozcan Vieira, e.ozcan@tudelft.nl

Potential below the poverty line

A squeeze bottle that enables children to purify their own drinking water. A bicycle that disabled unemployed people can use to sell ice cream. In Africa, inventions from Delft can make a world of difference. The paternalistic past is over, and locals are often involved in running the projects.

Maaike Muller and Joost Panhuysen

FOCUS

Fighting poverty and making money need not be mutually exclusive, according to famous business professor C.K. Prahalad in his book, 'The fortune at the bottom of the pyramid' (2005). According to Prahalad, rather than regarding the four billion people currently living below the poverty line as victims, we should see them as potential consumers and entrepreneurs. Businesses can open up markets of unprecedented scope if they are sufficiently innovative in coming up with cheap products targeted at local needs.

As professor of the design engineering department at the Industrial Design faculty, Dr. Prabhu Kandachar has supervised dozens of graduation assignments with a bottom-of-the-pyramid focus. He calls Prahalad's ideas 'not revolutionary, but smart and well-timed.'

Kandachar: "Many businesses are on the lookout for new markets and are willing to run their business along socially responsible lines."

Last year, after reading 'The fortune at the bottom or the pyramid', industrial designer MSc. Roelie Bottema contacted Kandachar. "I don't think the market offers the solution to every problem," she says, "but charities will sometimes have this 'let us improve your life for you' attitude. A business is forced to look into what the people themselves want."

Kandachar proposed a graduation assignment for Bottema at the Danish company, Vesterdgaard Frandsen, which had developed a portable tube for purifying water. A week later Bottema travelled to five villages in Ghana to distribute the Lifestraw, as it is called, to a total of twenty-five test users.

The testers were positive about the product. "Suddenly they weren't ill any more." The Lifestraw works by letting the user suck water through a number of filters and two 'chambers' that contain iodine granules and carbon, respectively. They thoroughly purify the water. Bottema: "Even the iodine taste of the purified water was not a problem to them, since it was proof that the water was now clean."

However, children under the age of five did not manage to suck up the water, and it is this age group in which the drinking of polluted water causes the highest number of deaths. So, Bottema designed a child's version, in which the tube was attached to a squeeze bottle. The company liked the idea very much. Bottema has since graduated and now works as a research and development project leader at Vesterdgaard Frandsen.

Saving

Once the Lifestraw receives the required safety certification, it will be marketed. "If charities decide to give away the product for free in large quantities, the users would not have to pay anything," Bottema says. "Another scenario is where some people would have to pay only part of the selling price, and the charities would pay the remainder. I am not allowed to say whether the market price is one dollar or not, but we are trying our best to keep the price as low as possible." One thing that Bottema noticed is that people are prepared to save up for the tube. "Nobody will pay as gladly for clean drinking water as the very poorest."

For the time being the Lifestraw will be produced in Asia. Bottema: "Africa simply does not have the know-how yet. And, Asia is cheaper because African countries often levy high taxes on each other's imports." ▸▸

Photo: Imke Schepers

Seventy ice creams a day

In Accra, the capital of Ghana, three disabled street vendors ply their trade from a hand-driven bicycle. Four students at the Industrial Design faculty developed the bicycle in situ for the Movendi Foundation, an organisation dedicated to helping the disabled in developing countries. In Ghana the disabled are often reduced to begging because they are unable to get a job.
In a workshop the students together with local labourers built a prototype of the bicycle. Local production is not only important for economic reasons, according to industrial design student Sietse Cieraad. "Many of the wheelchairs sent from Europe to Ghana do not reach the right people, and when they do, there is nobody to repair them when they break down. Our bicycle can be repaired using local components, and it is rugged enough to be used on their bad roads."
The production cost alone of the bicycle is 170 dollars, which is a major investment for the disabled. Fortunately, Danish dairy company Fanmilk ordered three bicycles to be fitted with coolers. These will enable three disabled people to make a living selling ice creams. Cieraad: "Thanks to the bicycle, one of them is now selling seventy ice-creams a day, as much as the able-bodied Fanmilk vendors." The Danish dairy, which is also present in West Africa, is considering expanding its operation. "Cambodia is another place where the bicycle could be a success," says industrial design student Imke Schepers.

Africa is not the easiest continent in which to turn a bottom-of-the-pyramid project into a success. Graduation assignments in design engineering often take place in Asia or South America. Supervisor Jan Carel Diehl MSc.: "In Africa you find multinationals and small companies. There is no intermediate layer to provide innovation. Africa does not have the entrepreneurial spirit you find in China and India, and at the universities there is a wide gap between science and practical applications. I know an African professor who gained a Ph.D. for his work on complex computer calculations, but knowledge like that is still far from relevant in Africa."

Algae soup

Bioprocess technology lecturer Dr. Wouter van Winden (Applied Physics) and his friend from his

Photo: Imke Schepers

Photo: Sam Rentmeester/FMAX

Spectacular spectacles

This is the kind of project that African can only dream of for the time being. Next year a thousand myopic children in India will all be fitted with identical spectacles. Price: one dollar each. The strength of the Focusspec can easily be adjusted from minus one to minus six. Eventually millions of school children are to receive a pair of glasses like these.

Frederik van Asbeck MSc. is an industrial designer who has been working on this concept for three years. The idea of spectacles in which the user can adjust the strength by sliding two lenses of different thickness across each other dates from the nineteen-sixties. When, decades later, production techniques had become accurate enough to make production possible, the concept was brought back to life.

Van Asbeck is being supported by his present employer, OTB of Eindhoven, who specialise in production techniques. "They really want to produce these glasses, and they don't need to make any money on them."

The Focusspecs could also come in handy for manual labourers such as cobblers and tailors. Van Asbeck: "On a worldwide scale, there are six million blind people who might still have had their vision if they had been given glasses in time."

The project could generate worthwhile spin-off, a cheaper way of manufacturing spectacle lenses that could also be used for more expensive glasses. To Asbeck the most important thing is that the glasses can be distributed in India, with other developing countries to follow.

student days at Wageningen University, Bram van Beek, are working closely together with the Eduardo Mondlane University of Maputo, Mozambique. In the Zambezi delta they have set up an eye-catching test plant, consisting of a large pond in which an algae soup is being formed. Van Winden's mission is to find out if and how these algae can be used to produce biodiesel fuel. The current source of biofuel usually consists of such crops as rape and oil palms, but these take up a lot of space which could otherwise be left to forests or agriculture.

When Van Winden established contact with people in Mozambique, the university welcomed the plan. "We were lucky, as they were just about to set up a subsidiary in the delta, which lies more than a thousand kilometres north of Maputo. Their support was important, since it elevated the project above the level of an idea imported by westerners."

Finding the right kind of algae is tricky. "Just like a garden will have its weeds, among the algae you will soon find types you don't want. If you want to keep the process profitable, you will have to create a stable algae culture that produces lots of oil." In the basins constructed so far – the largest of which measures a thousand square metres – the water is continuously kept in motion. "That is how you make the best algae soup."

'Africa does not have the entrepreneurial spirit you find in China and India, and at the universities there is a wide gap between science and practical applications.'

As soon as the ideal algae composition is reached in the basin, the research becomes less complicated. "Once you have the right algae, all you have to do is collect them from the water, dry them, and then press them to extract the oil. Next to the basin we have constructed a container in which the extraction can take place on a laboratory scale. It is not a high-tech process, but who needs that in Mozambique?"

Van Winden estimates that a car can run about fifty to one hundred kilometres on the daily production of the largest test basin. "The Zambezi delta covers thousands of square kilometres that could be used to construct larger basins." When the researchers reach the end of their funding this December, the basins and equipment will be handed over to the university. The contact with TU Delft will be maintained, and TU Delft students will be sent out to serve internships in Mozambique. Van Winden: "We have to make sure the project doesn't grind to a halt. Mozambique is one of the poorest countries in the world. If the plant were to become disused, people would start taking parts home with them, where the short-term benefits would be greater."

Van Winden has not yet read Prahalad's book. "When we started the project, we did know about the three Ps that form the basis of sustainable development: People, Planet, and Profit. ▸▸

The children's version of the LifeStraw.

Photo: Martijn Nitzsche

Solar waterworks

"You can keep pumping as much money into developing countries as you like, but the billions of foreign aid spent over the past decades have not managed to bridge the gulf between rich and poor. A better strategy is to enable people to establish their own business." Entrepreneur and mining engineer Martijn Nitzsche knows what he is talking about, since his Water Pyramid tested successfully in The Gambia and is now being introduced in Ghana, Indonesia, and Bangladesh. The Water Pyramids are solar-powered waterworks, and have proved capable of supporting local jobs.

Nitzsche invented the Water Pyramid in response to a problem that threatens so many developing countries, the lack of clean drinking water.

"During the wet season, the water pyramid can collect large quantities of water. During the dry season, it can also use solar distillation to extract pure water from brackish or salt water. Inside the pyramid salt water evaporates as it gets heated by the sun. The water condenses against the inside of a tent made from special materials, and then runs down the material into a trough that collects the distillate in a tank. In the tank the 100 percent pure water can either be remineralised for use as drinking water, or it can be used as distilled water for medical or industrial applications."

Nitzsche found out that it is not the technology itself, but the involvement of the local population that is crucial to making the water pyramid projects work. The one thousand people living in the Gambian village of Mandianri can become local entrepreneurs, selling the water in different guises as juices, bags of water, or cooled water. The employees of the water pyramid get their pay from the water sales. Nitzsche: "It is in the employees' own interest to make sure the Water Pyramid is kept in good order. The local people understand why the water does not come free, since they can see that one of their own needs to be paid for standing out in the sun to bottle safe drinking water." Nitzsche sees local entrepreneurship as the best way to prevent projects from failing after a while.

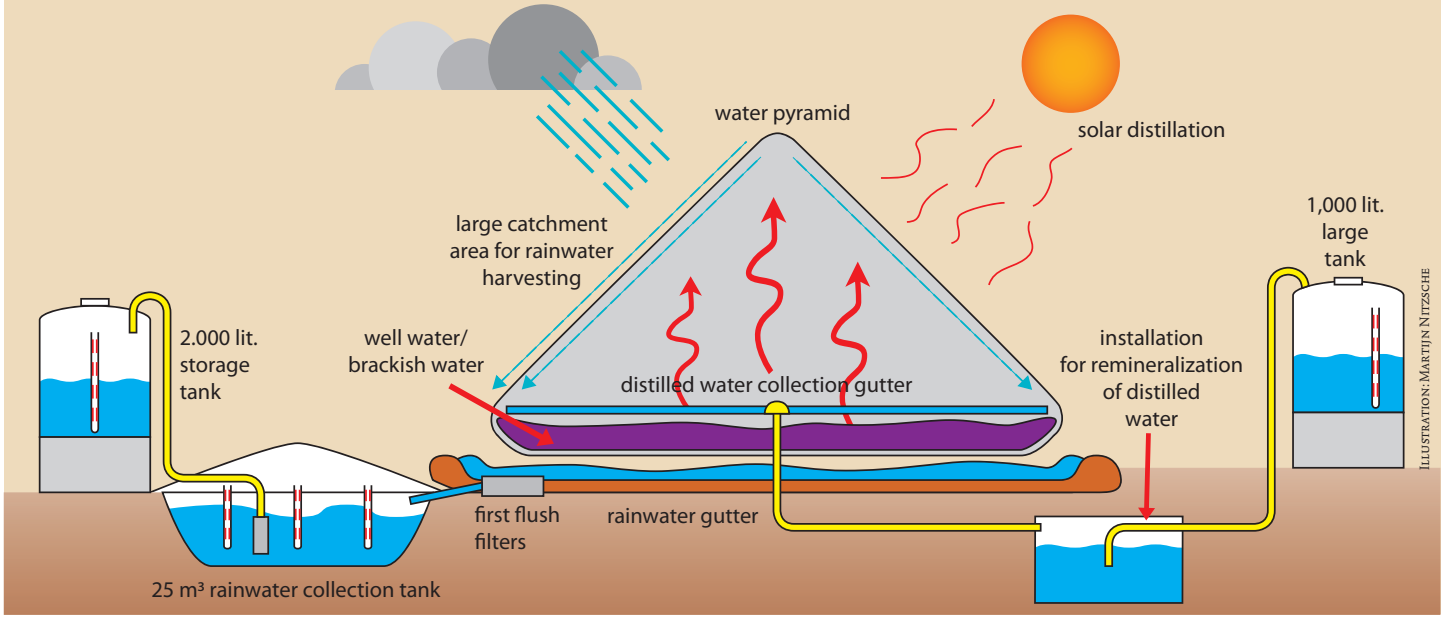


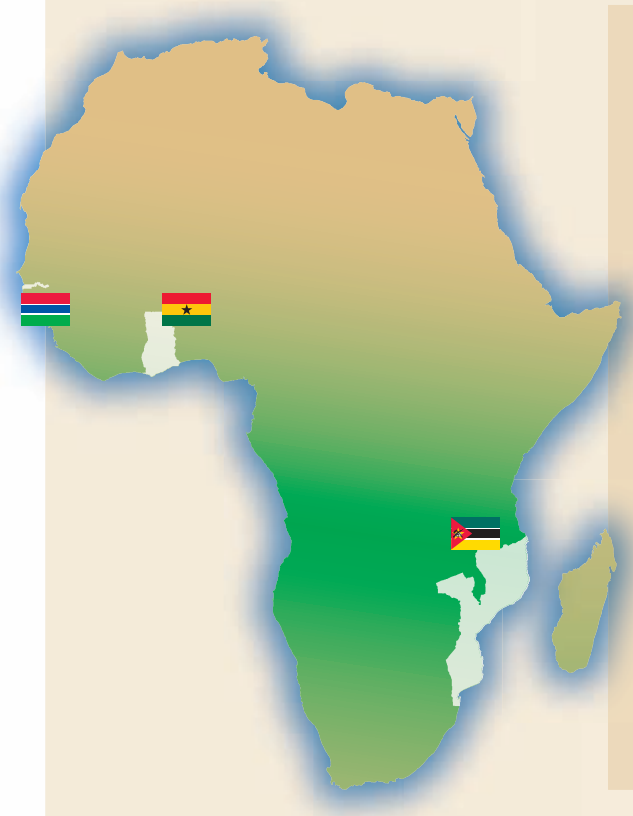
Illustration: Martijn Nitzsche

This is where you can see the parallels with Prahalad's idea: a project that does not generate a profit in the long term will never succeed and can therefore not be sustainable. As far as we are concerned, biodiesel fuel could just as well be produced by a western company in Mozambique, as long as it brings local jobs, tax revenues, and export currency to the Mozambique economy."
For Kandachar and his students, 'THE FORTUNE AT THE BOTTOM OF THE PYRAMID' has opened new doors, but this does not mean that he accepts the concept at face value. "I am a scientist. It takes proof to convince me, not ideas."
As the editor of a publication dealing with the base-of-the-pyramid philosophy, to be published next year, Kandachar comes up with a number of awkward questions. Should companies be allowed to expose people with hardly any income at all to intensive marketing and advertising campaigns? Should traditional countries dispense with their old strategies for foreign aid altogether? "I don't have the answers to all these questions," Kandachar says, "but I don't think the TU Delft should suspend such projects until every question has been answered. People need our help now. Academic discussions are the least of their interests." ◂◂

'Nobody will pay as gladly for clean drinking water as the very poorest'

PHOTO: SAM RENTMEESTER/FMAX

Prabhu Kandachar:
"Many companies are searching for new markets and want to conduct socially responsible business."



Africa

Surface area: approximately 30 million km² (approximately 20 percent of the earth's total surface area)
Population: circa 887 million (14 percent of the global population)
Illiteracy rate: 40 percent
GDP per inhabitant: 1,968 U.S. dollars per year
Percentage of people who must live on less than $1 per day: 36 percent
Economic growth: 5 percent
Division of labour per sector: agriculture (60 percent), industry (15 percent) services (25 percent)
Most important minerals: oil, gold, copper, diamonds

Gambia

Surface area: 10,000 km²
Population: 1.5 million
Gross Domestic Product (GDP), adjusted for purchasing power: 3 billion (2005)
GDP per inhabitant: 1,900 U.S. dollars
Percentage of people who must live on less than $1 per day: 59 percent
Percentage of people who live under the national poverty line: 64 percent
Life expectancy: 54 years

Ghana

Surface area: 230,940 km²
Population: 22.4 million
Gross Domestic Product (GDP), adjusted for purchasing power: 54.9 billion
GDP per inhabitant: 2,500 U.S. dollars
Percentage of people who must live on less than $1 per day: 45 percent
Percentage of people who live under the national poverty line: 40 percent
Life expectancy: 59 years

Mozambique

Surface area: 784,090 km²
Population: 19.7 million
Gross Domestic Product (GDP), adjusted for purchasing power: 26.2 billion (2005)
GDP per inhabitant: 1,300 U.S. dollars
Percentage of people who must live on less than $1 per day: 38 percent
Percentage of people who live under the national poverty line: 70 percent
Life expectancy: 39 years

Next year will be the 165th anniversary of TU Delft. The theme of the festivities is sustainable development, with a strong emphasis on Africa. "Over the next three or four decades something will have to be done to solve Africa's problems with energy, food, environmental issues, public health, and drinking water. Solving these problems requires technological breakthroughs, which is our task as a university," says Prof. Dr. Ben Droste, dean of the faculty of aerospace technology, and president of the anniversary committee. "Africa often gets mentioned in a negative context, but it offers enormous potential for the future."

ILLUSTRATION: TYGRON

Players of the game 'Simport' can reorganise the Second Maas Area.

Games for science

Higher education is cautiously exploring a new educational tool: computer games. Educational computer games were recently the focus of a symposium held in Delft. Will we soon be giving and following courses, lectures and trainings in a virtual 3D world, instead of in lecture halls?

TOMAS VAN DIJK AND MAARTEN KEULEMANS

The Second Maas Area in the year 2036. Viewed from above, the harbour consists of flat, right-angled plots of land. We swoop down. Container terminals appear. The outlines of a shrimp factory, a nursing home and a power plant are visible in the distance. "We'll reach the breakeven point around the year 2040," predicts Erik van de Luytgaarden (23), who, the scoreboard reveals, is still deep in the red. As part of his Master's degree course *engineering and policy analysis*, Van de Luytgaarden and his five teammates used the 'SimPort' computer game to design the future harbour area in just one day.

Serious game is the name for such games, and they aren't meant to be played for fun, but rather for educational purposes, for supporting policy initiatives or training professionals. Researchers at the Faculty of Technology, Policy and Management (TPM) were hired by the Port of Rotterdam and gaming company Tygron to create the game 'Simport'. 'Simport' reveals the results of various long-term organisational strategies.

"There are various strategies," explains game instructor Geertje Bekebrede. "Players can immediately start building and raise money among previous clients, or they can wait for lucrative offers. At the same time, you must plan for the unexpected, like the economy collapsing." He laughs: "This year, we've also added Colombian drug barons as clients. They pay really well, but the question is: do you really want to have them on your premises?"

"Games for higher education and for training professionals are hot," says Dr. Igor Mayer, a university instructor in public administration and the director of the *Center for Process Management and Simulation*. For past few years he has supervised the harbour game 'Simport'. "These games fit in nicely with the experiences of young people who grow up playing *fun games*, like 'WORLD OF WARCRAFT' or 'SECOND LIFE'." These are the so-called MMORPG-games: *Massive multi-user online role-playing games*, which millions of players can play simultaneously. Mayer believes that it is only a matter of time until the lecture halls are filled with the 'games generation', who want game-based learning.

Lifelike

Game-based learning is as least as old as the road to Rome. Ages ago Chinese warlords played out games with full battlefields, in order to devise victorious strategies before blood was spilled in the real battle. More recent examples that come to mind are the disaster-trainings that use 'real' actors; the courses in which participants play roles to learn how to deal with aggression; or even the notorious

Life 2.0

You can walk around, talk, move into a house, trade, work, shop – and now even attend law lectures at Harvard University. The population of the virtual world 'Second Life' is exploding: this 3D Internet world's population has increased fourteen-fold in the past six months, from 150,000 to 1.5 million residents.

"Reuters Press Agency now has a journalist permanently residing there, and many large companies use this medium as a portal for demonstrations and transactions," says Tom van der Maas, director of EPN: Platform for the Information Society. "Second Life is increasingly being regarded as a new, extremely user-friendly interface, in which you can do all kinds of things collectively."

University instructor Dr. Igor Mayer also expects Internet games to continue acquiring more serious applications. Thus, 'Second Life' now has at its disposal 'Edunation', a virtual island where the educational possibilities of 3D role-playing are demonstrated. "This will absolutely be big. It is in varying degrees a mixed reality-like environment, in which you can increasingly do more with combinations of gaming, chatting, video, audio, PowerPoint and other features."

prison experiments that psychologist Philip Zimbardo conducted in the basement of Stanford University in the summer of 1971. Viewed in this light, computer games are hardly unexpected. Until recently, the flight simulator had been the most important contribution thus far, but thanks to the games industry, people now have access to increasingly finer designed, visually lifelike educational games. And not only are games becoming less expensive, but they keep getting better at impacting situations like dikes breaking, evacuation methods or complex public administration issues.

Mayer has no doubt that in future *serious games* will have an even greater impact on higher education. But he does not believe that they will render books and teachers obsolete, as some game gurus predict. Mayer: "According to the renowned American game-based learning expert Marc Prensky, the young people of today only play games, and therefore you can no longer send them home with armfuls of books. But I doubt this, as well as his assertion that instructors barely have a role left to play." Meyer has worked on the two-year Surf-project Kodos (Knowledge development about and through online simulations). Together with his colleagues from Erasmus University Rotterdam, the University of Leiden and the Hogeschool Rotterdam, he studied the ways in which online game simulations can benefit higher education. The project was recently completed with a symposium in Delft: 'Game-based Learning in Virtual Worlds'.

Combining the real and the virtual is of course also possible. Take the game 'Sieberdam', for instance. The name stands for a virtual city that needs to be reorganised. The game is played partly via Internet and partly face-to-face. At TU Delft's TPM Faculty, game-based education is used to teach second-year students about the ins and outs of 'decision-making, management tools and the law'. After first becoming engrossed in the various games on the computer, the students then play out the various 'Sieberdam' management issues in a seven-week long role-playing exercise. "It's better to simulate the decision-making processes face-to-face," says Dr. Joop Koppenjan, who supervises the students.

Computer games are exceptionally good at simulating urban planning problems, according to TU Delft building information specialist Dr. Peter Paul van Loon. He created the game 'URBAN DESIGN & DECISION ROOM', in which students play the roles of project developers, taxpayers, urban planning experts and property owners.

Van Loon has no doubts about the importance of instructors. "My games are primarily meant to discover the complexities of urban planning design issues. An instructor is always needed for checking the hypotheses and directing the students toward achievable design solutions."

Van Loon does believe however that universities should devote more attention to serious games. "At home, students play games that are – at least in terms of appearance - much more advanced. They are a bit spoiled. Higher education institutions like TU Delft must find the right balance between fun games and serious games."

More information: Igor Mayer, tel. (015)2787185, i.s.mayer@tudelft.nl; Peter Paul van Loon, tel. (015)2784084, p.p.j.vanloon@tudelft.nl

ILLUSTRATION: CASPER HARTEVELD

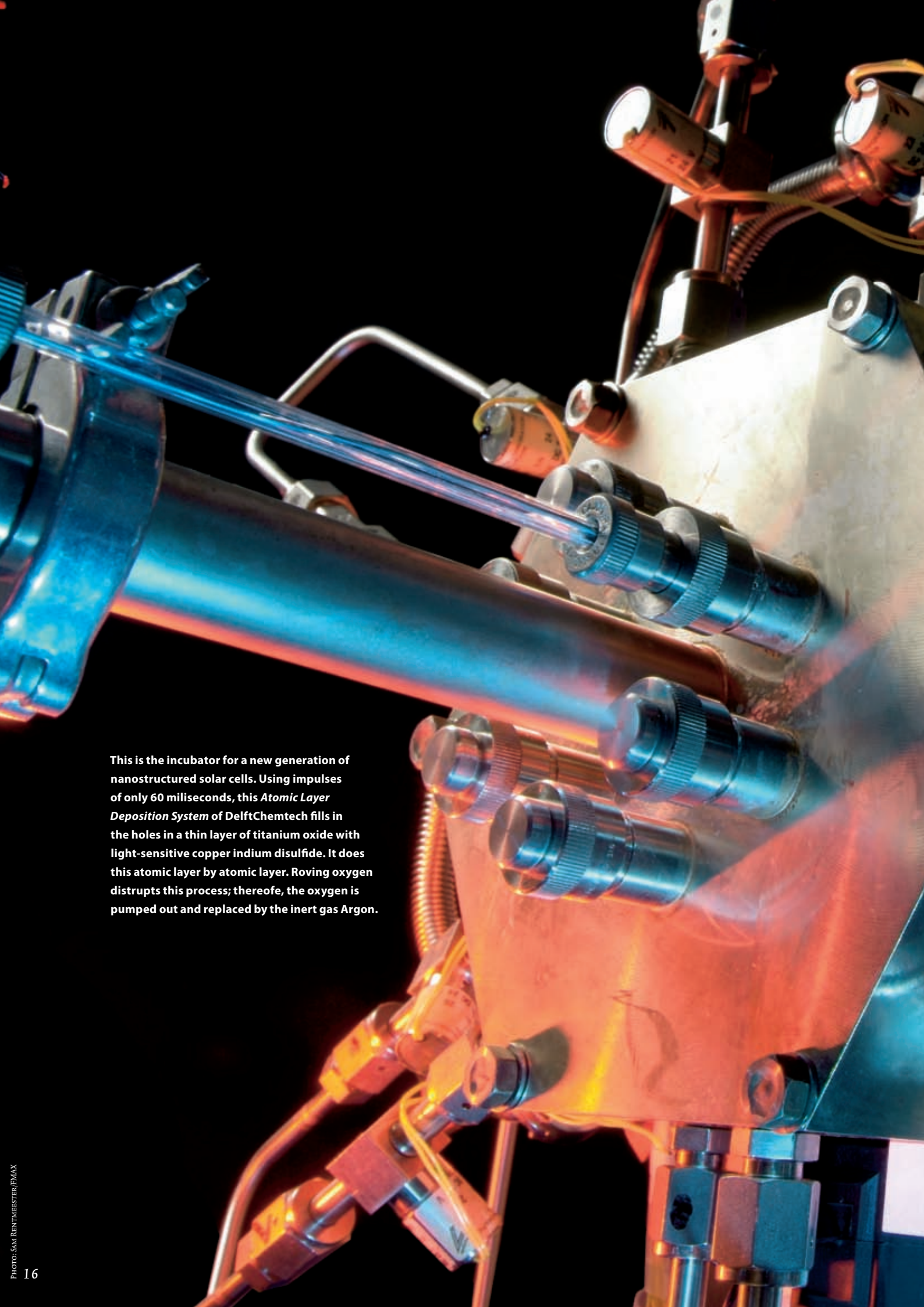
Dikes are breached in the serious game, 'Dijkpatrouille' (Dike Patrol), which was developed by TPM Faculty student Casper Harteveld during is internship at GeoDelft.

Serious sailing is also fun

A serious game can be really fun. Last summer the Rotterdam-based company, Vstep, introduced 'Ship Simulator' onto the market. It was meant to be a serious game for professional shipmasters, but the game was so attractive that many gamers began sailing through the Rotterdam harbour for the fun of it.

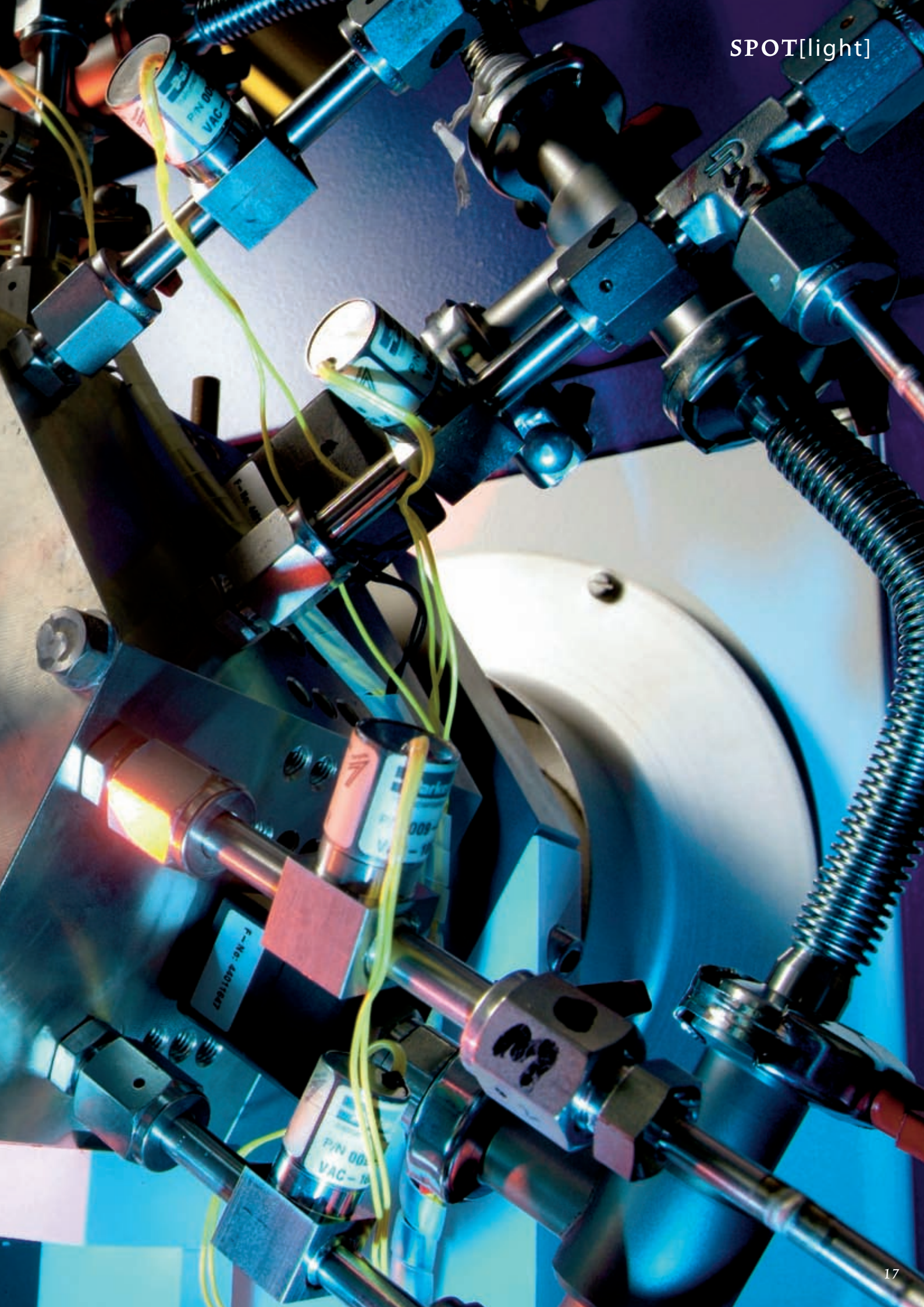
"And actually the game wasn't intended for this," says mathematician Dr. Kees Vuik (numerical analysis, EEMCS Faculty). "If, for example, you crash your ship into the harbour wall, the ship stays intact." Vuik and Vstep have since discussed the possibility of employing student interns to work on making the game more realistic. Vstep wants to add more variables to the game, such as tides, wind, waves and various ship names. "For us, that's an interesting challenge. We have lots of experience with simulations, but what's nice about such a game is that calculations must be made within milliseconds," Vuik says.

Additional benefits: games are alluring for students, and they can be useful in conducting scientific research. "We also possess a lot of knowledge about shipbuilding at TU Delft. So you can imagine that they are also extremely interested in tapping into that."



This is the incubator for a new generation of nanostructured solar cells. Using impulses of only 60 miliseconds, this *Atomic Layer Deposition System* of DelftChemtech fills in the holes in a thin layer of titanium oxide with light-sensitive copper indium disulfide. It does this atomic layer by atomic layer. Roving oxygen distrupts this process; thereofe, the oxygen is pumped out and replaced by the inert gas Argon.

Photo: Sam Rentmeester/FMAX



If the sea were to flood the southern parts of the agglomeration that covers most of the western part of the Netherlands, the death toll would be in the thousands, as predicted by a calculation method developed at Delft University of Technology (TU Delft). Evacuation would save precious few lives. So how can a disaster of this magnitude be averted?

Maaike Muller

Living on the edge

Evacuation is not an option

There is a fierce northwester blowing. The sea defences near The Hague and more to the south give way, and the sea water comes rushing in to flood the low-lying land behind. Swimming certificates won't do you any good. Cars will be floating about, and even entire houses will be washed away. Thousands of people will drown.
More precisely, if such a scenario were to become reality, the calculation method developed by doctoral student Bas Jonkman predicts a number of more than four thousand casualties. Jonkman's method for estimating the number of victims of a major flood mercilessly demonstrates that should such a flood occur, evacuation will save no more than six hundred lives. "A North Sea gale can be predicted one day or perhaps two days in advance," Jonkman explains. "Before the evacuation can start, the authorities have to convene, and everybody will have to be alerted. The population will then have to gather their belongings, collect grandma, and look for the cat. It will all take quite a bit of time." And once all the people have bundled themselves into their cars, the traffic will be gridlocked. "If the seawalls break at that point, we'll all be in deep trouble."

'A North Sea gale can be predicted one day or perhaps two days in advance'

Until recently, rules of thumb were being used to estimate the possible number of victims. Jonkman's casualty model is more accurate. It consists of a number of modules, including a model that simulates the evacuation and determines how many people will be left behind in the area when the sea rushes in. How many of those people will die depends on the speed with which the water comes in, the rate at which it rises, and the depth it finally reaches.
In order to predict all this, Jonkman used a model developed by TU Delft and the WL Delft Hydraulics research institute. "Other factors will also contribute, for example the construction quality of houses, but we can't include them, because there is simply too little information available."

The flood of '53

Jonkman combined the models to simulate the evacuation and the progress of the flood. Most of the time devoted to his work for his doctorate, which he hopes to complete soon, was spent on making the casualty functions, however. 'If the water ends up being four metres deep, 20 percent of the people in the area will not survive' is an example of such a function which calculates the number of victims using the model data.
Jonkman based his casualty functions on data from the 1953 flood, when 1,836 people lost their lives as large parts of the south western isles were inundated. He searched through commemorative publications, combined lists of inhabitants, traced water depths. He also used data from the flooding of England's east coast in 1953 and the flood in Japan in 1959. The information is slightly dated, but then catastrophic floods for which useful data still exist don't happen all that often. Until August 2005 that is, when hurricane Katrina breached the levees around New Orleans.
The world was suddenly confronted with the terrible effect of such a flood. As was Jonkman. On the other hand, he was able to use the event to test whether his model produced realistic results. He travelled to New Orleans and together with a fellow researcher from the LSU Hurricane Center in Baton Rouge collected the data he needed (see text box).
As was only to be expected in the chaos of a flooded city, it was not a question of simply asking for information which would then be provided in nicely laid out tabular format. The figures describing the event and its aftermath had to be reconstructed bit by bit. For example, the velocity of the water as it poured into New Orleans was never measured, but it does have a major impact on the ▸▸

AFP PHOTO/POOL/JEAN SNIDER

Some major flood disasters

	Cause	Casualties	Affected persons
1 February 1953 **Netherlands,** SW	Gale	1836	250,000
1 February 1953 **UK,** East Coast	Gale	304	32,000
26 September 1959 **Japan,** Ise Bay	Typhoon	5101	430,000
29 August 2005 **USA,** New Orleans	Hurricane	1100 *(current count)*	410,000

SOURCE: JONKMAN

chances of survival of the city's population. A computer simulation was used to calculate the information after the fact, and the LSU Hurricane Center used satellite pictures to determine the depth of the water throughout the city. The model used these depths to arrive at an estimate of two thousand victims. "That figure is of the same order of magnitude as the 1100 bodies recovered so far." Although his method calculated almost twice as many casualties as occurred in reality, Jonkman is satisfied, because his system came a lot closer than others, for example an American firm of consultants that came up with a death toll of 60,000.

Acceptable risk

Jonkman's calculations arrived at just the right moment. The Dutch Ministry of Transport, Public Works, and Water Management intends to revise its current assessment of flood prevention standards. These standards, which were defined in the 1950's, determine the acceptable risk of an inundation (see text box). The envisaged approach will look at inundation risks by including not just the probability of such an event, but also the effects, economic damage, and number of victims. The insight into the number of victims and the effect of evacuation on the casualty number provided by the method fits in well with the discussion about the acceptable risk of inundation and what to do to reduce the probability or minimise the effects.

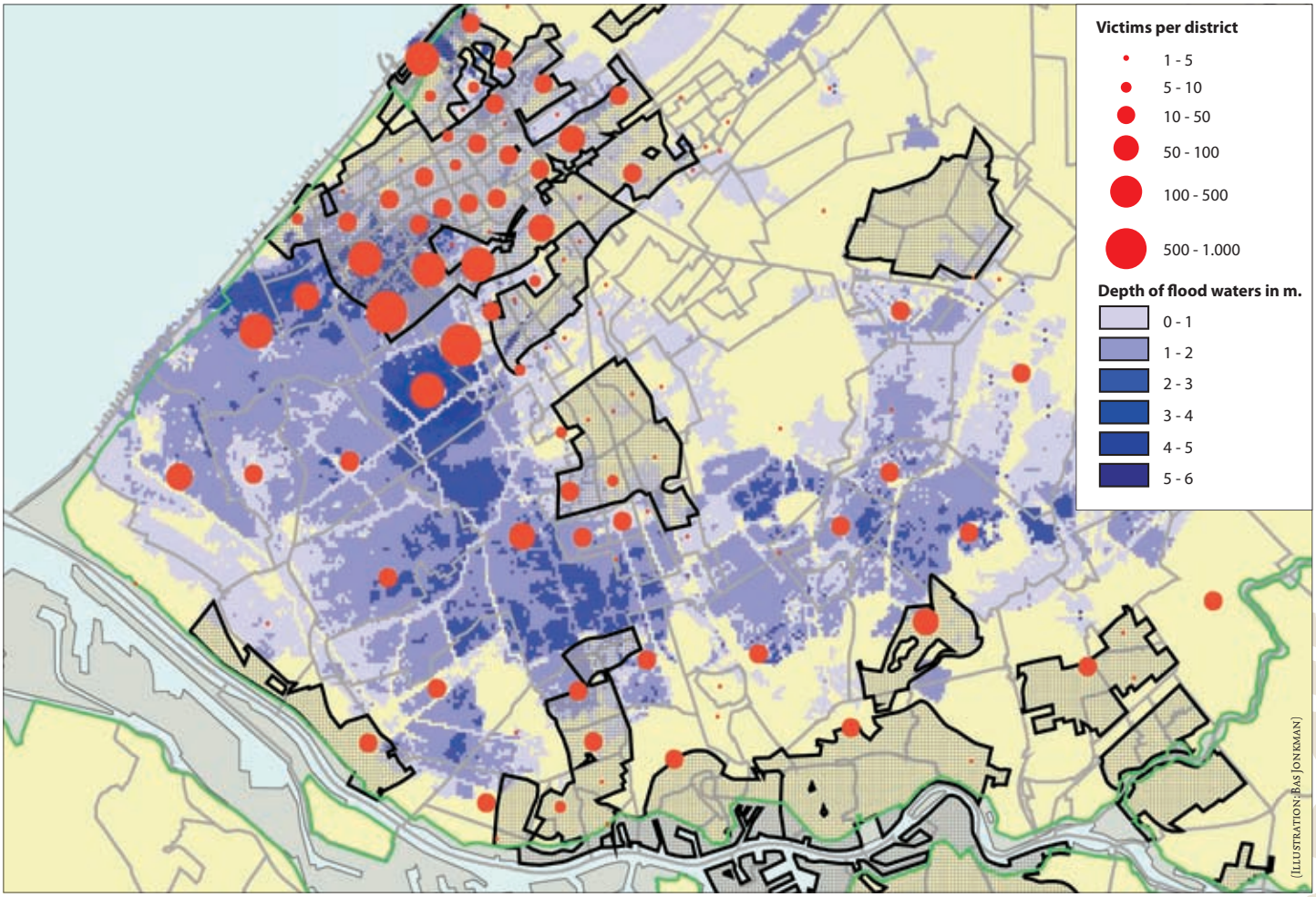
"The current vogue is to look at measures to minimise the effects. After New Orleans the Dutch government immediately called for contingency planning," Jonkman says. Dr. Ben Ale, professor of safety and contingency planning, agrees with this development: "The powers that be tend to think too lightly about evacuation. Jonkman's casualty model, and in particular the graphics that accompany it, make you realise that you can just forget about moving a couple of million people before the water arrives. Evacuation simply is not an option."

According to the model, evacuation may save many lives in low-lying areas alongside the Dutch rivers, where

Cover: Ezra Boyd, data: Hampton Peele, Rob Cunningham, DeWitt Braud, G. Paul Kemp

Collection data in New Orleans

Six months after disaster struck in New Orleans, Bas Jonkman travelled to the stricken city to collect data he could use to test his model, which calculates the number of victims after a flood. "Whole sections of the town have been devastated. There is still no drinking water, no power. People may be glad to be alive, but they have lost everything they owned," says Jonkman. He collected the data on the victims themselves from the mortuary. Even in the streets, there were signs pointing to the many people who perished. "Every house was marked with a cross to indicate that it had been searched, and a number indicating the number of dead that had been found there. Conducting casualty research is all very fine, but at times like that you suddenly realise what it is all about."



If the seawalls at Den Haag and Ter Heijde are breached, the resulting floods would claim approximately 4,000 lives. And another 700,000 residents of South Holland would be directly affected by the floodwaters if they were not evacuated. These predictions are based on a calculation method devised by Bas Jonkman. His method also reveals the areas where the most casualties would occur.

advance warnings will come earlier and the population is fewer in number. In a densely-populated area close to the sea however, contingency plans can do little to prevent a mounting death toll. That is not to say that the call for contingency planning is misguided in these areas. "Once the water comes pouring in, there will be millions of people standing all along the dykes. Whatever the case, it makes sense to think about what to do with all those people," says Professor Ale. He and Jonkman agree that there are better ways to prevent large numbers of casualties than evacuation, such as improving the seawall to reduce the risk of flooding.

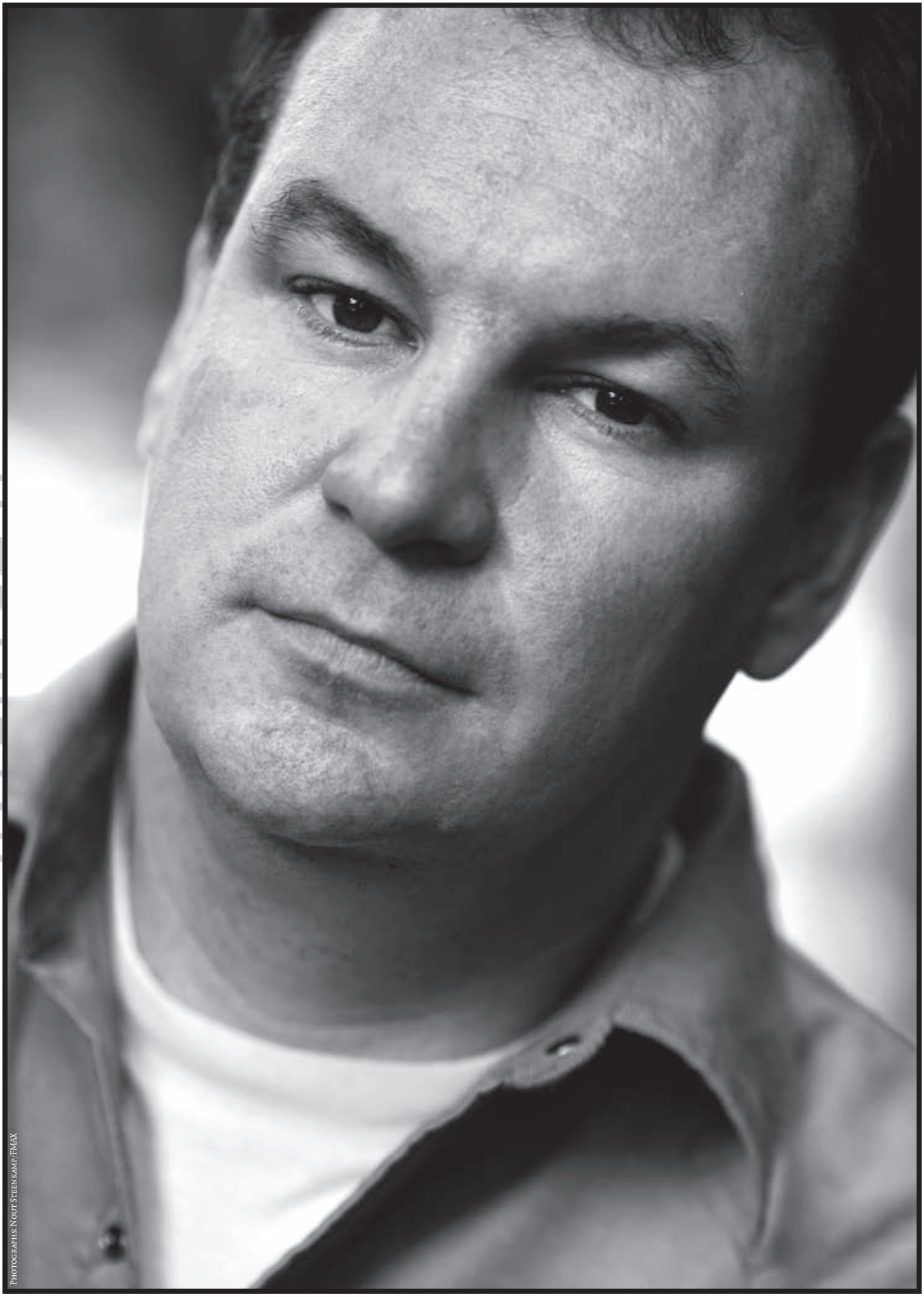
The problem is, what is an acceptable risk for a flood claiming thousands of victims? Politicians will weigh safety against other factors, such as the cost involved in securing the additional safety. Plans for new housing construction in deep-lying areas show that the weighing of pros and cons does not always result in better safety. In Gouda, a shortage of housing has resulted in plans to build new houses to the west of the city. "In this case, it was decided to accept the risk and to ensure that the land remains dry. This is a political balancing act, but it cannot be avoided, Ale says. "On the other hand, if you accept the idea that sea levels are rising, it may not be the wisest option. But then, you could also adopt a don't care attitude and sit back to wait for the inevitable to happen. As long as it doesn't happen while you're at the helm, you won't have a problem. And the chances that it will are not all that great."

The Netherlands was never as safe before?

The government is ignoring its own safety standards. It turns out that 24 percent of our dikes do not meet the statutory safety limit, while the status of another 32 percent is unknown. These are the results of a survey of the country's primary flood defences. "The survey is like an MOT test for dikes and dunes, and at this moment they simply do not pass," says Dr. Ir. Marcel Stive, professor of coastal engineering. He is exceedingly annoyed by the Ministry's assertion that the Netherlands is safer now than it has ever been before.

Granted, the risk to any individual being killed by a flood is less than that of dying from a bee sting, but the group risk, i.e. the probability of a large number of people being killed by a single flood event, is considerable. In fact RIVM, the Dutch Government Institute for Public Health and the Environment, has calculated that the flood risk exceeds all other external risks put together, such as chemical plant accidents and other manmade risks.

More information: Ir. Bas Jonkman, S.N.Jonkman@tudelft.nl; Professor Dr. Ben Ale, B.J.M.Ale@tudelft.nl; Professor Dr. Ir. Marcel Stive, M.J.F.Stive@tudelft.nl.



Photographs: Nout Steenkamp/FMAX

Delft futures researcher Dr. Patrick van der Duin

Delft futures researcher Dr. Patrick van der Duin subscribes to the unusual point of view that futures research should become a basic business skill and that it should be part of the educational curriculum, preferably replacing history. Together with TNO colleague Hans Stavleu he has written 'De toekomst in een notendop' (The future in a nutshell), which reads like a crash course in futures research. "The future is not necessarily dark and unknown. It is not something that just happens to us."

Maarten Keulemans

The man of the future

Imagine the world thirty years from now. You're walking along a street. What would you see around you?

"The trend is for technological changes to be increasingly less obvious. So if you were to ask what you would notice about the view on the street, the answer would be, not very much. The changes would all be there, but they would be hidden under the bonnet and in the surroundings. ICT will be an invisible technology. There will still be shops, but their function will have changed. They will be more like social meeting places, a place where people will be doing things rather than exchanging goods over a counter."

In your book you write that the essence of futures research is not so much the extrapolation of trends into the future as it is pinpointing things that will be different in the future. Which of these developments will really surprise us?

"I'm fascinated by social empowerment, the phenomenon which has finally happened thanks to the dissemination of information. The average Joe knowing what the world is about. Politicians are being bombarded with e-mail messages, civil servants are being chastised by citizens who are better informed than they are, and GPs are complaining about smart patients. The change has been a long time in the making, but the next few years will really see it take off. Call it a kind of reverse chain effect. We still hark back to a culture in which the tribal elders were always right. We're on the verge of a transformation, from travel agents becoming superfluous to solicitors coming under pressure. The interesting thing is that changes like these used to happen only very gradually. Nowadays we have more of a staccato effect. So another occurrence we will be seeing more often is that things can happen pretty quickly."

You prefer not to be called a futurologist.

"Futurologist is a rather old-fashioned word dating back to the 1950's and 60's; a person predicting what technology will be like in the long term. A good futurologist can be great fun, a source of inspiration. I'm a bit more down-to-earth. I try to look at the wider picture, and in the shorter term, 10 to 15 years, rather than stating that we will have a colony on the moon 50 years from now. I get quite a few invitations to give talks. People want me to tell them about the future, look into my crystal ball and reveal what I see. I tend to steer away from occasions like that."

Your book reads like a cookery book on how to prepare a future scenario. Why write a book like this using plain language?

"We want to democratise and demystify futures research. Everyone thinks about the future, but when it comes down to it most people will say that the future can't be predicted anyway. That is a bit facile. We can do a lot more than that. We can explore, make scenarios, extrapolate, fantasise. The future is not necessarily dark and unknown. Of course you can't shape the whole future; things never go exactly the way you want them to. On the other hand, the future is not something that just happens to us. It is not something we have no control over whatsoever. The future does offer several degrees of freedom."

And so you propose to "make the future part of the curriculum in schools, organisations, and society in general". Isn't that overdoing it a bit?

"No. In our opinion futures research should not just be the domain of a handful of experts. Students will eventually be taking up responsible positions. They are the ones who have to make sure the organisations they work for will still be there in the future. They will have to be able to think ahead. We get taught all kinds of things about innovation, management, you name it. But strategic thinking about the future is something we don't learn. We have history in our curriculum, but not the future."

It's easy to reproach this by saying that futures research is not a science. After all, you cannot validate your claims.

"True, the future does not exist. The future isn't something you can drop on your foot. Even so, there is no reason why that should hinder research. Science is also a process that has to satisfy certain requirements. It should be transparent, independent, verifiable. On those grounds alone, futures research is a true science. I can use scientific methods to investigate how people consider the future, using questionnaires, surveys, and scenario studies. If a meteorologist says that tomorrow it will rain, that assertion is impossible to validate immediately. It doesn't follow that meteorology is not a science."

Even so, you write: "Many fellow scientists still consider futures researchers to be mavericks or even renegades".

"There is something shady about the subject. The guru, the man who will tell us what ▸▸

Dr. Patrick van der Duin (1970) studied macro-economics at the University of Amsterdam and was a researcher at KPN Research before joining the TU Delft's Faculty of Technology, Policy, and Management in 2001 as a lecturer. Van der Duin has written various reports and books, including 'Qualitative futures research for innovation', a manual (2006).

INTERVIEW

'A good futurologist can be great fun, a source of inspiration. I am a bit more down-to-earth.'

the future has in store for us. Another problem is that many businesses tend to go for short-term planning only, and see long-term planning as an impractical waste of time. Speculations and scenarios are all very well, but we have different things to worry about today. Future research is the first to fall by the wayside."

Perhaps this is partly because the differences between the prognoses can be somewhat bizarre. Futurologist Ian Pearson of British Telecom expects us to become immortal by 2050, because we will be able to upload our minds to a computer. On the other hand, British astronomer Sir Martin Rees, in his book 'Our Final Hour', gives the human species a fifty percent chance of surviving the present century. One would say that only one of them can be right.

"Look, the point is that a discussion about whether in 50 years' time we will be immortal or swept off the face of the earth serves no purpose. It is not a discussion at all. This is where transparency comes in. Fine, so we have these great statements. Now let's do some backtracking and ask how come? On which facts do Rees and Pearson base their ideas? Under what circumstances exactly did they volunteer their statements?"
(After some deep thought): "I don't go along with Pearson. I think that people tend to be more wary of technology than he thinks. And whether the world as we know it will still be here in 50 years, well that's a tough one. But, I am a bit more optimistic."

Whatever the case, some predictions for the future made in the past have turned out to be way off course.

"That's right. Most predictions are disappointing because they fall short of the mark. However, the point is that such predictions will trigger certain developments. People set out to achieve something, but then they end up with something else. It takes vision to go places. Better to have the wrong vision than to have no vision at all."

So how can we assess predictions for the future?

"In our book we mention a couple of reasons why predictions fall short. Sometimes they turn out wrong because futures researchers say that some things will happen just because they are made possible by technology. But then the people may have other ideas. There is also the effect of the spirit of the times. Predictions will sometimes reveal more about the period during which they were made than about the period they deal

with. A prediction may also reflect a certain interest. Therefore the first thing you should ask yourself when reading a prediction is, who is predicting? Market research agencies are prone to this kind of error. They will go out and ask a manufacturer what will happen. Of course, this may give rise to an overly optimistic view. This is one of the messages our book tries to convey. Futures research should become much more transparent. Predictions are fine, but remember to show how you arrived at them. Many market research agencies fail to provide insight into these matters."

Some trends and visions from the future studies of the Future Scanning team of TNO Information and Communication technology:

- People will become more critical and self-confident. Ad-hoc collectives will emerge in which people will further their own interests.
- 'Lifelong learning' — Employees will continually educate themselves, while students will gain practical experience in addition to their theoretical work.
- There will be a shift from gaining factual knowledge to learning skills. The critical assessment of information in particular will become a skill that is in great demand.
- Rise of small-scale, decentralised power-generation systems. Neighbourhoods will unite as largely self-sufficient 'mini power stations'. Useful residual energy will be tapped from the human body.
- Sensor revolution: everything will be tagged with sensors acting as senses. Auto location of equipment, objects, and people will increase dramatically. Employers will know exactly where their employees are, and hauliers will know exactly where their vehicles are.

(Source: Van der Duin en Stavleu, 'The toekomst in een notendop')

Would you care to give an example?

"WAP (Wireless Application Protocol, internet for mobile telephones – ed.) is one of the things that went wrong. I have done research on the prognoses for WAP from the 1990's. They were very positive. But after the UMTS auctions, you could see the predictions being toned done. Now this wasn't because UMTS was regarded as competition, but mainly because the sellers realised that the market wasn't going to be as big as they thought. Together with a colleague from Delft, Dr. Roland Ortt, I'm setting up a research project entitled 'Modern Prophets', in which we will be looking at the way market research agencies make their predictions. We hope this will become a research project in the tradition of 'The Fortune Sellers' by William Sherdon, 'Megamistakes' by Steven Schnaars, or 'Megaprojects and Risk' by Bent Flyvbjerg. We are seeing the development of a great tradition in this type of critical evaluation literature."

'We are playing a technological game, but we don't really know the rules. There might well be something in store for use that would force us to pull the plug right now.'

A fairly popular prediction in futurology is that of the 'technological singularity', as described by artificial intelligence pioneer Ray Kurzweil, mathematician Vernor Vinge, and more recently, by Nobel Prize winner Gerard 't Hooft. According to this view, our computers will soon be self-aware, as a result of which mankind will no longer be the only intelligent species on the planet, nor the smartest. This would then result in a situation that is basically inconceivable to humans: technological singularity.

"I'm not very well versed in this field, but the concept reminds me of something I heard not so long ago, which is that the Greeks played with dice, but knew nothing about statistics. They didn't know when to bet money, they had no idea what the odds were. We may be seeing the same thing again. We are playing a game, but we don't really know the rules. We know what nanotechnology is and what the Internet does, but what it's all really about, what the ultimate effects will be, is extremely difficult to perceive. There might well be something in store for us that would force us to pull the plug right now. It would be totally bizarre, and we would have to learn how not to use some knowledge, simply because we cannot see its effects in the long run. One way to deal with this kind of thing might be something akin to an environmental impact study, so you would only be allowed to do this or that if you can prove its effect in other areas."

Are you saying that you are in favour of effect studies?

"Umm, well yes, in a way I am. It is a bit like the situation with nuclear warheads. Once you have them, you can use them. Terrorists can steal them, and countries like North Korea can stir up trouble. These are side-effects that most hard-working nuclear physicists don't like to think about too much. Doing so is considered slightly sissy-like, pious almost. It has to be done, though. On the other hand you should always remain receptive to the good things. There is no need to be technophobic about it. Otherwise you might as well go back to being a cave-dweller. Sometimes the discussion tends to go that way."

You are already working on your next book, a pamphlet against history. In your current book you also rage against what you describe as 'the history virus'. What is your problem?

"I get annoyed by the fact that we're occupied with history all the time. It really is amazing: history week this, history museums that, compulsory history in schools, and history programmes on television. There is nothing wrong with that in itself, but what annoys me is that it is being made into an instrument. History propagates, history repeats itself. I maintain that history teaches us very little. Ours is an incredibly dynamic era, and things are changing, whether you like it or not. This makes history an increasingly less useful guide to the future. I'm amazed at the ease with which concepts from the past are applied to future. I've noticed that we're always looking back. And meanwhile... Look, new diseases call for new medication."

More information: Dr. Patrick van der Duin, p.a.vanderduin@tudelft.nl, 015-278 1146. Patrick van der Duin and Hans Stavleu: 'De toekomst in een notendop' (Bert Bakker, 2006)

When study was drill

The Royal Academy (1842-1864)

The Royal Academy (1842-1864) was Delft's first step on the long road to what would eventually become Delft University of Technology. However, the Royal Academy was an educational institute based on weak foundations, which the government did not believe in, and which was perpetually struggling to survive. One false move, and Delft would never have had a technological university at all.

Henk Makkink

The main building of the Royal Academy at Oude Delft 95 in 1859. This building would later also serve as the main building of the Polytechnic School, and of the Polytechnic Institute into the 1950's. The building is currently being used by the International Institute for Hydraulic and Environmental Engineering (IHE). (Source: Municipal Archives, Delft)

Looking at Delft University of Technology today, it is hard to imagine that the initial stages of its existence hung by a thread. But that's the way it happened. The early precursor of TU Delft, the Royal Academy, was threatened with closure several times. There were plans to move its engineering courses to the academy of arts in Amsterdam, and to combine the Delft engineering school with the Royal Military Academy at Breda. And in order to make the young apprentices – who enrolled at ages varying from 15 to 23 years – toe the line, government circles regularly suggested that the students be interned at the Academy in military-style barracks.

In any case, establishing a dedicated educational institute to train civilians as engineers was not a priority of the Dutch government during the first half of the nineteenth century. Those who could not find a suitable place of training here were advised to look abroad, where the development of technology and rise of industry had resulted in the establishment of wide-ranging educational institutes dedicated to training engineers, as in Paris (1794), Prague (1806), Vienna (1815), and Berlin (1821).

Higher technical training facilities in the Netherlands in those days were a hotchpotch affair. At Delft the Artillery and Military Engineers School (1814-1828) at Oude Delft 95 did offer civil and maritime engineering training courses, but the school's main reason for existing at all were the officer training courses it also offered. Architects could apply to any of several draftsmanship schools and visual art academies, while chemical and mechanical engineers were directed to the universities. Industrial revolution or not, the status quo was considered more than acceptable by the Dutch government in what was then still for the most part an agricultural country.

Creation

Unsurprisingly, the Royal Academy did not arise at the initiative of government or industry, but rather was advocated by a number of idealists who could see the use and indeed the necessity. In fact the Academy became the creation of just one man, State Councillor and surveying engineer Antoine Lipkens (1782-1847). Lipkens, the son of the Clerk of the Maastricht council, had himself studied at the École Polytechnique in Paris, and spent a long time working in France. He undoubtedly envisaged something along the lines of the French institutes when he devoted himself to the establishment of a polytechnic college in the Netherlands.

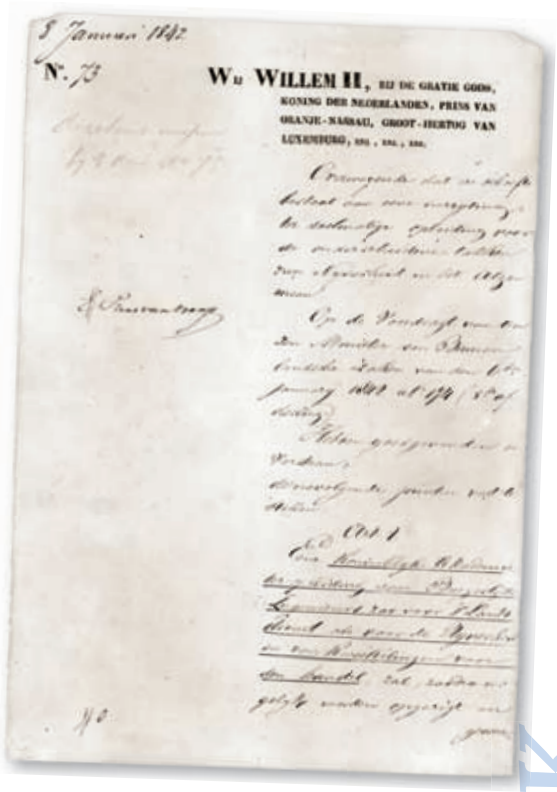
It would not be until 1842 that Lipkens saw his endless endeavours bear fruit. By royal decree of 8 January 1842 King Willem II called for the establishment of a dedicated polytechnic school in Delft, with Lipkens to be its first principal. The institute was established with the intention of reviving declining trade and industry, according to the text of the decree. At the official opening, a year later, the minister of the interior again stressed this mission in phrases characteristic of the era: "Given the existence of diverse local raw materials, local fuels, moderate wages, proper means of transport, an advantageous location, considerable colonies, sufficient capital, and mild government, the gross lack of knowledge must be averted."

Two days later the classes began, with three professors, five lecturers, and 48 students. There was no balance in the size of the departments and curriculum whatsoever. More students came to be trained for the civil service than to become engineers, and the number of students enrolling for the courses, most of which covered four years, varied widely, from just a few to several dozen. Of the 578 students who graduated during the 22 years the school existed, 318 became civil servants in the East Indies, 207 became engineers (mostly civil engineers), and 53 became inspectors of weights and measures, or tax officials. Although the Academy catered expressly for those expecting to enter into trade, this branch of the institute saw only one student throughout the years of the school's existence. To make matters even worse, he dropped out before finishing the course.

Government circles regularly suggested that the students be interned at the Academy in military-style barracks

Barracks

Life as a student at the early precursor of TU Delft was anything but easy. Contrary to what one would expect at an academy, Lipkens, whose formative years had been spent in the military surroundings of the École Polytechnique, had organised his training institute along the lines of a military establishment, very similar to army barracks. The students, who lived in private rooms, were closely supervised, and had to study till late in the evenings under the


8 Januarij 1842
N. 73
Wij WILLEM II, BIJ DE GRATIE GODS, KONING DER NEDERLANDEN, PRINS VAN ORANJE-NASSAU, GROOT-HERTOG VAN LUXEMBURG, enz. enz. enz.

Founding charter of the Koninklijke Akademie (Royal Academy).

The Delft engineering schools

1814-1828:	Artillery and Military Engineering School
1842-1864:	Royal Academy
1864-1905:	Polytechnic School
1905-1986:	Polytechnic Institute Delft
1986-today:	Delft University of Technology

A Delft mystery

The reason why Delft got its engineering institute may well remain shrouded in mystery for ever.

On 4 January 1842 the mayor of Delft read out a letter from the cabinet to his councillors. It said that the government had elected the town to accommodate Lipkens' new institute. The government was looking for a suitable building, which Delft could provide in the shape of the former Military Engineering School at Oude Delft 95. Only four days later, on 8 January, a royal decree was announced to the effect that Delft would become the official residence of the new engineering institute.

The exact circumstances behind the choice of Delft are still a source of speculation however, partly due to lack of archive material, and partly due to the fact that some meetings and considerations probably remained undocumented. It would appear probable that the establishment of the Academy on 18 August 1841 had already been the subject of discussion when King Willem II paid a visit to Delft. Did secret talks pave the way? Did the shrewd mayor of Delft play a decisive role? The motives behind the selection of Delft will have to be guessed at.

J.A. Keurenaer (1810-1875), major, army engineers (retired), and the third and last principal of the Royal Academy (1859-1864). (Source: TUD)

Dr. R. Lobatto (1797-1866), Professor of mathematics at the Royal Academy and at the Polytechnic School (1842-1866). (Source: Municipal Archives, Delft)

Dr. T. Roorda (1801-1874), the first Professor of Eastern languages, geography and ethnology at the Royal Academy (1842-1864). (Source: Iconographic Bureau, The Hague)

supervision of a tutor. Tests were taken every three months, and any absence was meticulously entered in an elaborate register.
On top of that the teachers were obliged to submit reports on each student's dedication, behaviour, and progress to the principal, preferably daily. A typical example of the grim discipline is embodied in the report of a teacher on one of his students: "In defiance of the rules, Mr Teding van Berkhout smoked a cigar during studies. When called to account for his conduct, he replied: 'I do so because I like the taste so much'."
In the meantime, the national authorities showed scant interest in the new school. The school wasn't even mentioned in the national budget. And once, when Lipkens tried to be reimbursed for his travelling expenses between Delft and nearby Voorburg, where he lived, the ministry told him that that would only be possible if he promised to keep the number of trips to a minimum. Lipkens replied by reassuring the ministry that he did not intend to claim any travelling expenses at all.

The founding of the Royal Academy was advocated by a number of idealists who could see the necessity of it

When the Academy was established, Lipkens had received a budget of ten thousand guilders to pay for refurbishing the accommodation and he was handed the books and instruments that had come from Franeker Polytechnic, which had closed in 1811. After that, Lipkens was left to his own devices, and the school had to cover its own costs. This it did with the annual teaching fee of two hundred guilders per student, and with contributions from the ministry for the colonies, which housed its school for the East India civil service in the Academy.
Nonetheless, the Royal Academy was plagued by constant financial worries. To keep the cost as low as possible, teachers were selected mostly from the ranks of those who had other jobs which provided them with a living. The results were disastrous. The quality of the scientific staff was deplorable, and the level of teaching fell far short of the then current requirements. Small wonder that one of the last committees to discuss the Academy's future, in 1862, concluded: "As long as the Academy in Delft fails to be a national institute, funded from national resources, no good will come of it, and the institute will be doomed to disappear."
In the meantime the erstwhile strict and disciplined culture of the Royal Academy was also being toned down. To ensure that the more youthful among the students were kept in order, Lipkens had devised

The Royal Academy

	Graduated	Left prematurely
Civil engineers	183	180
Maritime engineers	5	1
Mining Engineers	17	-
weights and measures, excise	53	5
Chemical and mechanical engineers	2	3
Trade	-	1
East Indies civil servant 1st class	118	43
East Indies civil servant 2nd class	200	213
Total	**578**	**446**

Course and number of students during the existence of the Royal Academy (1842-1864) Source: H. Baudet, 'De lange weg naar the Technische Universiteit Delft' (The long road to the Delft University of Technology) (The Hague 1992) p. 176.

a rather militaristic set of regulations, which he and the first crop of teachers intended to enforce. This approach however, was not to the liking of everybody. It certainly did not appeal to Lipkens' successor, Dr. Gerrit Simons, who took over in 1846. Simons vehemently opposed any form of compulsion and subjugation, and most of all, the accommodation in barracks. Simons, follower of the new, liberal wind that was beginning to blow in those days, maintained that a budding engineer could only develop himself though freedom and independence. He therefore granted the students more freedom in their studies. In 1848, the turbulent year that saw so many popular uprisings throughout Europe, he even consented to the establishment of the Delft Student Union.

Problem child

The backlash did not take long. Simons' policy resulted in students skipping classes, and teachers rattling off their lectures. Complaints started to be voiced about the quality of teaching. The Delft Academy became unpopular, the government's problem child.
It would take another ten years before the government decided to intervene. In 1859 it appointed J.A. Keurenaer as principal. Keurenaer, a retired major, had served as an army engineer in the East Indies, and his appointment was clearly intended to rectify the lack of discipline. His approach did not fail to make an impact in Delft. Keurenaer started by re-establishing a military regime in which he regulated the studies in every possible way, "as if studying were a special form of drill". For example, the ex-officer gave the order for "the doors of the Academy building to be closed from 9.10 until 10.00 a.m. on the grounds that someone had once shown his interest in science at eleven minutes past nine."
The teachers grumbled about the administration, the supervision, the rights and obligations, the regulations. The polytechnic's reputation suffered. Even the newly-appointed Lower House of Parliament did not think much of the Royal Academy: "It is an ambiguous institute between

higher and secondary education. [...] the students are a mishmash of adults and adolescents, the latter of which, to their detriment, are as free outside the school as adults. In addition the youthful apprentices spend most of their first year of studies in idleness, as they learn hardly anything other than that which they were required to know to be admitted in the first place."
When in 1861 Keurenaer came up with a set of regulations, which the students were actually required to put their signature to, matters came to a head. Led by the Delft Student Union the students protested so persistently that the Academy was closed for two months in late 1861. The reviled regulations were retracted, but this could not stop the decline of the Academy. When in the following year the second cabinet to serve under prime minister Thorbecke was installed, the complaints about the Delft institute had accumulated to such an extent that the government finally had to step in. On 20 June 1864 the Royal Academy was officially closed.
It proved to be the overture to a thorough make-over.

The students had to study until late in the evenings under the supervision of a tutor

The Academy was liberated from its non-technical courses, and was reformed into a Polytechnic School for technical training at the highest level. The East Indies civil service trainees were also removed, to a separate institute for Eastern languages, geography and ethnology. In addition a secondary school was established in the town to provide a proper basis in the exact sciences, so the entrance exams could be dispensed with. At last the Delft school of engineering was able to establish itself as a further education institute at the highest level.
On 26 September, less than three months after the closing of the Royal Academy, the new Polytechnic School, which would eventually evolve into TU Delft, was fully established.

With acknowledgements to Ir. J.M. Brans, Professor Dr. J.M. Dirken, and Ir. J.H. Makkink.

The quotations in the text were taken from:
H.H.R. Roelofs Heyrmans,'Gedenkschrift van de Koninklijke Akademie en van de Polytechnische School 1842-1905' (Memoirs of the Royal Academy and of the Polytechnic School 1842-1905) (Delft 1906).
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COLUMN

[PRIEMUS]

If all minds think alike, teaching and research tend to suffer, as was demonstrated on 28 September 2006 during a panel discussion on the Superbus proposed by Wubbo Ockels.

The Superbus project is a TU-wide initiative, which receives financial support from the university executive board. Even so, the project is the subject of criticism from sources within TU Delft who are using the media to launch their arrows at Superbus. Albert Pols accuses Wubbo Ockels of overplaying his hand. In other words, Wubbo is promising too much. Ingo Hansen considers the project utterly unfeasible, stating that there are no easily transportable batteries of sufficient power capacity around, that the infrastructure is poorly conceived and unsafe, and that the number of prospective passengers is being overestimated.
The university executive board organised the internal panel discussion mentioned above with the intention of bringing together the different points of view.
Problems were stated in bold terms, for example the threat of damaging the reputation of TU Delft. Right from the beginning of the discussion the participants had been conveniently separated into those in favour and those against.
A number of panel participants appeared to favour the ideal of a research and development procedure in which all minds think alike. Any criticism is perceived as interference, and skeletons must be kept carefully locked away. If you ask me, this paradigm is wrong. Of course it is handy if a project has its advocates who put their backs into it and set their goals high.
In order to achieve the possible, it is often necessary to pursue the impossible. On the other hand, one of the greatest dangers along the way is that of 'group think' (Janis), in which a group filters out any critical signals and soon develops tunnel vision. This can result in major mistakes. According to Mentzel in his doctoral thesis (1989), the Bijlmermeer high-rise estate near Amsterdam is a graphic example of this. It is much better to mobilise criticism during the development process. In order to confirm a hypothesis, you will first have to disprove the null hypothesis. Thesis and antithesis often result in synthesis. It makes sense (and is becoming increasingly the norm) for a project organisation to organise an 'audit' from time to time. The project group prepares exhaustive project documentation; external, critical experts are then invited to criticise the project and pose critical questions. If the project group survives the criticism, it is one step closer to its goal. If any weak spots are exposed, or if new aspects come to light, there is reason to go through a learning process. Above all, a project organisation should be on its guard against 'entrapment' (Brockner & Rubin, 1985), in which the fish keep swimming into the net until there is no turning back.
Starting with a thorough problem analysis always makes sense as does actively looking for alternative solutions, allowing the pros and cons of each solution to be assessed. Exposing the organisation to external information encourages learning processes that leave room for taking a step back, rethinking matters, even taking a completely different route. This can lead to a result that is utterly different from what was expected at the start. Along the road, knowledge will have been gained. Taking a step back at the right moment makes it easier to make the jump. Learning seldom is a linear process, and learners will find the occasional surprise in store for them. This is what makes research, development, and learning worthwhile and inspiring. Surprises and interference should be cherished.
Hugo Priemus, dean of the Faculty of Technology, Policy, and Management.

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Mentzel, M.A., 1989, 'Bijlmermeer als grensverleggend ideaal; a studie over Amsterdamse stadsuitbreidingen' (The Bijlmermeer estate as ground-breaking ideal; a study of urban development in Amsterdam), Delft (DUP).

[HORA·EST]

Propositions

The stickiest bacteria are the slipperiest.
Dimitra Dodou
Materials Engineer

Marketing experts have made 'nano' the most abused word in the English language.
Alexander Polyakov
Electrical Engineer

The true environmentalist has no children.
Christiaan de Ruijter
Engineer in Materials Science

A smile is infectious, just like a frown.
Sinar Juliana
Aerospace Engineer

Scientific articles written in American English have a better chance of being quoted than articles written in British English.
Pepijn Pronk
Engineer in Process Technology

The greatest inaccuracy in George Orwell's novel '1984' is found in the title. He was off by about 25 years.
Bas Swinkels
Engineer in Optics

The devil's advocate must have a starring role in scientific research.
Edith van Veldhuizen
Engineer in Applied Physics

'Diamonds are a girl's best friend. Carbon nanotubes are a boy's best friend.'
Hon Tin Man, nanotechnologist

[Sound]bites

"Like a sorcerer's apprentice, mankind has pulled the cork out of the bottle of carbon dioxide and released a load of greenhouse gases into the air. But don't then leave it to the sorcerer's apprentice to get the gas back into the bottle. His magic remedy is probably worse than the problem. And certainly more expensive."
Geology professor Dr. Salomon Kroonenberg in HP/DE TIJD

"In principle, no car needs to go faster than 130, or at the most, 140 kilometres per hour. Yet, most new diesel-engine cars can reach speeds of 180-kmph and most gasoline-engine cars 200-kmph. That we can pay for these cars is a luxury problem."
Chemical engineer Dr. Michiel Makkee in NRC HANDELSBLAD

"It's still often the case that discussions about newly built buildings tend to lead to the question of who has the highest one. There must indeed be a story behind the thought of adding another 10 extra floors."
Mr. Frank Wassenberg of the OTB Research Institute, in De VOLKSKRANT

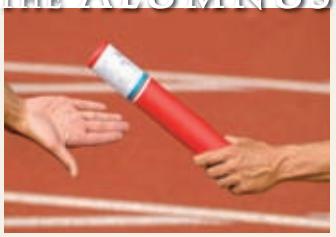
"The problem with the House of the Future in Amsterdam is that few people visit it. Thanks to the sustainable dance club we've developed in partnership with TU Delft, we've brought sustainability to young people. By introducing sustainability in dance clubs, you're also able to portray sustainability as something that's sexy. Otherwise, young people aren't interested. We want to remove the tree-hugger image that is always associated with the sustainability."
Mr. Stef van Dongen, Enviu foundation for sustainable entrepreneurship, in NRC HANDELSBLAD

Photos Sam Rentmeester/FLUX

Sadly, even in the academic world, not very many people are aware of Thomas Edison's famous adage: "Results! Why, man, I have gotten a lot of results. I know several thousand things that won't work."

In Defense

"*Professors place far too much emphasis on publications. When you apply for a post-doc position, they primarily want to know in which journals and in how many journals you have been published. But this score says practically nothing about a person's knowledge of his or her specialist subject. During your research, you can try a virtually limitless number of research methods that ultimately prove not to work. But this isn't a disaster. Trying various methods sharpens your approach to problem-solving, provides valuable insights and leads you to new ideas. During job interviews in Romania, the professors place much more emphasis on testing your theoretical knowledge than in Western countries. This allows you to really demonstrate what you know about the background of your field of study. This is the Eastern European style. And I prefer it.*"
Ion Necoara, Doctor in Control Theory (3me)



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

You can start your own business in all kinds of different ways. You can jump straight in, or you can take the careful approach. Or, as in my case, it can be a gradual process. About four years ago, freshly graduated, I left for Japan, the land of sushi, sake, game boys, robots that look like people and animals, and of course, sterile white face masks to protect you against the common cold.

The enormous demand for the animal-print masks I produced as a joke suddenly had me having to answer questions and make decisions about such matters as my company name, logo, production, and, last but certainly not least, my business card. In Japan business cards undergo a kind of personification as it were; they are studied closely, and only after a conversation are they carefully stored away.

I slowly grew up in this business world, established a network, and extended my collection. My smattering of Japanese soon proved woefully ineffective. The language of the business world contains so many rules of etiquette that it merits a language of its own.

On top of that, generally speaking, a woman in Japan does not have much of a say in business matters, except when she is the boss – which doesn't happen very often. Another phenomenon in Japanese business life is the unwritten rule that you cannot leave for home before the boss is ready to go. So never work from home. The same goes for the sake bar or the karaoke bar, where the Japanese like to show their prowess on stage. The last, often overloaded, trains that leave around midnight in Tokyo are a legitimate and welcome excuse to go home. The trains also make sure the Japanese economy does not suffer too much.

The result is that after midnight, the town appears completely deserted, with the exception of the 24-hour shops you can find on every street corner. The scene is in total contrast to the dynamics and turbulence of daytime, when eighteen metres above ground level the motorways are packed with traffic winding its way through the city, and trains flash by through the countryside at 300 km per hour.

All this industry and action simply oozes energy. The passion of the Japanese, their dedication, the serenity that people look for in the temples between the high-rise blocks, and their untiring readiness to help also intrigue and inspire me.

We are looking for expansion on the Japanese market by introducing our latest products at the second business fair in Tokyo in early November. I recently relocated to Amsterdam to focus on the development of 3-D fabrics and expansion in Europe.

Back home has taken on an entirely different dimension for me now. Here in my home country, which should be so familiar, I have no language or culture problems. Even so, the market is totally alien to me, and business cards disappear into back pockets without a thought. But it is also the place where combining business and home life as equally precious commodities is considered an art.

Samira Boon

Ir. Samira Boon (31) studied Architecture at TU Delft from 1994 to 2002. Boon currently lives and works in Japan and the Netherlands. Samira Boon passes on the pen to George van Montfort, an alumnus of TUD Technical Informatics, and currently working as a management specialist with the United Nations in New York.

Artificial muscle for the robot fly

PHOTO: SAM RENTMEESTER/FMAX

Sensitive pliers that can pick up cells, or artificial muscles for robot flies are some of the applications Dr. Hans Goosen of Mechanical Engineering, Maritime Technology, and Materials Science (3ME) envisages for his invention. In September, together with doctoral student Gih Keong Lau, he filed a patent application for an extra powerful thermal microactuator.

TOMAS VAN DIJK

Minute machines, also known as MEMS (microelectromechanical systems), are often fitted with thermal microactuators, microscopically small rods that expand when heated. By passing an electric current through them they can be heated up so they will change shape for an instant. They can thus be used to drive a small pump for example, or toggle a switch on and off.

The actuator invented by Goosen is very promising because it is powerful and at the same time changes shape considerably. "Until now we were always forced to weigh the pros and cons," Goosen explains, "since soft-rubber microactuators expand quite a lot, but their softness prevents them from applying the force stiffer materials can bring to bear. Harder materials gave us the force, but not the expansion."

Goosen uses a scrap of paper to sketch his brainchild, the concept of which is deceptively simple. The rubber is enclosed between two pieces of metal. As a result, it can only move in one direction when heated, which is up. Any sideways expansion is also deflected upwards. "I cannot understand why no one else has come up with this simple idea before," the inventor says.

Things get even better when Goosen draws a pattern of metal rods in the rubber. "You can attach a metal strip along one side of the material. The metal expands less than the rubber. This causes the actuator to bend towards the side of the metal when current passes through it. Various patterns of metal inserts can be used to make actuators take on different shapes. The device responds quicker and is more efficient because the metal helps to conduct the heat."

Another advantage is that the device can work on voltages as low as two to three volts. This makes the actuator easy to combine with normal electronics. Other actuator types that can apply the same force, piezoelectric crystals for example, require hundreds of volts.

Co-inventor Lau recently prepared a number of prototypes of the actuator in the clean room of the Faculty of Electrical Engineering at the Delft Institute for Micro-Electronics and Submicron Technology. "We are now running tests to see what it can do," Goosen says. "Colleagues of ours at the department are working on a micro robot fly. Perhaps the microactuator can be used as an artificial muscle in that."

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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Technology, Policy & Management
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Multidisciplinary Centres

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Biotechnological Sciences Delft Leiden (BSDL)
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Centre for International Co-operation and Appropriate Technology (CICAT)
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Dutch Institute of Systems & Control (DISC)
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Student Advisory Office
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Liaison between business and research:
Liaison Office
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Information on research fellowships:
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General information on university education in the Netherlands:
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Central Information Dpt.
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For information on courses in the Dutch language:
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