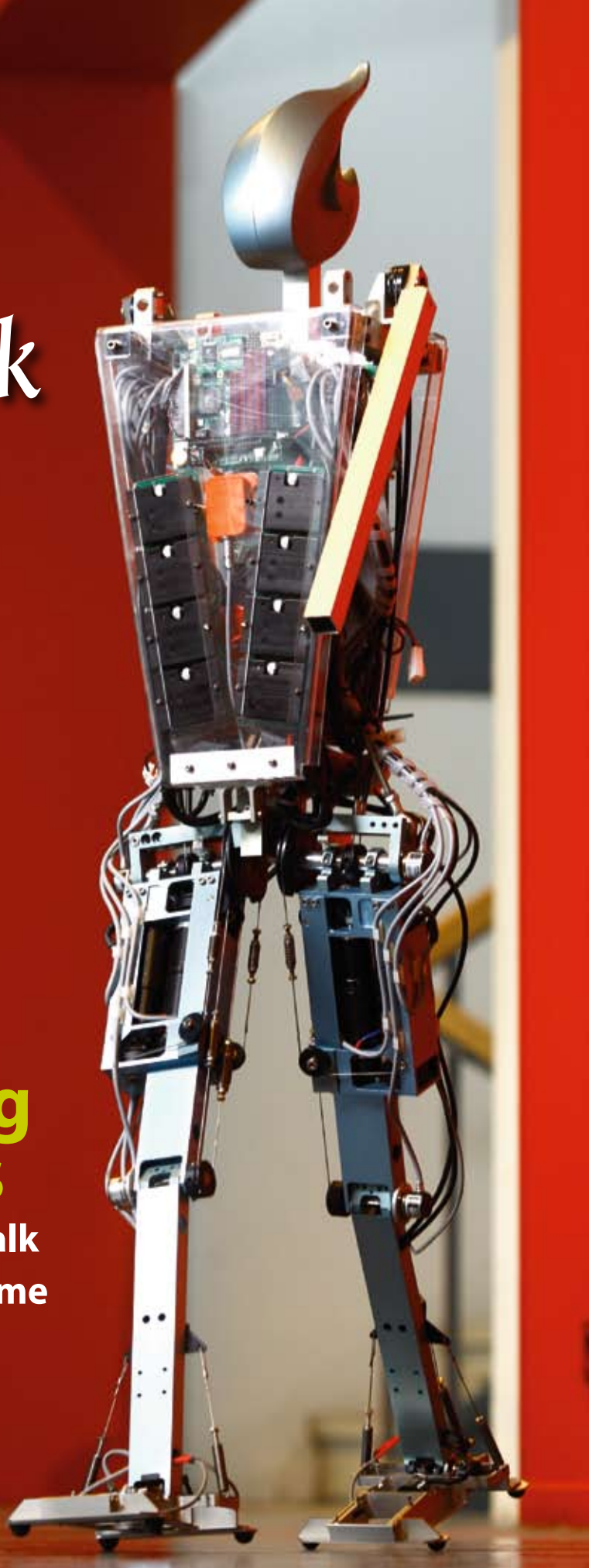
2008.2

Research and education at
Delft University of Technology

Delft Outlook



Walking robots

Learning to walk one step at a time

Filming the wind • **Coastal engineer Marcel Stive** • Super atoms
Living Chips • **Artificial cells with a backbone** • **'Bouwkunde' burns**

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Delft Outlook

[Edit]DO

There were no casualties, but even so there were lots of tears. Incalculable years of scientific work were destroyed in the fire that gutted the Faculty of Architecture on 13 May. The tears of Professor Franziska Bollerey as seen on the television news weren't just for the loss of her own collection of slides, books, papers, research projects, and exhibition content. The blaze also consumed the intellectual work of many of her colleagues at Bouwkunde. A small consolation is the fact that a major part of the common cultural heritage of the faculty was miraculously saved from the charred ruins, including the unique historic collection of chairs and architectural models that were waiting to be exhibited to the public the day after the fire.
Delft University of Technology fights back its tears and picks up the pieces. Different ideas about the new faculty building have already triggered a lively debate. For the time being the faculty will move into the university's former main administrative building, where the exhibition of chairs and models is now scheduled to open in September. Attendance could well be very high.

Frans Godfroy,
Editor-in-chief, Delft Outlook

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CORRECTION

The previous issue of Delft Outlook (March 2008) contained an error. The article 'Windmill desalinates sea water' states that the combination of a wind turbine and desalination plant using reverse osmosis is a new Delft invention. However, a German company, Enercon, has for some years been marketing reverse osmosis plants that can be coupled to windmills.

COLOFON

coverphoto

Photo: Sam Rentmeester/fmax
Walking robot Flame
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IN·BRIEF

Claustrophobia in colour

The street map devised by Dr Ir. Arthur van Bilsen is rather special. Instead of indicating the nature or size of the streets and roads, the colours show the extent to which a pedestrian feels hemmed in by the urban environment, a feeling that is not the result of neighbourhood surveys, but is based on mathematical analyses. Professor Nikos Salingaros, architecture critic and mathematician, who was a member of the doctoral degree examining committee when Van Bilsen was awarded his doctorate, said it was an issue other researchers had been avoiding for thirty years.
Van Bilsen analyses 'isovists', which he loosely defines as 'anything you can see from a certain viewing position'. Urban planners often don't do much more than using lines of sight as guidelines for designing the urban environment. Van Bilsen uses mathematical techniques (involving lots of integral calculus) to analyse the area of sight from a certain viewpoint. The smaller the distance to the built environment, the higher the calculated value, and the redder the colour on the map.

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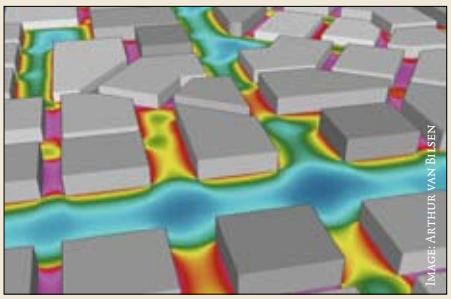

A street plan processed by Arthur van Bilsen and Egbert Stolk. Blue indicates space, red points to claustrophobia.

Proton clinic at Technopolis

In a few years, the grounds of the Reactor Institute Delft, on the new industrial estate Technopolis, will be seeing the construction of a clinic in which cancer patients can receive proton radiation treatment, a first in the Netherlands.
The proton clinic, named Holland Particle Therapy Centre (HollandPTC), is an initiative of TU Delft, the Erasmus Medical Centre in Rotterdam, the Dutch Cancer Institute/Antoni van Leeuwenhoek Hospital, and the Leiden University Medical Centre. TU Delft will act as liaison. Professor Karel Luyben, dean of the Faculty of Applied Physics, and Professor Tim van der Hagen, both delegates from TU Delft, will act as chairman and member of the steering committee. In the future clinic the radiation treatment will use a narrow beam of protons that specifically smash tumour cells. Unlike the current radiation treatment using photons, the proton technique leaves the surrounding organs and tissue intact.

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IN·BRIEF

Superbus won't go to China

The presentation of the Superbus during the Olympic Games in Beijing is off. Additional rules imposed by the Chinese government make a proper presentation impossible, according to programme supervisor, Professor Dr Wubbo Ockels.
The broken dream was the result of gradual insight, Ockels explains. The Chinese government kept imposing additional rules to control the traffic in and around Beijing during the Olympic Games. Registration number checks will be used to see who is allowed onto the roads. On top of that there is the experimental nature of the Superbus, which doesn't fit into any existing category. Ockels' understanding was that all the Superbus would be allowed to do was sit there on a stack of pallets, a meagre presentation that didn't merit the sizeable investment. In consultation with the president of TU Delft's Executive Board, Dirk Jan van den Berg, it has been decided to forego the Olympic Games presentation. Ockels denies rumours that the Superbus wouldn't have been ready for the presentation. It is a government problem, he summarises. Ockels expects to present the Superbus to the press in late June.


Image: TU Delft

Chips swimming

Laboratory-grown heart muscle cells on a microchip providing electric power to implants. This vision of the future held by Professor Dr Ir. Ronald Dekker, flexible chip researcher at Philips and recently appointed associate professor at the Faculty of Electrical Engineering, Mathematics, and Computer Science.

"Living microchips, it may sound futuristic, but demonstrations have shown that it is possible. Stem cell researchers can apply laboratory-grown heart muscle cells very accurately in patterns on a substrate. I was completely floored when I saw what some of the guys at Harvard can make those cells do: in one of their films, you can see a piece of rubber with heart muscles that are contracting. The contracting cells have been applied in such a pattern that they propel the substrate. You can see the substrate swim under the microscope. The first thing that went through my mind when I saw this was that instead of a simple substrate you could have a microchip. Today's technology enables us to make flexible and stretchable microchips from ultra thin silicon. Together with stem cell researchers of the Hubrecht Institute for Development Biology and Stem Cell Research, I will be fitting stretchable microchips with heart muscle cells at DIMES. The possibilities for medical applications are endless. You could fit microchips with piezoelectric material, so that beating heart muscle cells on the microchip can supply energy to small pumps that dispense medication inside the body. You could dispense with batteries."

Photo: Sam Rentmeester/fmax

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IN·BRIEF

Robotic arm

ESA astronaut Christer Fuglesang tries out the Exarm robot interface. On the right is researcher Dr Ir. Andre Schiele.

Robocop eat your heart out: an armour that follows human movements exactly. Dr Ir. André Schiele designed the Exarm Interface for space missions.
It looks as if Schiele has built something that the space industry has been looking for forty years. It is a portable, universal exoskeleton that can be used to control a space robot. Previous attempts never got beyond the stage of structures bolted to a wall, recording only part of the arm's movements, and were mostly made to measure so they weren't exchangeable. The remarkable thing is that for Schiele the point isn't the device – unique as it may be – but the underlying design guidelines. He received his doctoral degree with honours, supervised by Professor Dr Frans van der Helm of the biomechatronics & biorobotics department of the Faculty of Mechanical, Maritime, and Materials Engineering (3ME). Even before he was actually awarded his doctorate, Schiele was already busy at the European Space Agency (ESA) with the next exoskeleton, the X-Arm-II. Weighing six kilos, the X-Arm-II is slightly heavier, but it features built-in force feedback, enabling an astronaut to actually feel how much force the robot is using. Some of these forces are transmitted using smart cable systems, the rest use electric motors. Schiele dreams of building a system that complies with every space standard and can go along with ESA or NASA as a remote control system for space robots. ESA will decide on the issue in November. Schiele is still in discussion with NASA.

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Pinprick

How does light pass through a pinprick hole? Professor Dr Paul Planken (Applied Physics) and his group have demonstrated this for the first time. The results were recently published in the *Optics Express* journal. For their research, Planken and his group used terahertz radiation with a wavelength of up to three millimetres and holes of 0.2 millimetre diameter. They were able to show for the first time how electromagnetic radiation squeezes itself through a hole smaller than half the wavelength of the radiation.
In their experiments the researchers discovered that even if the hole is as small as one-fiftieth of the wavelength used, enough light still comes through for measurements to be performed near the hole. This is extremely difficult to do using other techniques.
The new technique has also made it possible to take pictures of the entire process, slowed down to a thousand billion (10^{12}) times to show how the light emerges from the hole, after which the light waves expand like concentric waves in a pond into which a pebble has been dropped.

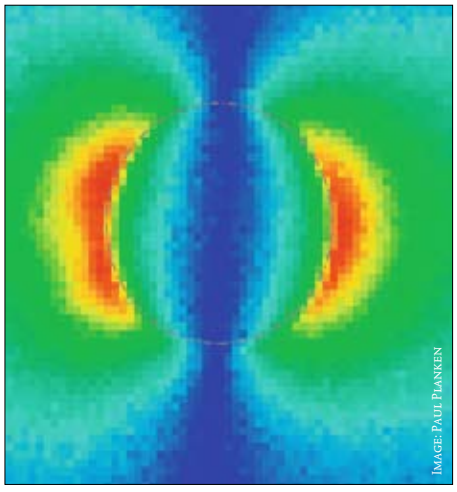

Image: Paul Planken

‘I can even see when people flush the toilet’

Using a long fibre-optic cable to measure water temperature, TU Delft researchers are surveying a sewer system. They can see exactly which households have their waste water pipes connected the wrong way round.
With its wide streets and luxury villas, Blixembosch seems to come straight out of a property developers’ prospectus. Below street level however, this neighbourhood in Eindhoven is not all it’s cracked up to be. Like any modern housing development, Blixembosch has separate sewer systems for rain water and for household waste water. The rain water can go straight into a canal, saving the water treatment plant a lot of work. Or at least that was the plan. In reality the ends of the two separate sewer systems had to be joined to prevent surface water being polluted, because incompetent contractors and DIY enthusiasts had connected many of the drains to the wrong sewer system.
The council called in the help of Dr Ir. Olivier Hoes of the Faculty of Civil Engineering and Geosciences, who responded by stretching a 1,300 metre long fibre-optic cable through the rain water sewer. This enabled him to measure the temperature of the sewer contents at 2-metre intervals throughout the neighbourhood, every thirty seconds. “A laser fires pulses of light through the fibre-optic cable,” Hoes explains. “The wavelength of the light reflected by the cable depends on the temperature of the water. Sensors measure the wavelength, which gives the temperature.”
The researcher can see exactly where temperature peaks occur, showing which of the houses have been connected the wrong way round. He shows a colour diagram illustrating the water flows through the rainwater sewer. Near some of the houses recurring red peaks coincide neatly with the rhythm of people’s lives. “I can see exactly when people flush the toilet.”
Distributed Temperature Sensing (DTS), as the technique is known, has been in use for about a decade to trace leaks in oil pipelines and dams, among other tasks. Hoes is the first to use it for sewers. Several councils have called on him for help, and a sewer company, Valk en De Groot, has also expressed interest, according to Hoes.

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Laptop bath mat


Photo: Sam Rentmeester/fmax

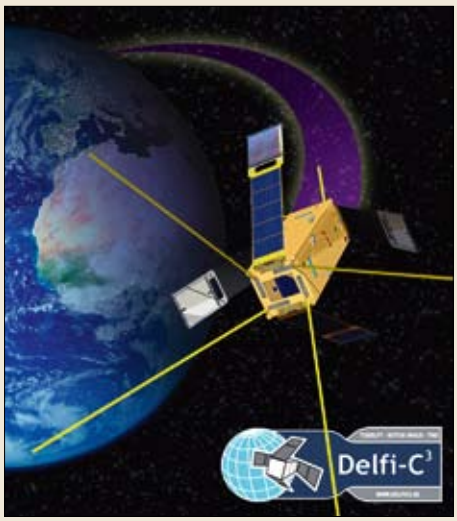
Masters’ student Bram de Zwart (Industrial Design) in Milan transformed a bath mat into a laptop computer must-have accessory: the ComputerCouch.
During his semester studying at the Politecnico di Milano, De Zwart saw how students in the park and at street cafés were always carrying their laptop computers with them. He also noticed how students were looking for solutions to work with their laptops.
The idea for a laptop add-on to simplify working with the computer and to make it easier to carry was easily arrived at. That was when the real work started. For weeks on end De Zwart experimented with different materials until in a rubber shop he finally discovered a rubber bath mat. He added velcro, rope, and elastic, and the ComputerCouch was born. The mat helps to cool the computer, is ergonomically sound, protects its contents, and is affordable, according to the product description.
Besides his university work, De Zwart runs a design company, ‘Sorpresa’ (Surprise), in which he intends to develop other smart, playful, and affordable laptop accessories. He sees chances for innovative designs: “The existing products on this market look hopelessly conservative to me.”

More information:
www.sorpresadesign.com

IN·BRIEF

Space carton

“Incredible! Even with my smallest aerial I was able to pick up the satellite from the roof for a whole ten minutes. Amazing, since it passed way beyond the horizon.” Enthusiastic e-mail messages like this one from an amateur radio operator in Finland are pouring in at the tracking station of the Delfi C3 ‘nanosatellite’ in Delft. Hundreds of amateur radio enthusiasts all over the world have already been in contact with the satellite, helping TU Delft to collect data.
The milk carton-sized satellite, designed and built by students, was launched from India on Monday 28 April. It carries two ‘missions’, solar cells from the Leiden-based company Dutch Space, and a solar angle meter built by TNO. The satellite transmits readings of the degradation process affecting the solar cells, and the power supplied by the cells at different angles of incidence to sunlight.
The Delfi C3 team has repositioned the satellite several times to vary its operating mode, including a transponder mode in which the satellite acts as a communication satellite. “It’s quite a kick, controlling a satellite spinning around the earth at an altitude of 630 kilometres and at a speed of over seven kilometres per second,” says project supervisor Ir. Rob Hamann of the Faculty of Aerospace Engineering.
Hamann is already working on an extension project, the Delfi-n3Xt, which is to be launched in 2010. Its work schedule includes experiments on micropropulsion. In addition, the flash memory carried by the Delfi-n3Xt will be protected against radiation. The memory of the Delfi C3 is exposed to cosmic rays, which sometimes causes some technical problems. The transmitters will also be more powerful, and the equipment will include an instrument to analyse radiation.



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Race against the tides

Hydraulic engineers from Delft use a jet-ski to map the currents in a Brittany bay in a bid to find out why the local eelgrass thrives.

PHOTO: TOMAS VAN DIJK

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"This is a race against the clock," says Ir. Jasper Dijkstra, up to his knees in water in the middle of a large field of eelgrass. He quickly attaches a flow meter to a metal frame before it is engulfed by the incoming tide. "This is a perfect research area," he continues. "We can calculate exactly how much water flows over the eelgrass."
In the northern hemisphere, common eelgrass, or Zostera marina, forms nurseries for a whole range of fish species and crustaceans. It used to be abundant in the Wadden Sea, but an eelgrass disease decimated the worldwide population of the plant in the 1930s. The Wadden Sea population never recovered.
All attempts to reintroduce the eelgrass have failed. "The fields probably have to be fairly big," Dijkstra says. "Large fields slow the current, causing clay particles to sink to the bottom. This renders the water clear, and makes for a good growing environment for the plants."
Dijkstra is creating models of this type of interaction between sea currents and eelgrass fields to find out why the eelgrass refuses to grow in the Dutch seas. He is collecting data in Brittany to verify his models. He has four metal frames with pressure sensors attached to them that record the water depth and wave height. In in addition there are sedimentation meters.
"And there's more," says fellow researcher Ir. Matthieu de Schipper, after the water level has risen several metres. "Our data sets are combined with current measurements all over the bay."
In his hand he holds a walkie-talkie to guide Dijkstra, who, dressed in a wet suit, is turning circles on a jet-ski, dragging along a small red boat carrying an acoustic Doppler current profiler, a device that measures the current at twenty different depths.
De Schipper and his colleague Ir. Sierd de Vries have even greater plans for the jet-ski, which was purchased recently by the hydraulic engineering section. They plan to investigate the sedimentation processes in the surf off Scheveningen to see if it would be possible to create an artificial reef for surfers.

Artificial cells with a backbone

Professor Dr Jan van Esch of the self-assembling systems section at the Faculty of Applied Physics imitates the way in which nature constructs cells. His artificial cells could lead the way to a treatment for cancer.

Artificial life it isn't, but the small cells, so-called liposomes, which Van Esch is producing do have a touch of magic about them. Just like our own cells, the cells have outer walls consisting of lipids, soap-like molecules that have a hydrophilic head while their tail repels water, and which are full of fibres that resemble the cytoskeletons of natural cells. Even more remarkable is the way in which the cells came into being. In a process borrowed directly from nature called auto-organisation, lipids suspended in solution spontaneously group together to form clumps or cells, simply because that is their most stable configuration.
Liposomes have been made from lipids for many years in laboratories, but a post-doctoral student of Van Esch, Dr Aurelie Brizard, was the first person who succeeded in giving the cells an internal skeleton. The method is simple: at the microfluidics section the researchers conduct gelatin through a microscopic tube, adding lipids at either end. The lipids enclose the gelatin fibres and cut off the gelatin flow. "It's like making sausages," Van Esch says. He thinks he will soon also be able to make liposomes with small compartments in them.
The trick lies mainly in preparing the right molecular building blocks, gelatin fibres and lipids. In his laboratory, Van Esch constructed versions of these ingredients that do not adversely affect each other's stability when mixed. He is the first to succeed in doing so. The breakthrough was recently described in the scientific journal, *Angewandte Chemie*.
The technique could lead to a treatment to fight cancer. Doctors are already making good use of liposomes to guide medication through the body. Once introduced into the bloodstream, the cells are carried along until they arrive at a cancerous growth. "By filling the cells with fibres we can eventually make sure that the cells will erupt at exactly the right moment. This is because tumours form a relatively acidic environment around them, and at low pH values the fibres start to grow. Eventually they can expand to the point where they will puncture the cell membrane."

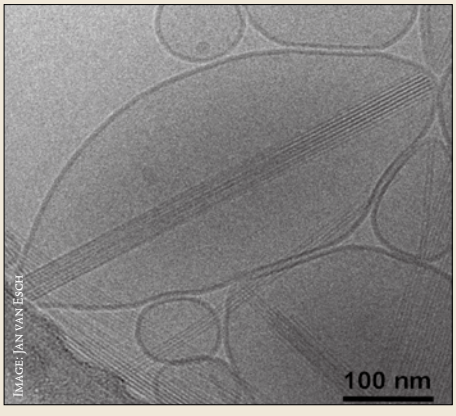

IMAGE: JAN VAN ESCH

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‘Walking on two legs is difficult’

Robot experts learn a lot from the human body, like, for example, how to walk without falling over or wasting energy. Research being conducted at the Delft Biorobotics Laboratory also contributes to a better understanding of how we humans walk. Dr Ir. Daan Hobbelen: “Dynamically, the walking human is an unstable system.”

Saar Slegers

One robot has a Tupperware bowl for a head, the other a small blue bucket. The heads don’t really serve a practical purpose. In fact, the only reason these robots are fitted with heads is to make them look a little more like people. “A robot with just arms, legs, and a torso looks funny. It’s just not right,” Daan Hobbelen of the Delft Biorobotics Laboratory explains. “It’s important for a machine to have a head in order to evoke associations with the way humans walk, but in view of the mechanical nature of the machine, we didn’t want to add a realistic head. That could easily become scary.”

The robots Hobbelen is working on are far from scary. They are stilted figures with silly heads, and once they are switched on, they seem funny, not frightening. The website of the biorobotics lab features films of some of these robots walking, with their researchers walking alongside. Whereas the robots march blindly through the hall, the researcher, like a protective mother hen, is constantly on the lookout for edges of furniture and other hazards. Of course learning to walk involves standing and falling over; it’s just that with robots the falling over part can be very expensive.

The robots Hobbelen developed during his doctoral research are named Meta and Flame. Meta doesn’t look particularly human. The robot is a kind of cephalopod, a control system with four legs, two of which prevent the machine from falling over sideways. Meta is being used to study stability in the walking direction. Flame however has a rather more human appearance. The robot has two legs with wide, flat feet, arms, and a V-shaped upper torso. His head is shaped like the flame in the TU Delft logo. At first glance Flame appears less stable than Meta, but Flame’s active ankles and hips enable it to remain upright as it walks.

Falling as you walk

As self-evident and simple as the process of walking is for humans, so complex is it to imitate the way humans walk in a robot. Researchers are still puzzling over how humans manage to maintain their balance as they walk. Hobbelen: “Walking is very difficult, because the entire time you’re standing on one foot only. This means that you’re actually continuously in the process of falling over, unless you’re actively trying to stay upright. Dynamically, a walking human is an unstable system.” At the biorobotics lab, Hobbelen and his colleagues are trying to get a better understanding of how people nevertheless manage to remain upright.

Why would a mechanical engineer bother with the physics of the human body? Surely there are enough motion scientists and physicists better suited for the job? Hobbelen: “There are two ways to gain insight into the way humans walk. The first and most commonly used way is to measure people as they walk. You can learn a lot from this; for example, you can measure at what point people in motion tense their muscles, and you can record their movements using cameras. The problem with this analytical method is that it’s difficult to distil from these data exactly what is going on inside the body. People use lots of muscles and tendons and go through lots of motions as they walk. Body measurements are practically useless when it comes to determining what makes people, as a whole, stable as they walk.” ▸▸

Learning to walk involves standing and falling over; it’s just that with robots the falling over part can be very expensive

Photos: Sam Rentmeester/fmax

At the biorobotics lab, researchers are taking another approach to studying the motion of walking. Instead of analysing it, they are reconstructing the motion. Using the simplest possible models, they are trying to determine which factors make for a stable, human walking motion. The advantage of this synthetic approach is that it is possible to vary the parameters. Joints can be made stiffer or loosened, and the power output of the control system can be adjusted. According to Hobbelen, the various types of research complement each other nicely: "Based on the results of our research, we will formulate hypotheses that can then be tested by motion researchers. And then we, in turn, will go to work using their observations."

'Our aim is to make the robot walk exactly like a human'

The contacts between the various disciplines are growing rapidly. The biorobotics lab is currently collaborating with the medical rehabilitation department of the Vrije University Medical Centre, Amsterdam, in a research project on stability during walking. Hobbelen: "We adapt our simulation models for the motion scientists' research, and help them make the calculations. We then conduct the practical tests on our robots, using the knowledge they've gained from these simulations."

Robot-like

Meta and Flame aren't the first walking robots. Who hasn't seen images of Asimo, the robot created by Honda to look like the Michelin Man? Not only does Asimo walk, run and climb stairs, he can also serve drinks, play soccer, and look around. The Honda website also states that the robot can help teach schoolchildren how to cross the street, and that he also performs daily in his own live show at Disneyland. What can Hobbelen's robots do that Asimo can't? Hobbelen: "Honda uses very advanced technologies. What they can make their robots do is absolutely impressive, but the control mechanism of those robots is based entirely on control technology and technological know-how. It has very little to do with what people actually do."

The movements of a robot like Asimo are always fully under control, and the system is designed to be continuously locally stable. In order to ensure this local stability, for each step it takes, the robot first establishes firm ground contact with its foot and then proceeds to stabilise its body over that foot, using conventional control mechanics. To ensure it can stabilise itself, the robot always walks and stands with its knees slightly bent, which allows it to adjust its posture in any direction, should its position be disturbed. The way in which the robot is stabilised introduces many restrictions. The robot uses a lot of power and its range of movement is limited. And even such an advanced robot is limited in the ways it can handle interference. There is a considerable risk that an unexpected step will cause it to fall over. The way the robot walks doesn't really look very natural, either. "People describe the way robots like this move as wooden or robot-like," Hobbelen says. "The robots we make walk more smoothly. Their walking motion is more human-like, and that is exactly what we're trying to do: create a robot that walks exactly like a human being."

Dynamic walkers

Unlike the walking motion of fully controlled robots, a relatively large part of the human walk is uncontrolled. As we walk, our legs go through a natural pendulum motion. Maintaining this pendulum motion requires very little energy, because for most part our legs keep themselves in motion.

Hobbelen demonstrates this principle, known as a ballistic walk, using a passive dynamic walker, a robot that goes through a walking motion without any control mechanism. Hobbelen positions the robot at the top of a slope and lightly pushes it in the back.

▸▸

Daan Hobbelen with walking robot Meta at the Delft Biorobotics Laboratory

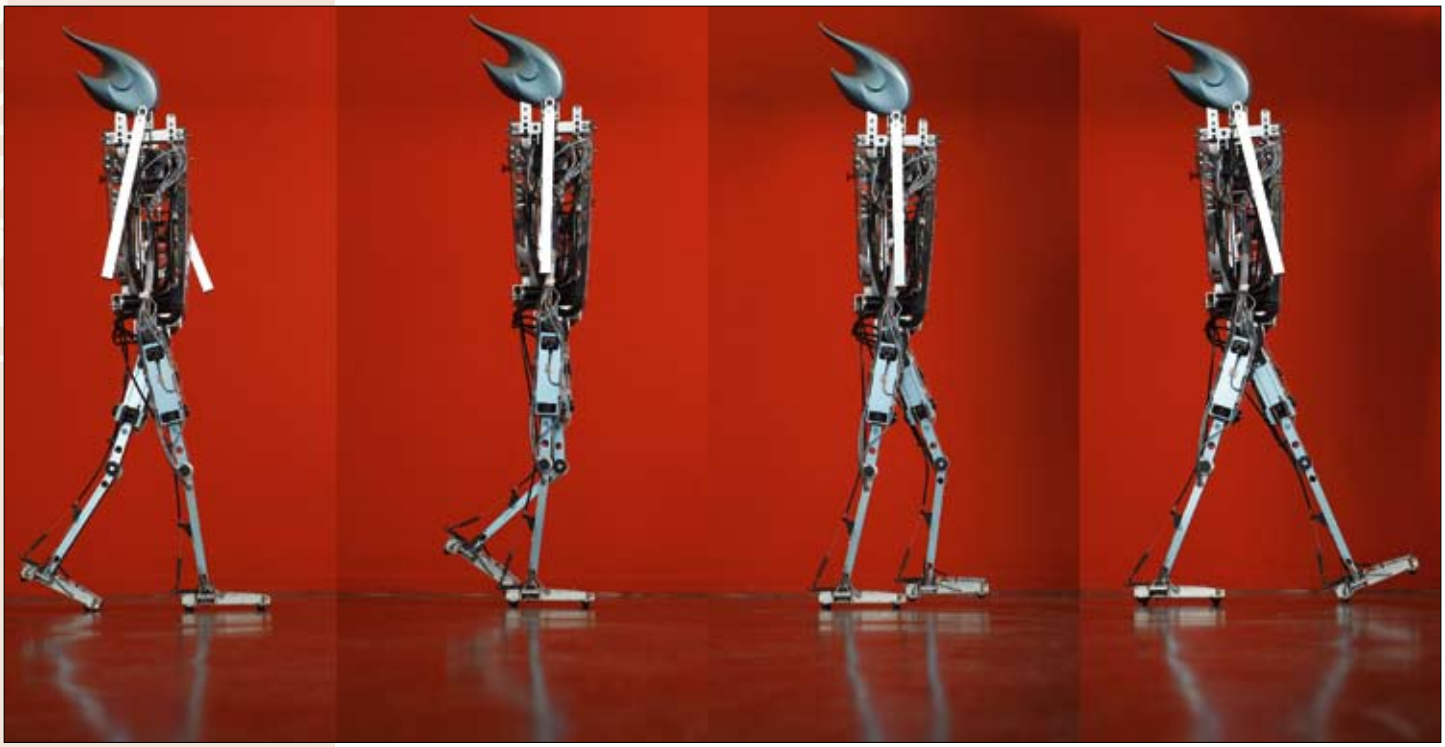
Gravity gives the device sufficient energy to move forward – the robot goes from one foot onto the other, as it were, until it reaches the bottom of the slope. The natural pendulum motion of the legs not only renders walking a low-energy process, but also increases the stability during the walking motion. Whenever a passive dynamic walker is about to fall over because it is moving too fast, its foot hits the surface with greater impact, automatically reducing its speed. The natural frequency of the pendulum motion is restored within a few paces, and the robot stabilises itself. "One of the major lessons we learnt from the passive dynamic walking process is that a robot can perform a stable walking motion without having to be locally stable at every point in time," Hobbelen says. The walker's movements are partly uncontrolled, but the natural dynamics of the system automatically restore mild disruptions to the motion over a number of steps. In his doctoral thesis, Hobbelen named this principle *limit cycle walking*: "Although many researchers are working on this concept, nobody so far had analysed and defined it as such."

Unlike the walking motion of fully controlled robots, a relatively large part of the human walk is uncontrolled

Hobbelen, in collaboration with Dr Ir. Martijn Wisse and Ir. Jan van Frankenhuyzen, developed the prototypes Meta and Flame to further research the principle of limit cycle walking. Hobbelen: "Passive dynamic walkers are of some interest, but in order to render a robot's walking motion closer to that of a human being, the robot needs to be controlled to a certain degree. People also use muscles to move and maintain their stability. If we fit the robots with extra means of control, they will be better able to cope with sudden disruptions, and they will become capable of varying their walking speed." Adding the control systems is a step-by-step process. The preferred option is to keep the control elements in the robots as simple and as local as possible. "It is not our intention to turn it into a super intelligent computer, because that would defeat the purpose. We want to stabilise a machine with the least possible means." Meta and Flame are the successors of another robot, Denise, which Martijn Wisse developed in 2005. Whereas the control systems in Denise were limited to the hips, Meta also features ankle controls. Flame has both ankle and upper torso controls.

A small step

Hobbelen studied how to improve forward and sideways stability by means of control systems located in the ankles and upper torso. For this purpose, he confronted the Meta prototype with



1 A normal step by walking robot Flame begins with the push-off by the rearmost foot, pushing the toe of the foot downwards.

2 Next, the rearmost foot is lifted off the floor. The knee bends to ensure that the leg can swing forward without catching on the floor, and the upper leg is pulled forward.

3 As the standing leg performs a forward falling motion, the knee of the swinging leg stretches.

4 At the end of the step, the knee of the swinging leg is fully stretched, and the foot of the swinging leg makes contact with the floor.

unexpected downward steps, and then studied the effect of the disruption. If a person fails to see such a step, they will probably stumble. If the height of the step is about ten centimetres, chances are that they will be unable to recover. Meta currently manages to remain stable after a three-centimetre misstep. This may seem a minor accomplishment, but scaling the step to human measurements brings it up to the equivalent of a five or six centimetre misstep. "In robotics, that is quite an achievement," Hobbelen proudly states. The main advantage of the controlled robots used by Hobbelen is their versatility. "Passive devices either work or they don't. These prototypes form a research platform: they allow you to make studies of various aspects of the walking process." Hobbelen may have completed his doctoral research, but that doesn't mean that Meta and Flame can now retire: "We have another whole series of experiments planned."

Dynamic Walking 2008

The researchers at the Delft Biorobotics Laboratory are already working in close collaboration with motion scientists, and the number of contacts with robot experts from industry is increasing. At the 'Dynamic Walking 2008' conference held in late May, researchers from various disciplines met at TU Delft to exchange knowledge about the way we walk.

Movies

See Meta, Flame, and Denise walk at the Delft Biorobotics Laboratory website: www.dbl.tudelft.nl.
See http://asimo.honda.com for movies of Asimo as he climbs stairs, runs, and waves his hand.

Stiff ankles

"What do our ankles do when we walk?" This is the question that occupies the minds of both clinical researchers and robot experts. By combining walk analysis and walk synthesis, researchers hope to find answers to the questions they share.

When human beings walk, they derive a lot of power from their ankles. As the calf muscles contract, extra energy is generated, and the tendons act like springs for the ankles. With each step, energy is absorbed and stored, and then released as we push ourselves forward. People who have an ankle dysfunction – possibly resulting from a brain infarction, multiple sclerosis, or partial paraplegia – have a reduced ankle power generating capability, which makes it much more difficult for them to walk. Such patients are often prescribed elastic ankle-foot orthoses (externally worn ankle supports) to compensate for the reduced push-off power.

Daan Bregman, a doctoral student at the Vrije University Medical Centre, Amsterdam, is conducting research on the properties of ankle-foot-orthoses. "When you fit a patient with an orthosis, the big question is how stiff the spring must be to provide the best support for the specific patient," Bregman says. Determining the optimum degree of stiffness is easier said than done, however. "Currently, measuring a patient for an orthosis is largely a question of experience. The physician and the orthopaedic fitter together determine what properties the orthosis should have," Bregman explains. "That the current method leaves room for improvement is shown by the fact that many patients do not wear their orthosis. We simply lack the objective data needed to fit a patient with a made-to-measure orthosis."

It is very difficult to use walk analysis for determining the optimum stiffness of an orthosis. It takes time for people to get used to an orthosis, and, moreover, quite a burden is placed on the patient. It also costs a lot of money to build different made-to-measure orthoses for just one patient.

To gain insight into the relationship between ankle stiffness and length of stride, walking speed, and energy consumption, Bregman used walk simulations developed in collaboration with the Delft Biorobotics Laboratory. Bregman: "These allow us to easily vary the parameters and study how this affects the stride length and walking speed," Bregman says. "The underlying models we use for this purpose are the same as the ones used for the robots."

It will take a while before patients can be fitted with fully customised orthoses. Bregman: "The ideal situation would be one in which we collect a patient's data by means of walk analysis, determine the patient's deficiency based on this data, and then use the results to create an orthosis that compensates for exactly that deficiency." Unfortunately, human ankles don't lend themselves to tinkering as readily as those of Meta and Flame.

Photos: Sam Rentmeester/fmax

‘A large part of my intellectual life is gone’

The Faculty of Architecture (‘Bouwkunde’) building burnt to the ground on May 13.

The fire was started by a short-circuit in a coffee machine.

Many people lost their academic work in the blaze.

Saskia Bonger / Connie van Uffelen

Professor Dr Franziska Bollerey lost decades worth of work. The entire country saw images of her crying as she watched the building burn. Later, in a television interview, she was once again overcome by emotion. A week after the fire, she says she should’ve never watched the building burn. “It was a traumatizing experience to see the rooms of our library burning. I never should’ve gone there to watch. But even now, I still don’t feel any better. I keep thinking of all that was lost. I just can’t imagine that soon I must give a lecture. On Monday and Wednesday I had to attend a PhD thesis defence. I went, because I didn’t want to let anyone down. But what must my colleagues and I do now? How can I give a lecture if all the slides I need are gone? We had 60,000 slides, but only half of them had been digitalized. I really don’t feel very well. I sometimes sit at the table and begin to cry. I dreamt that I was at home and wanted to take a glass from the cabinet, but immediately thought: I can’t, the cabinet is on fire! A large part of my intellectual life is gone.”

‘There’s nothing left’

Dr Ozer Ciftioglu sits with a student at a table in the Aula. They both have laptops open in front of them. They’re trying to do some work. Ciftioglu is actually far from home. “My research focuses on building technology. But let me clarify: I’m a professor at a technological university in Istanbul, but for the past nine years I’ve worked at TU Delft. I lost two important book manuscripts in the fire. One of them contained a year’s worth of work, the other six months. It’s all gone. I had also saved the back-up files in my office. I have no idea what to do. There’s nothing left to refer back to, and I can’t just simply write it all again from memory. What am I supposed to say to the publishers? They commissioned me to write these books. Will they give me time to start over? I just don’t know.”

‘Rowing with the oars we have’

Madeleine de Morree, staff member of the Faculty of Architecture’s International Office, has relocated to the foyer of the Aula, where she hopes international students will be able to find her.

“The International Office was located in the Blokkenhal, so it should be intact. But who knows what damage the smoke and water have done to the files, especially to the portfolios of MSc and exchange students? And what about the demolition work? This is the busiest time of year for new student enrolments, so losing all the portfolios couldn’t have happened at a worse time. Yet we must evaluate the incoming students. If necessary, we’ll take special measures. But for now, we’re making do as best we can, or as we Dutch say, ‘just rowing with the oars we have’.”

‘Okay, we’re leaving soon’

Fourth-year architecture students Jan Wilbers (22) and Benjamin Groothuyse (22) may have only recently completed a course to become emergency building assistants, but it was they who first discovered the fire near the coffee machine. “There was water and electricity there, and that combination is of course dangerous,” Wilbers says. “We stood there thinking: we’ve got to handle this. We decided not to use water.”

The students immediately tried to disconnect the electricity in a fuse box and then grabbed a fire extinguisher. “I don’t remember what type of fire extinguisher it was. Flames were shooting out of the coffee machine, exactly at the place where the coffee normally comes out. We had tried to extinguish the fire a few times, when another emergency building assistant came along and told us to evacuate the building. I thought: ‘Okay, we’re leaving soon’, but in hindsight I’m glad we were forced to leave.”

Wilbers and Groothuyse identified themselves as emergency building assistants and were told to help evacuate people via the staircases. “Everyone was evacuated within a minute. I was surprised that everybody listened so well to us.” ▸▸

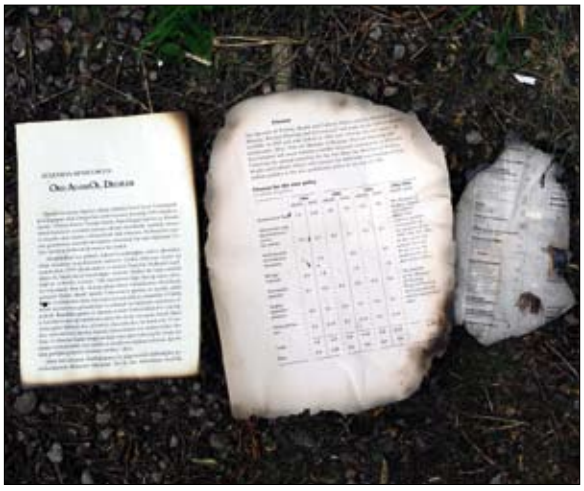
Ongoing investigations

"The fire at the Faculty of Architecture will go down in history as a normal fire," thought Professor Dr Ben Ale, shortly after the fire. He is professor of Safety & Disaster Prevention at the Faculty of Technology, Policy & Management and the former research director of the Netherlands Institute for Fire & Disaster Prevention.

"Fire-fighters attempted to enter the building during the first hour of the fire, but most of them left because the building was in danger of collapsing. At that point, everyone knew the building would burn to the ground. This is normal for tall buildings built in the 1960s if there is a severe fire on the building's middle floors."

The reason why such buildings cannot be saved is partly due to the fact that they are usually not equipped with sprinkler systems – as was the case with the Faculty of Architecture – and also because the fire-resistant materials used in the building are only fire-resistant for 20 minutes, whereas nowadays that period of time is two to three times longer. Ale says mistakes were not made: "Everyone evacuated the building in time. This was exceptionally well done."

It was later revealed that at the time of the fire the TU did not have an occupancy permit for the Faculty of Architecture building. This is a legal requirement for buildings with more than fifty occupants. Work was still being done to meet the fire safety requirements, such as adding fire-resistant partition walls. When this work was completed, a permit would've been issued. This is also the case for other TU Delft buildings. Ongoing investigations must clearly establish whether the added partition walls slowed the spread of the fire less than was expected; if cutting off the electricity was considered to prevent a short-circuit; and if the repairs being made to the burst water pipes caused the water pressure in the building to be too low for extinguishing the blaze.



Planned, laid to waste, and risen from the ashes

Robert Nottrot is the curator of the exhibition 'Architecture Collections — past, present & future', which was scheduled to open on 15 May at the Faculty of Architecture. Sadly, two days before the opening, the 'Bouwkunde' faculty building was gutted by fire.

Jos Wassink

The press release lists the exhibits on show: eighty models of designs by such great names as Le Corbusier, Loos, Duiker, and Frank Lloyd-Wright. Then there are scale models by Gerrit Rietveld, chairs by J.J.P. Oud, Prouvé, Gispen, and Rietveld, among others. And some antique artefacts from the Sluyterman Collection. But then, two days before the exhibition was due to open, a burst water pipe causes a coffee vending machine on the sixth floor to short-circuit and catch fire. At the time, exhibition curator Robert Nottrot is in a meeting and has to leave the building. He later says about the event: "With coffee flasks and papers we walk against the flow of people being evacuated, through the hallway and to the dean's Portakabin office to continue the meeting."

'When I get home to my wife, I weep'

Evacuation is rapid and goes entirely according to plan, but the fire unexpectedly takes hold and spreads. Nottrot: "Watching the fire we cancel the next meeting. When I get home to my wife, I weep. She and I had worked late until Friday night working on the exhibition. Now it was all gone. That's what we believed, and many others with us."

National newspaper *De Telegraaf* led with 'Treasure Room Inferno', and education minister Plasterk called it 'the worst disaster to hit Dutch academia'.

The next morning however, the low-rise extension to the faculty building, which is where the exhibition was staged, turns out to be intact. A colleague tells Nottrot how the fire service plans to retrieve the exhibits from the venue. "At that point my misery roller-coasted to great joy," he recalls. "I went to the site, saw all those hulks of men, and thought, Oh dear, those models need careful handling. In the end they let me near. All but three of the models had already been collected from the building, and all the chairs where waiting outside. When we inspected them at close range, everything turned out to be clean, and even the smallest details had remained intact. The exhibition suffered no damage from smoke or water. We were very lucky."

Now it is known that Architecture Collections had been saved, messages pour in from museums offering space to store or exhibit the collection. Nottrot decided to wait. "The great amount of grief tends to go unnoticed. I feel ashamed. The collection that has been saved has suddenly multiplied in value. Never in its wildest dreams could the Architecture Collections initiative have hoped for so much publicity. What was originally intended to be educational material has suddenly been promoted to museum pieces."

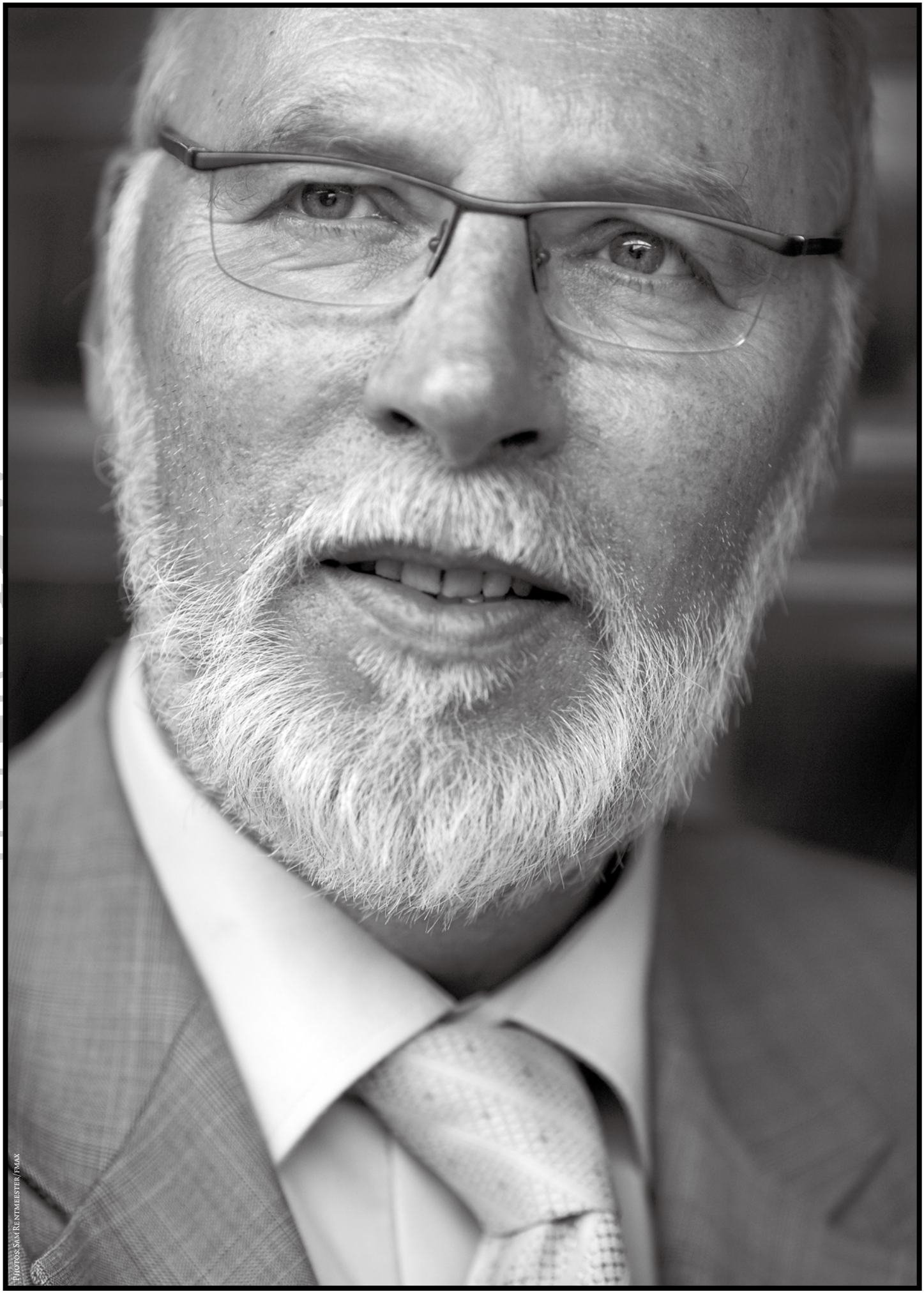
Photo: Sam Rentmeester/fmax

Stick chair by Gerrit Th. Rietveld, 1924, in temporary storage.

Robert Nottrot set up the Architecture Collections exhibition together with collection curator Tessa Wijtman-Berkman, Charlotte van Wijk (curator of the chair collection), and student-assistant Inge de Boer. The plan is to open the exhibition in September when a suitable location on the university campus is found.

Photo: Hans Stakelbeek/fmax

FOCUS



Photos Sam Rentmeester / fmax

‘Holland will never be finished’

In 2005, coastal hydraulic engineering professor Marcel Stive issued a warning that was quickly pounced on by the national media: Holland was not as safe from floodwaters as we had thought. Some of the primary defences failed to meet the requirements established in the Water Defences Act. Stive has now become a member of the new Delta Committee, which will publish its recommendations later this year. “The best possible protection from floodwaters is a kind of basic right.”

Joost Panhuysen

Are the dikes weakening?
“No, they have even been reinforced. But they were never given the strength required by the Water Defence Act. Maintenance has been given too little priority. It wasn’t a question of indifference, but rather that politicians have simply never made sufficient funding available.”

You have stressed that the problem is not limited to the coast.
“Along the rivers the quality of some of the primary defences against floodwaters also fail to meet the prevailing standards. We do have weak points in our coastal defences, although some of them have recently been redressed. In Noordwijk, a ‘dike in dune’ solution has been chosen. This prevents the dunes from being further eroded into the sea, and brings the promenade and surrounding buildings behind the dikes. Scheveningen has also opted for a similar approach. Spanish architect De Sola-Morales has already designed a modified promenade. I’m pleased to see so much energy being spent on coastal defences.”

So your warning is being heeded?
“The process was accelerated because the media picked up the issue in 2005. For years, my colleague at TU Delft, Han Vrijling, and other professors in the expertise network on floodwater defences, had been shouting warnings that the limits were reached. In 2005, that warning suddenly got full media attention. The time must have been ripe, and, to my surprise, I found myself at the centre of it. I was just the messenger bringing the bad news, that’s all.”

And so the messenger had his head chopped off?
“Not quite. True, the civil servants at the Ministry of Transport and Public Works were afraid that my story could spell political trouble for their state secretary, or even the minister. But many others welcomed the message.”

Those parts of the defences that have been found lacking in quality, do they fall just short of the standards established in the 1996 Water Defences Act, or are they totally inadequate?
“Just short of the standard or way below it, it doesn’t matter. If or when the critical water levels are exceeded, the problem will be just the same. The statutory standards for acceptable risks are based on the calculations that mathematician Van Danzig, of the Centre for Mathematics and Computer Science, made for the first Delta Committee. Having higher, stronger dikes means reducing the risk of flooding to once every ten thousand years, or once every five hundred years, for example. And in the long term this also lowers the cost, because the smaller the chance is of a flood occurring, the less the damage to the economy. At the time, a conscious decision was made not to accept a greater risk that would put the burden of the consequences on future generations.
I’d be happy if only the defences met the standard, even if at the time the standards were set we couldn’t take into account the information we now have at our disposal, such as the risk of rising sea levels, or waves that hit the coast harder than previously thought. The effects of a flood today would also be much worse, because more people live behind primary defences and there is more trade and industry, not to mention the ecological damage and damage to the Netherlands’ reputation.”

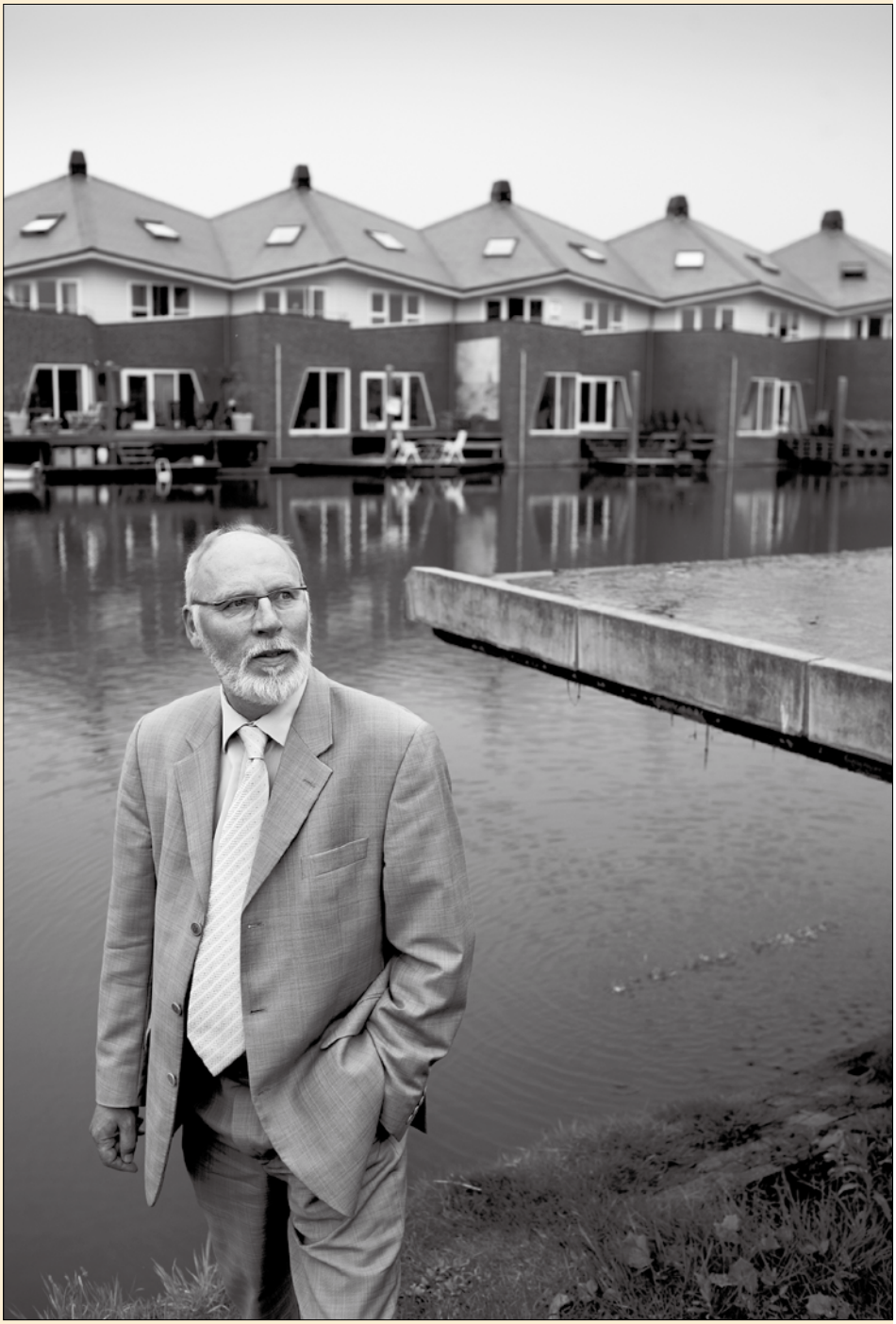
How high is the risk of flooding?
“Higher than we initially thought. Traditionally, a ring of dikes is assessed by subdividing the ring in dike or dune sections, but if you regard the system as a whole, altogether different failure mechanisms appear, and then suddenly the chance of a flood occurring is much higher. The major flooding that would originally occur only once every ten thousand years could happen once every thousand years. This is something to be worried about.”

Once every one thousand years might sound reassuring to the average person in the street.
“It might, but this is one of those disaster scenarios in which large numbers of people could be killed. And a flood is the most probable disaster scenario.”

Suppose the weakest links at Ter Heijde and Scheveningen were breached, which areas in the ▸▸

Who is Marcel Stive?

The composition of the new Delta Committee is remarkable, with members that include Professor Louise Fresco; Jaap van Duijn, the former manager of Robeco; and Marcel Stive, a coastal hydraulic engineer specializing in coastal structures and known for his critical and independent positions. Of the Delta Committee, Stive says: “These are people who are open to arguments.”
As a civil engineering student, Stive was captivated by the hydraulic engineering lectures of Professor E.W. Bijker. Later, when he found he was in danger of becoming too much of a manager with too little time for research, Stive decided to give up his career at the WL Delft Hydraulics Laboratory and accept a position as a top researcher at the Polytechnic University of Catalonia, in Spain. He has been professor of coastal hydraulic engineering since 2001. Despite his reservations (“Actually, I thought they should’ve found someone younger than me”), Stive was recently persuaded to serve as one of the chief planners responsible for helping to set up the four new International Research Platforms (health, energy, infrastructure, and environment). He is also the chief planner of the environmental research platform.



province of Zuid Holland would be in greatest danger?

"Not the central areas of towns like The Hague, Delft, Rijswijk, or Zoetermeer, because they are all on higher ground. The people who settled there ages ago wanted to keep their feet dry. However, new housing developments like the Wateringse Veld near The Hague were built in low-lying areas. The best houses are often found in the most poorly situated areas."

How much time would the people in those areas have to reach higher ground?

"Hardly any. If you were to see the speed at which everything happens in simulations... But I'm betting that the politicians will eventually opt for a sustainable long-term solution to these problems. It must be possible. And it would also cost next to nothing: only one billion euro, which is just 0.1 percent of the gross national product. Peanuts when you compare it to the eleven billion euro the state fails to collect annually because mortgage interest is tax-deductible."

How long would that one billion euro investment last us?

"We'd have to spend 1 billion every year, as long as the country exists. When the Eastern Scheldt Flood Barrier was inaugurated, the queen – and who would dare speak against the queen? – said: 'The Delta Defences are finished'. That's a misconception. We've had district water boards for over a thousand years because, in this sense, Holland is not finished and never will be."

A government could do lots of other nice things with 1 billion euro a year.

"It should be seen as a business case. We're all living in a delta region. So is 1 billion really so much money for something that is absolutely essential if we're to keep living here? The fireworks disaster in Enschede and the pub fire in Volendam led to extreme safety measures being enacted for very specific aspects. There's nothing wrong with that, but you can see how the emotions surrounding those events resulted in drastic measures aimed at further minimizing what was already a very low risk. The government can

When the Eastern Scheldt Flood Barrier was inaugurated, the queen said: 'The Delta Defences are finished'. That's a misconception

do this by shifting the costs to the citizenry. But it seems the government cannot insist on something being done that would benefit us all, like protection against floods, even though that is where the real risk lies. Now that is strange. It would be normal to expect a politician to act before disaster strikes, and not only after."

So why don't they?

"Members of government always begin their cabinet term with a shopping list that is based on the cabinet formation negotiations. Only later do they learn what the real problems are, but by this time they are bound hand and foot to the national budget."

Will it really take a major flood disaster for an annual one billion euro to be invested in Holland's coastal defences?

"It's possible. And that's why the experts were 'happy' to see the levees break in New Orleans, almost three years ago now. They weren't happy about the humanitarian disaster, but they were happy about the warning it conveyed."

Where could be the next New Orleans?

"All the US coastal areas have problems. They're working on them, but there too it's a question of how to solve the problems and at what cost."

And rising sea levels: isn't it difficult to predict how such a risk will develop?

"Fortunately, the rate of climate change is very slow compared to the life span of our coastal defences. There is enough time to modify them. Of course we must closely monitor the situation, but so far climate change hasn't caused any major problems for our coastal defences. In four successive reports, the Intergovernmental Panel on Climate Change (IPCC) has issued increasingly lower than expected estimates of sea level rises."

So the situation is not as bad as we thought, but still alarming?

"Something like that. But it has become easier to calculate the risks to our coastal defences."

Do offshore islands make a valuable contribution to coastal defences?

"They do of course protect the coastal areas behind them, as the Frisian Islands do. Offshore islands act as breakwaters; however, these islands won't simply remain stationary. It's often the case that you must extend your primary defences to twice their original length. This is incredibly expensive. Adriaan Geuze estimated forty billion cubic metres of sand. One cubic metre of sand costs at least one euro, so that says enough. I'm not opposed to such islands, but you need a good business case, like, for example building an airport or a couple of nuclear power plants on the island."

Offshore islands don't appear to be the best solution right now. So what is?

"The dike in a dune concept is an innovative scheme that offers a real solution. As for the water defences of urban areas, such as Dordrecht and Rotterdam, a much more systematic approach is required to ensure that the dikes are wider and breach less easily. People could live and work on such dikes, and there are some good examples of this. The homes of the people living atop such a dike might occasionally get flooded during extreme flood levels, but the dike would not be breached."

Another innovative solution: live on artificial hills. Let the water go its way, as in olden times.

"It is of course a romantic notion, but let's consider the dike ring in which the university is located – no. 14. Suppose we decided to construct a new urban area on an artificial hill. If a flood occurred, the damage in the area around the hill would be worse, because the hill itself takes up space, which would cause the water levels in the surrounding areas to be higher. The soil required to construct that hill could be put to better use reinforcing weakened dike structures, which would make everyone safer. This is about the solidarity among us all. It is not a problem you can solve for individual cases. This is also why flood insurance is such nonense. We all agree that the state must ensure that we have the best possible protection from floodwaters. This is a kind of basic right. You would therefore need very strong arguments to make exceptions for certain groups."

You are one of the new members of the newly formed Delta Committee, which has many critical, independent minds on it. Is this a sign that your message has been received in political circles?

"People have been listening, and I'm glad of that."

Or is it that you've been assimilated. If someone is being troublesome, then stick him in the committee.

"It's still too early to tell whether anything has actually changed. Nonetheless, the signs are positive. The chairman, Cees Veerman, put his hand on his heart and swore that this will not be a report that simply gets buried in the back of a drawer somewhere. And he was serious."

What is your assignment?

"Our assignment is to advise the government on the sustainable coastal developments of the next hundred to two hundred years, but we have interpreted our assignment to include more than that. The rivers are also an issue, and fresh water management is just as important an issue as coastal defences. Closing off the Zuyderzee created a unique fresh water basin, but if the sea level rises, it will be difficult to get rid of excess water by natural means. We would then have to start pumping, and pumping costs a lot of money and energy."

Won't the government have great difficulties accepting the Delta Committee's recommendations?

"We must very carefully consider how best to convey the message. Scaring politicians or the public is not always the best strategy. You don't want to be viewed as a prophet of doom, yet you also want to ensure that you get your message across clearly. Fortunately, Veerman is highly effective at prompting political action. We know that we should not make recommendations without providing insight into what they mean in financial terms."

It is the most fuel-economic vehicle in the country, the powered banana of the Eco-Runner II team. The design is a radical change from last year. The aluminium frame has gone, to be replaced with a monocoque of carbon composite for the body and a polyethylene canopy. The combustion engine has been replaced by an electric motor powered by a fuel cell running on hydrogen. The students' calculations say the new drive system doubles the vehicle's efficiency. At the Shell Ecomarathon event in Nogaro in France they managed the equivalent of 1467 kilometres on a single litre of fuel. Not bad at all, they thought, but they can do even better.

Photo: Sam Rentmeester/fmax


DOW

Measuring in a wall of air

Researchers at TU Delft's aerodynamics laboratory are developing a unique method for visualising fast airflows. The research, led by Professor Dr Fulvio Scarano, received a welcome boost this year in the form of a European Research Council grant and a professorship. The research project aims to help create quieter aircraft and safer space shuttles.

Jos Wassink

It was twenty years ago that Joris Ivens completed 'A Tale of the Wind'. In what was to be his last epic, the old master of cinema set himself the impossible task of capturing the wind on film. The result was a whirlwind of associations and memories from a rich life, in which the veteran film maker was propelled by – here it comes – the wind. "The wind sees everything," Ivens explained, "it is the grand force that moves mankind along."

Although today's researchers at the aerodynamics laboratory have the same goal, to capture the wind on film, their approach to the problem is rather more pragmatic and focused, and the results are likely to be somewhat less poetic.

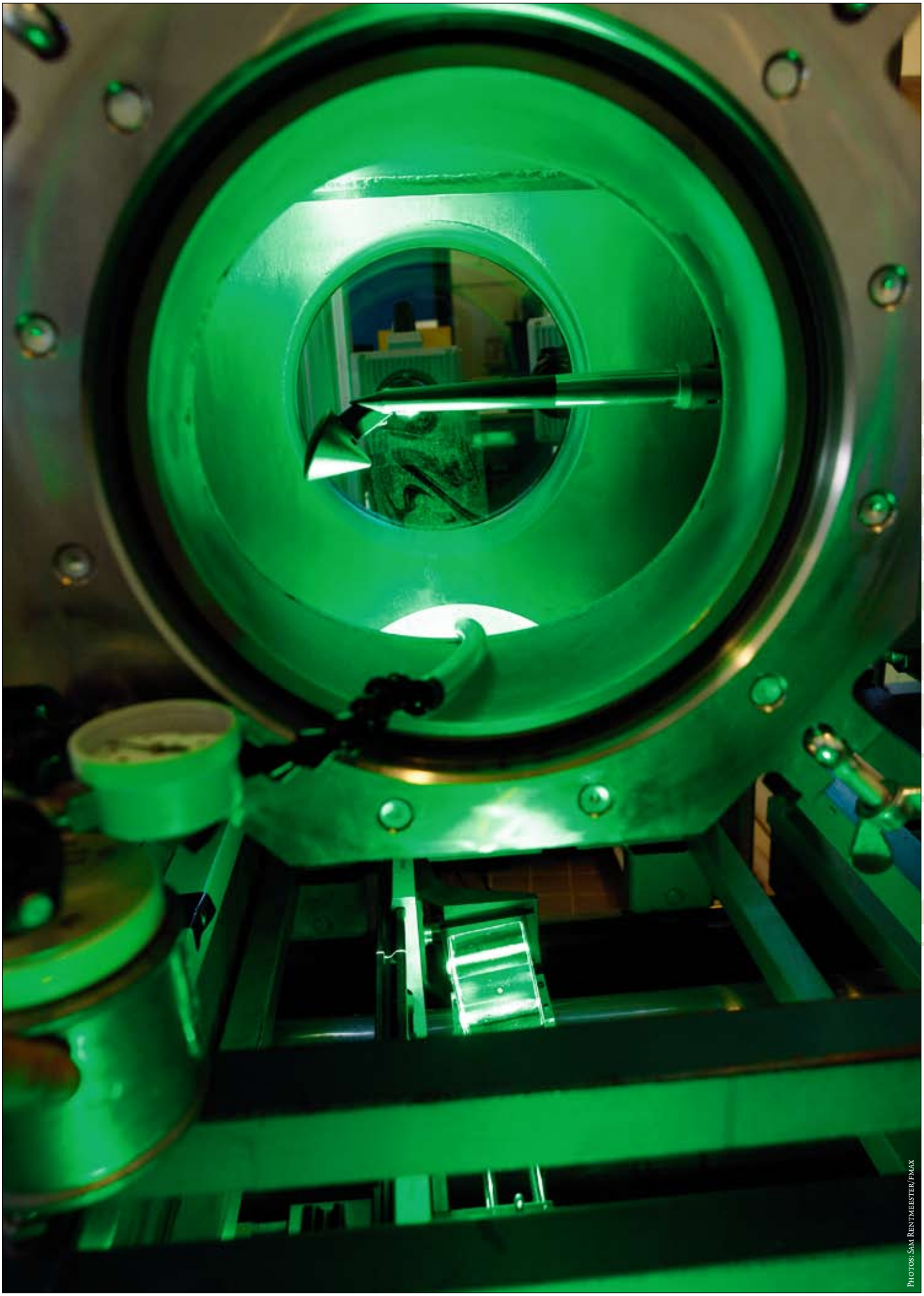
When the experiment is about to start in the wind tunnel hall of the *Hypersonic Test Facility Delft* (HTFD), most of those present are wearing ear protection to protect them from the engine noise of the compressors and the vacuum pump. The equipment stretches the length of the hall, at the end of which sits the faded green vacuum tank, in front of which is the measuring section with a porthole through which two cameras are pointing. Inside is a scale model of a space capsule that is smaller than a sparrow. The whole structure has been screened off as much as possible to contain the literally blinding green light of the one hundred kilowatt laser within. The researchers wear special goggles that filter out the laser light. Once a vacuum has been created at one end of the equipment, with eight hundred degrees Celcius air at a hundred times atmospheric pressure pushing against the other side of the valve in the Ludwieg tube, everything is ready for the test. The laser light is switched on, the cameras start to run at a thousand frames per second, and someone gives the go-ahead. Then a bang like cannon fire reverberates through the hall. In slightly over one-tenth of a second all the air has rushed from the high-pressure chamber into the vacuum tank, passing the test object at speeds of up to a thousand metres per second – or as fast as a bullet in flight. Converted to the scale of the model in the wind tunnel, this corresponds to six to eleven times the speed of sound (Mach 6 to Mach 11), which is enough to simulate a space capsule during re-entry at an altitude of sixty to seventy kilometres. A returning space shuttle initially reaches Mach 24.

A bang like cannon fire reverberates through the hall

Heat

"During re-entry a spacecraft has enormous kinetic and potential energy levels," says Professor Dr Fulvio Scarano. In March of this year, Scarano was appointed professor of aerodynamics at the Faculty of Aerospace Engineering, specialising in experimental aerodynamics. "Just imagine driving a truck at seven kilometres per second and having to descend a one hundred kilometre high mountain," Scarano says. "There's no chance your brakes would survive that. To a space ship coming down through the atmosphere, the air feels like a brick wall." The heat rises to thousands of degrees, causing the gas molecules to disintegrate and form a plasma that attacks the skin of the spacecraft. The heat, like the pressure, is a serious challenge facing spacecraft engineers. This is the type of problem being investigated with the help of the hypersonic wind tunnel.

"We didn't pick the altitude of sixty to seventy kilometres at random," aerodynamicist Ir. Ferry Schrijer adds. "It's the height at which the airflow, which starts as a laminar flow along the surface, ▸▸



Photos: Sam Rentmeester/fmax

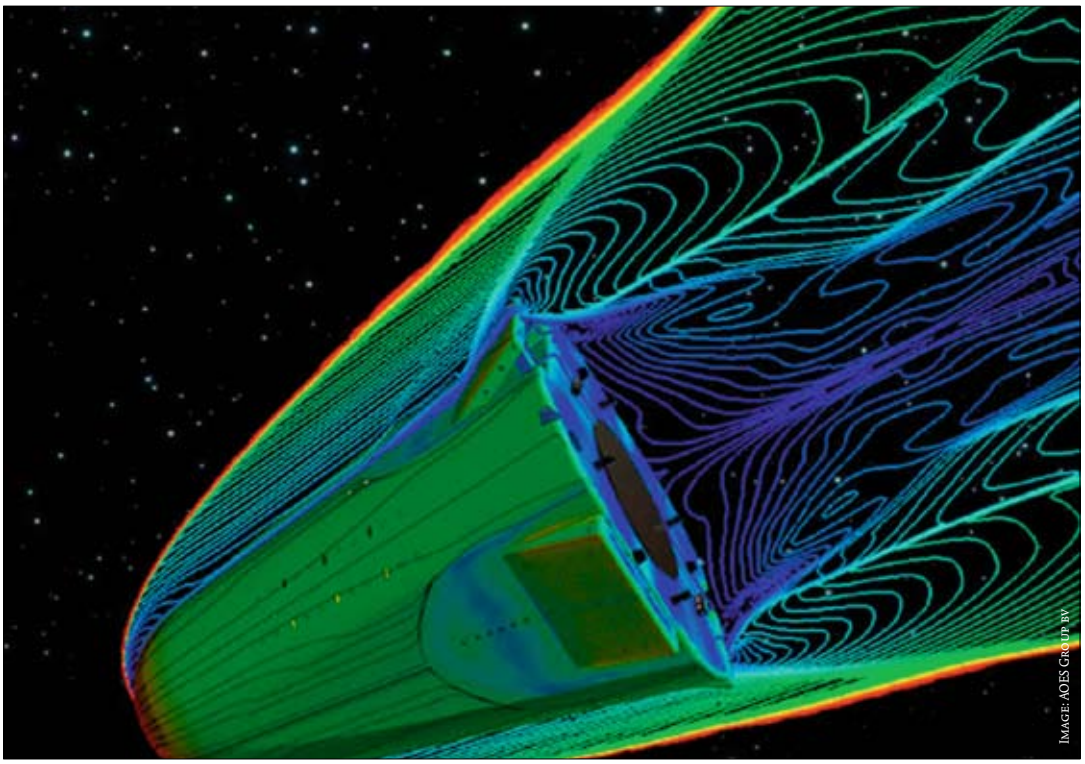
Ir. Ferry Schrijer: "The airflow becomes unstable at a height of between sixty to seventy kilometres"

begins to become unstable, so that the least disturbance will transform it into a turbulent flow that detaches itself from the surface. The result is a much more pronounced mixing of air, tripling the amount of heat transferred to the space capsule."
In the hypersonic wind tunnel, Schrijer and his colleagues are investigating the extreme airflows around models of space capsules in order to gain more insight into where the heat is most likely to build up, and how the shape of the capsule affects this. Traditionally, this type of research uses solid steel models featuring dozens of ducts and tubes acting as pressure probes. Such models are a real challenge for the model workshop, as well as a source of pride to the lab, but they are also difficult to make and therefore expensive. A new imaging technique renders the steel models superfluous, however, as it is now possible to use solid plastic scale models.

Filming air

The method used by researchers to visualise airflows is called *particle image velocimetry* (PIV) and uses minute, white titanium dioxide globules (half a micrometre in size) that are mixed with the airflow. Titanium oxide, TiO_2, is a whitener, best-known for its use in toothpaste and primer. The globules, about ten of them to each cubic millimetre of air, are illuminated by the laser using two ultra-short (two hundred nanoseconds) flashes separated by a pause of one microsecond. A rough PIV image can be recognised by its pattern of dot pairs about a millimetre apart. A computer program converts the distance between the dots of each pair into a local flow velocity and a flow pattern for the object as a whole. This reveals where laminar flow breaks up into turbulent flow, and how a shock wave progresses along the model.
The use of two cameras rather than one also makes it possible to measure the velocity across the airflow in the direction of the cameras. The stereo PIV tests on an angle beam in the wind tunnel show that the velocity in the observation direction is considerable in turbulent regions. This means that a 3-D image of the flow was required, in particular in the case of a realistically formed model of a capsule.
In a proposal submitted in 2005, Scarano wrote: 'Flow turbulence is intrinsically three-dimensional and its full description requires the application of measurements able to capture instantaneously its three-dimensional structure, the complete stress tensor and the vorticity vector.' In the article, which he wrote together with Dr Ir. Gerrit Elsinga, Dr Bernd Wieneke, and Dr Ir. Bas van Oudheusden, Scarano lays the foundations for a PIV system capable of creating a three-dimensional image of the airflow in a volume the size of a mobile phone. The system requires more cameras, at least three, and for practical purposes often four or five. Each of the cameras records images of the titanium globules illuminated by the laser pulses. This results in two sets of camera images separated by a microsecond. A computer algorithm converts the camera images into a three-dimensional distribution of the illuminated particles, similar to the way a hospital scanner constructs a three-dimensional view of a human body using a large number of sectional images. The process, known as tomographic reconstruction ('tomography' meaning 'writing in sections'), results in a set of three-dimensional particle distributions with a one-microsecond interval. These can be used to reconstruct the flow pattern in three dimensions. For practical purposes the researchers use the average value of at least thirty images for a single reconstruction in order to be able to distinguish patterns from random turbulence. The first images to be recorded using this process exposed the vortices behind a cylinder. Scarano shows them on his laptop computer: "You can actually see the airflows!" he exclaims. "This is a completely new field of research. For the first time we can actually see how complicated the air turbulences are that cause a flag to flap and flutter in the wind."
To develop this technique, Scarano recently received funding to the tune of 1.5 million euros from the European Research Council (ERC), in the form of

'For the first time we can actually see how complicated the air turbulences are that cause a flag to flap and flutter in the wind'



An impression of the airflows around the experimental European space capsule EXPERT. The shockwaves against the nose and the rear flaps are clearly illustrated.

a Starting Independent Researcher Grant. "This support gives me ample autonomy to lead the research and appoint doctoral students," says Scarano, who also received his professorship in late March. "This degree of freedom is very important to me, because some countries, including my native Italy, will not give a young researcher the opportunity to lead a research project and decide about expenses."

In his application to the ERC, Scarano emphasised the importance of knowledge about air turbulence to create quieter and more economic aircraft. He gesticulates to show how the air flows along a wing surface, and how turbulence is created in the process. The turbulence induces the vibrations we hear as hiss, noise, or rumble. Knowing how exactly the air flows will help contribute to the construction of quieter aircraft and silent helicopter rotors. However, before we can reach that point, a lot of laboratory work will first have to be done. Calculating the speed of each of the approximately hundred thousand dots in the research cavity currently takes an 8-processor computer no less than three weeks. Together with two post-doc researchers and a doctoral student, Scarano expects to be busy until 2012 accelerating the processing of the video images. He thinks that smart algorithms running on larger computers can speed up the calculations 10,000 times. In addition, Scarano intends to increase the size of the available research cavity, which is currently only twenty cubic centimetres or approximately the size of a mobile phone. This will require an even more powerful laser.

As a specialist field for TU Delft, Scarano sees unique opportunities in the application of three-dimensional PIV in hypersonic conditions. "As far as I know nobody else is doing this yet," he says. "Certainly not in Europe." The European research programme, EXPERT (European eXPErimental Re-entry Testbed), which focuses on exploratory research into the feasibility of a re-usable European spacecraft, is in dire need of just such a test facility, according to the TU Delft researchers. At a later stage, Russian Volna rockets (left over from the Cold War) will carry research capsules outside the atmosphere, from where they will re-enter the atmosphere at speeds of five, six, even seven kilometres per second. A Perspex model of the EXPERT capsule is already ready and waiting to go at the Delft lab.

Prof.dr Fulvio Scarano: "You can actually see the airflows!"

Orion space capsule during re-entry
The velocity of a satellite in orbit around the earth is 7.5 km/s. A capsule returning from space drops back into the atmosphere at the same speed of 27,000 km/h (Mach 25). During re-entry a capsule needs to provide as much resistance as possible while generating as little heat as possible in order to reduce its speed without burning up. Friction from the air heats up the surface of the capsule to very high temperatures, several thousand degrees Celsius.

Orion capsule
NASA is working on a new capsule for missions to the Moon and Mars. The Orion capsule (5.5 m diameter) is to replace the Space Shuttle in 2014. Advanced insight into the airflow around the Orion is to result in an improved capsule design.

Experiment
in hypersonic wind tunnel

1 Capsule model
Solid plastic scale model of a capsule (5 cm diameter)

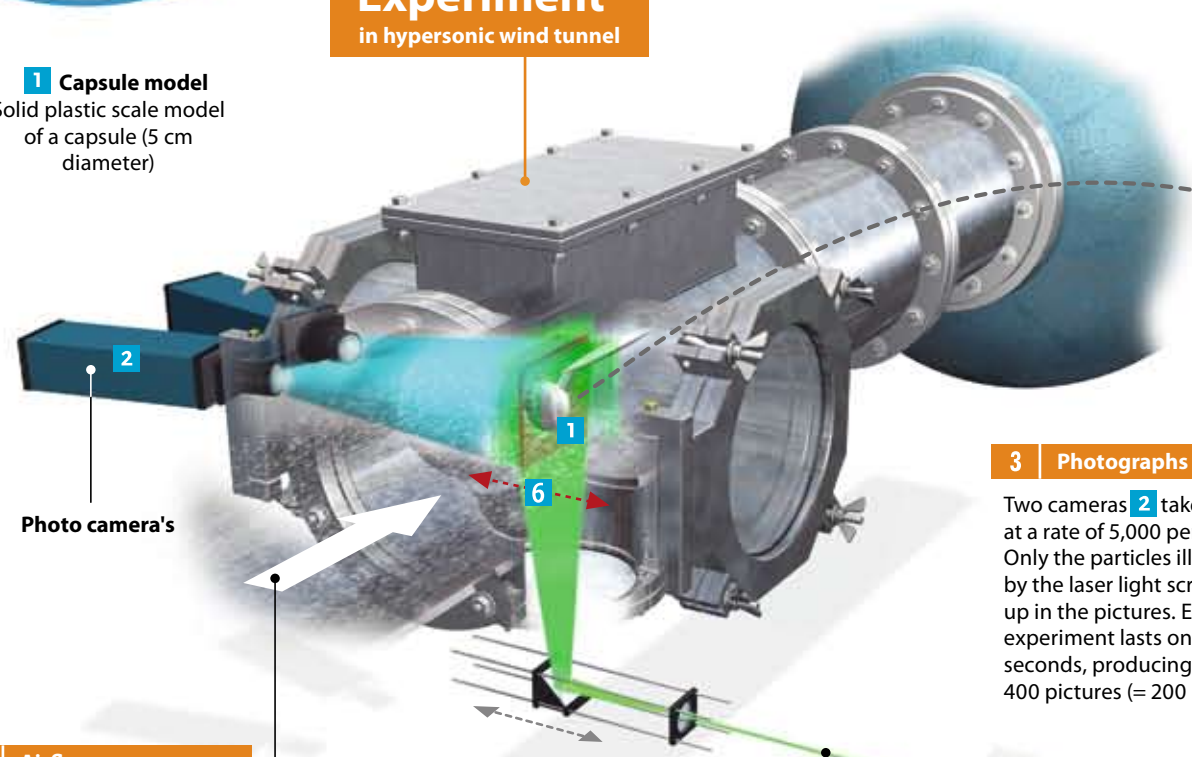


Photo camera's

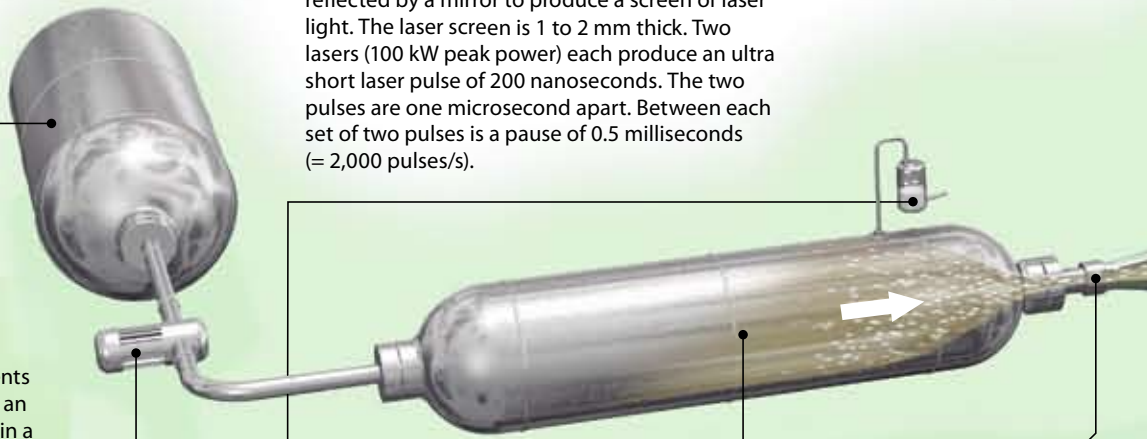
3 Photographs
Two cameras 2 take pictures at a rate of 5,000 per second. Only the particles illuminated by the laser light screen show up in the pictures. Each experiment lasts only 0.13 seconds, producing approx. 400 pictures (= 200 PIV images).

2 Airflow
The valve 3 opens and the air rushes from the high-pressure chamber into the vacuum tank, passing the test rig at a speed of 1000 m/s (Mach 6-11). The airflow lasts 0.13 seconds, during which time the laser produces 200 pulse pairs.

6 Shifting mirror

1 Laser pulse
A laser beam passes through a lens and is reflected by a mirror to produce a screen of laser light. The laser screen is 1 to 2 mm thick. Two lasers (100 kW peak power) each produce an ultra short laser pulse of 200 nanoseconds. The two pulses are one microsecond apart. Between each set of two pulses is a pause of 0.5 milliseconds (= 2,000 pulses/s).

Storage vessel
300 m^3 of air at 40 bar



Compressor

Reservoir containing white particles
White titanium dioxide particles (0.5 micrometres across) are mixed with air (approx. 10 particles per mm^3 of air) and injected into the high-pressure chamber.

High-pressure air chamber
100 bar, 500° C

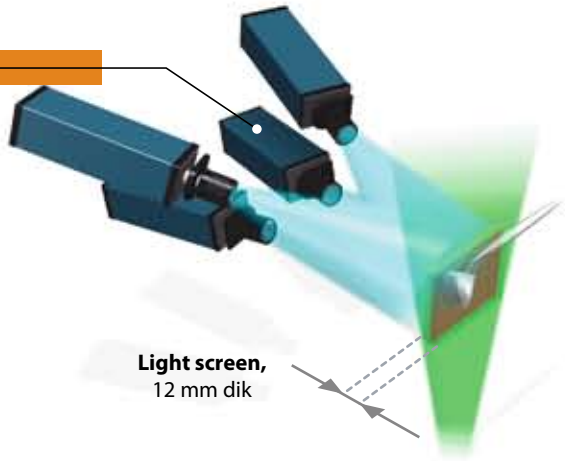
Valve 3

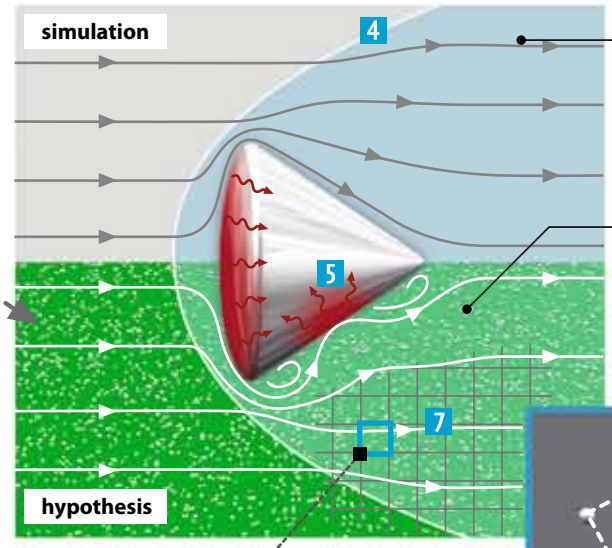
Mach number
The Mach number (Ma) represents the ratio between the speed of an object and the speed of sound in a medium. At Mach 2 the object's speed is twice the speed of sound. At sea level the speed of sound in air is 1,224 km/h, while at an altitude of 11 km it is 1,062 km/h. Speeds are classified as subsonic (Ma < 1), supersonic (Ma >1), or hypersonic (Ma > 5).

Shock wave 4
When an object exceeds the speed of sound, a large pressure differential is created just in front of the object. This pressure differential expands in all directions, but as the object is moving forward, a cone-shaped shock wave is produced. Behind this shock wave the flow speed decreases, and the temperature and pressure increase.
At very high Mach numbers the temperature increases to such a level that air molecules degrade into separate atomic nuclei, creating a cloud of charged particles (plasma).

5 Three-dimensional PIV system

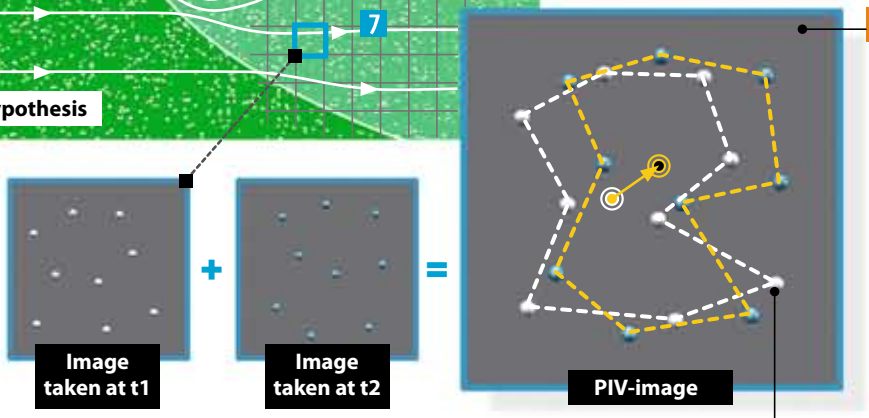
By using at least three cameras the depth coordinates of the white particles can be distinguished, enabling a 3-D flow pattern to be visualised in a three-dimensional volume (rather than in just a flat plane). The light screen of the laser has a thickness of approx. 12 mm.





Computer simulation
It is unknown how the hot air flows along the sides and rear end of the capsule. According to computer models the airflow hits the front end of the capsule (which as a result becomes extremely hot) and then move along the sides of the capsule.

Hypothesis of possible experimental result
It is possible that in reality the hot airflow becomes detached from the side of the capsule and then comes back into contact with it 5. This would put a higher thermal load on the side wall than originally envisaged, so additional thermal shielding would be needed in those spots to protect the capsule.

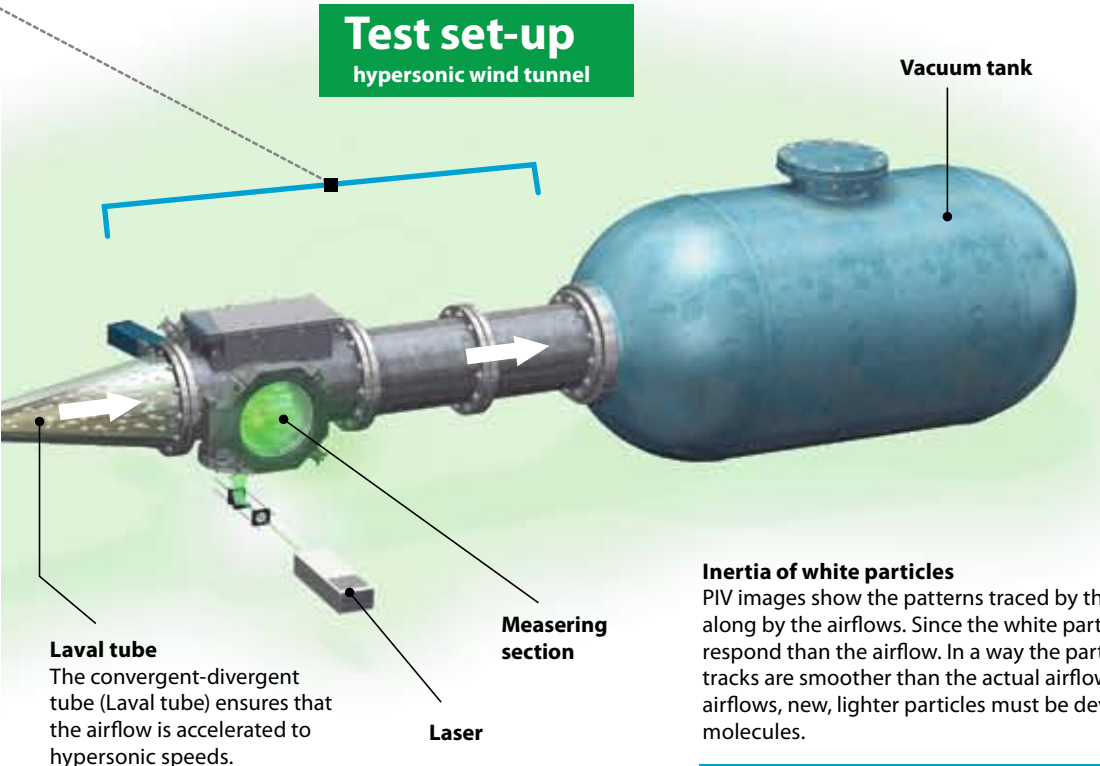


4 Particle Image Velocimetry (PIV)

Two images taken by the two successive laser pulses together form a PIV image. A computer converts the two images into a 3-D distribution of the white particles and then uses their shift in position to calculate the velocity vectors. The maximum shift is about 1 mm (1000 m/s × 1 microsecond). By moving the laser plane 6 a series of velocity profiles are produced which together form a 3-D image of the flow pattern of the air rushing past the model. By using two cameras instead of a single camera the velocity at right angles to the airflow can also be measured.

Smart algorithms
The computer has to determine how a dot moves. This is not so easy because the dots all look alike. The computer divides each image (1024 × 1024 pixels) into a grid 7 and searches for unique patterns of about 10 dots that undergo a shift and a deformation between the two images. The grid size is continuously reduced throughout the process. The smallest grid window measures 21 × 21 pixels, corresponding to 1 × 1 mm. A PIV image contains about 100,000 particles. At 10 particles per window, 10,000 velocity vectors are calculated for each measurement. If smarter image recognition and calculation algorithms can be devised, the velocity calculations could be speeded up 10,000 times.

Test set-up
hypersonic wind tunnel



Laval tube
The convergent-divergent tube (Laval tube) ensures that the airflow is accelerated to hypersonic speeds.

Inertia of white particles
PIV images show the patterns traced by the white particles as they are borne along by the airflows. Since the white particles have mass, they are slower to respond than the airflow. In a way the particles go wide at the bends, so their tracks are smoother than the actual airflow. In order better to visualise the airflows, new, lighter particles must be developed that behave more like air molecules.

Super atoms mimicking elements

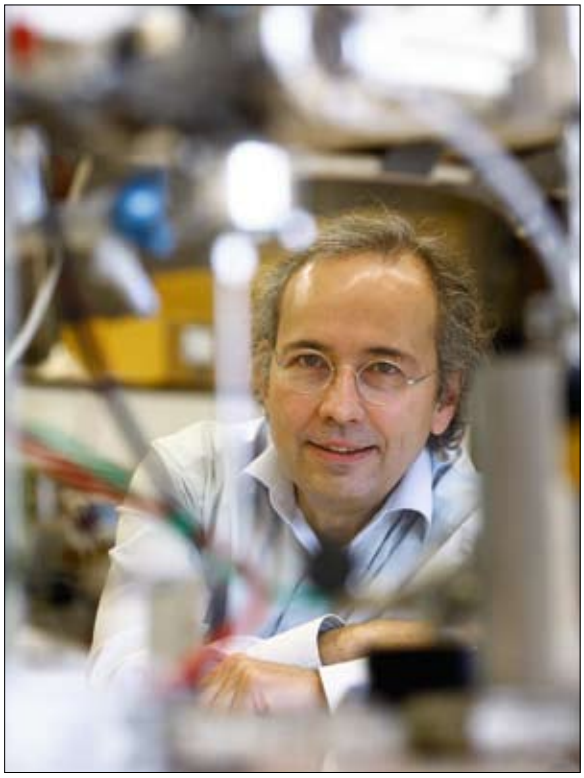
The achievement falls short of actual alchemy, but the silver 'super atoms' recently created by TU Delft researchers have turned the periodic table of elements on its head. "This research is leading to a whole new branch of chemical engineering."

Tomas van Dijk

"A modern form of alchemy? Well yes, in a certain sense we are creating new atoms, so-called super atoms, but we're not going to create gold. Our work focuses on entirely new types of matter, such as crystals with new, special magnetic, optical, or electrical properties. It's fascinating. Our research is leading to a whole new branch of chemical engineering, cluster chemistry." Professor Dr Ir. Andreas Schmidt-Ott, of the Faculty of Applied Physics, can't hide his enthusiasm when discussing this research. Together with Dr Christian Peineke, who recently earned his doctorate degree under Schmidt-Ott's supervision, the professor has developed a technique that will enable him to create atomic clusters, called 'super atoms', from metals that mimic the properties of elements in the periodic table. Depending on their size and charge, the particles for example can behave like inert gases, or like halogens such as iodine or chlorine.
More importantly, the two scientists managed to capture the particles in a very pure state, without any contamination, and select them according to size, ready to be used in chemical experiments. This was something that American researchers who achieved fame some years ago when they created aluminium super atoms, could only dream of, as they were unable to lay their hands on sufficient quantities of pure super atoms. According to Schmidt-Ott, the way forward now lies open for cluster chemistry.

Magic numbers

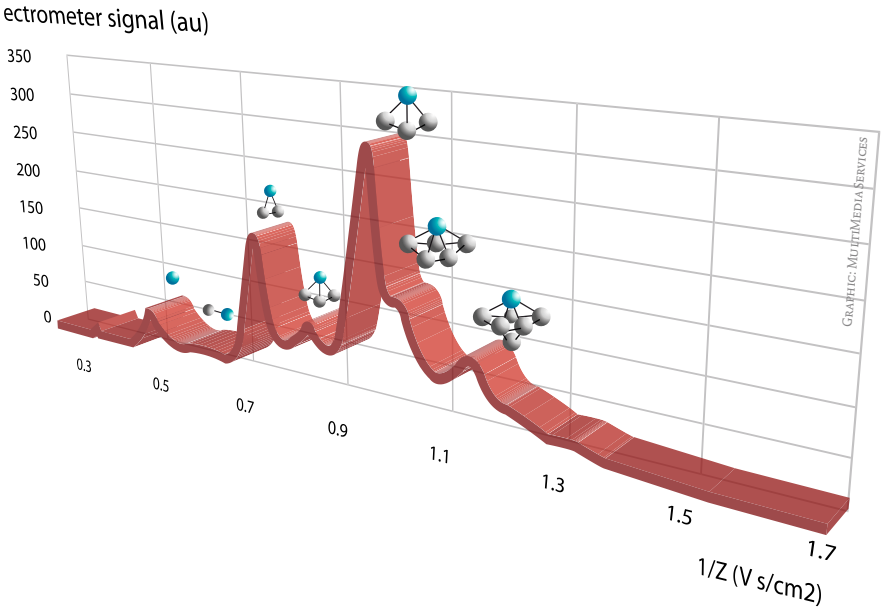
A small twisted wire, just like the filament in an incandescent bulb, but made of silver, forms the basis for the special silver particles. "If you heat this silver wire up to about nine hundred degrees Celsius – just below its melting point – you create a vapour of silver atoms," Peineke explains, as he gives a tour of his laboratory at DelftChemTech. Like water molecules forming into fog, the floating atoms stick together in clusters; but unlike fog, they don't do this at random. For example, clusters of silver containing 9, 13, or 55 atoms turn out to be highly energetically stable, and consequently appear in conspicuously large numbers in the mist of silver. These are the *magic numbers*.



Professor dr ir. Andreas Schmidt-Ott: "We discovered the *magic numbers* of silver."

The super atoms add a third dimension to the periodic table

The mechanism underlying the stability of super atoms with magic numbers was described in some detail in *Science* magazine in 2005 by American researchers at Virginia Commonwealth University. They had already discovered metal super atoms, but theirs were made of aluminium rather than silver. Their aluminium clusters of 13, 23, and 37 atoms behaved just like solitary atoms, because they had electrons that circled the entire atom cluster. These so-called 'shells' showed a remarkable resemblance to the shells of elements from the periodic table. It was the spatial arrangement of the atoms, combined with these super atom shells, that made the particles so stable. ▸▸



After performing calculations on the spatial structure and the distribution of the electrical charges of the clusters, the researchers concluded that there had to be a whole range of other large and small clusters that were stable. They also discovered that their aluminium 13 exhibited special properties if it had an iodine atom attached to it, as this created several electrically charged regions that made the cluster eminently suitable for use as a catalyst.
The super atoms add a third dimension to the periodic table is what several popular science magazines reported at the time. Schmidt-Ott shares that opinion, although he adds that the third dimension still needs to be mapped: "The super atoms found so far share chemical properties with elements from the periodic table because their shells are similar. It is not unthinkable that we will find atoms with other shells that will give us entirely new properties. Those are the super atoms that form the third dimension."
In future, Schmidt-Ott hopes to discover such atom clusters with new special magnetic, optical, or electrical properties that at the same time will be so stable that they can be used to create crystals or other solids. The turn of the last century saw the discovery of the 'buckyball', a spherical, hollow super atom with remarkable electrical properties and made up of sixty carbon atoms. "There are probably many more super atoms out there that are equally stable, waiting to be discovered," the professor adds.
It is improbable that any structures even more spectacular than buckyballs will be discovered. "Clusters of fewer than one hundred atoms offer the best prospects, as it makes a real difference to the chemical properties of those particles whether you add an atom or take one away," says Schmidt-Ott, who himself focused on particles up to nine atoms in size.

The spiritual father of the aluminium super atoms has high expectations for TU Delft's efforts

The spiritual father of the aluminium super atoms, Professor Shiv Khanna of Virginia Commonwealth University, has high expectations for TU Delft's efforts. He sees many applications for his aluminium super atoms: as catalysts in fuels, for example, or in the form of super-conducting crystals, but he has had little opportunity to experiment with the particles, which until recently remained elusive. Now that the technique developed by TU Delft is available, the days of modelling are over, and actual experiments can begin.
Until recently, super atoms were primarily created in a vacuum, using so-called cluster beams. In this process, particles are produced by means of condensation of a damp, and immediately sucked into a mass spectrometer for analysis. Although this type of technique allows the particles to be observed, after doing so they cannot be used for any other purpose. Schmidt-Ott and Peineke however have managed to capture the particles under normal pressure in an inert gas, called argon, and then to accurately sort them according to size, both of which are prerequisites for any further experimental work.
"Our filament technique makes use of small positive charges in the super molecules," Peineke explains. "We use argon gas to feed the particles through a capacitor. As we apply a voltage to that, the particles veer to one side because of their charged state. The bigger they are, the more resistance the gas offers and the less the particles are deflected. By varying the voltage we can effectively sort them by size and collect them."
"This is a graph showing the clusters made by means of this mobility analysis," Schmidt-Ott says. "At first all we saw were small spikes that hardly seemed significant. Then we compared the graphs of many tests, and in each case the spikes showed up in the same spot. We had discovered the magic numbers of silver. Together with a French colleague, Dr Michel Attoui, we refined the technique by lowering the temperature and using more sensitive equipment."
Khanna, Peineke and Schmidt-Ott are now collaborating on an article about silver super atoms. "The research on super atoms has now become a joint effort," Khanna says. This is confirmed by Schmidt-Ott: "They can do calculations on super atoms and predict certain properties. We can then use our technique to supply on demand any particles that look promising."
Ironically, Schmidt-Ott and Peineke owe their success to a contamination of the silver filaments with potassium. It was this impurity that ensured that the particles could be sorted by size. "Silver always contains traces of potassium," Schmidt-Ott says. "As the filament heats up, potassium ions are released which then attach themselves to the silver clusters. It is these atoms that give the silver a slight positive charge. They hardly affect the stability and the electrical properties of the super atoms, while at the same time enabling us to separate the super atoms later on. In a similar way we can also make aluminium super atoms. The only thing we have to do is to add some potassium to the filament, or caesium, which we will also be experimenting with. The technique remains the same. We discovered it all purely by chance."
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Patenting academic invention

Henk Makkink

Time was when technological universities restricted themselves to furthering the interests of scientific technology for its own sake. This was a noble task, not to be tarnished by 'pernicious industry'. These days however, commercialising university knowledge and invention is a core business. Delft University of Technology is on its way to becoming a patenting university.

Graphic: Leon Musschе

Just like any industrial enterprise, a university can use a patent as a strategic instrument to improve its standing, or at least to maintain it. Consequently, Delft University of Technology (TU Delft) now follows an unequivocal and consistent patent policy. The university currently has a patent portfolio of over two hundred inventions – making it the leader among Dutch universities – and emphasises the importance of commercially viable inventions to research groups and researchers, while offering royalty arrangements aimed at encouraging them to protect their inventions with patents.

Until about fifteen years ago, the rule was that the company that TU Delft conducted research for, or with, would apply for any patents. Today however the university usually applies for patents itself, while also handling the marketing of its inventions. This enables the university to better protect the freedom of research, publication and education, while also providing an opportunity to generate additional income. Applying for patents for the university's scientific-technological knowledge is not new, but what is new is that the university actively encourages this and that the government applauds it. Why this reversal in patent policy?

TU Delft has close ties with trade and industry. The university's predecessor, TH Delft Polytechnic, also had close contacts with the world of commerce. Industry was interested in knowlegde, and in return gave the university its support. As an ▸▸

The Patenting Paradox

The number of patents filed by Delft University of Technology and other universities, businesses, and research institutes, has been growing, in particular since the 1980s. Practical application has been lagging, however. Various European surveys show that currently most patents (up to seventy percent) are not being used effectively. Dr Gasnier, assistant-director of TNO's patent office, who lectures on patent management at TU Delft and other universities, calls the phenomenon the patenting paradox. In his book, 'The Patenting Paradox' (www.patenting-paradox.com), he demonstrates that although institutes recognise the importance of patents, after being granted a patent they fail to follow up on its practical use.

'Serious gaming' is an effective solution to help understand and improve a complex system such as patent management. Gasnier has developed a game for the institutes involved, the purpose of which is to help scientists, technology marketers and managers understand how patent management works, and to demonstrate how they can improve the yield of a patent portfolio. The game improves the participants' awareness of not only the importance of patenting, but also of improved collaboration and a detailed patent-based strategy for technology development.

example, the *Bataafsche Petroleum Maatschappij* (now Royal Dutch Shell), which started research in Delft in 1928, provided Delft Polytechnic with funds in 1951 to construct and outfit two pilot plants for physical and chemical technology on the corner of the Mekelweg and the Prins Bernhardlaan.
The common opinion was that the results of technological research should be made generally available at no extra cost through publications and conferences. This is why scientists did not – and still do not – have any interest in patents. They seldom filed for a patent on any of their inventions, and if they did, it was because they had solved an industrial problem and their commercial partner wanted to quickly protect the invention. Since the protection of intellectual property was not an issue, at least not formally, there was no policy to manage the rights and other matters relating to patents.
The research conducted at Dutch universities is partially supported by public funds, however, and as research efforts and interest in research grew, the patenting of research results came in for questioning. During the 1970s, a patent application for a new transport system – filed by a professor at Twente Polytechnic at his own expense – led to questions being asked in the Dutch Parliament about who held the rights to an invention. Was it the inventor, or the university? A committee looked into the case and awarded the rights to the inventor, a decision that met with little resistance.
During the 1980s, new developments led to the university taking a fresh look at its intellectual property. Government spending cuts resulted in universities gaining autonomy and thus having to find ways of generating part of their income themselves. The university executive board become more business-like, and the government wanted the universities to take on more socially relevant research projects, and to make them pay for it. The university became aware of the fact that its intellectual property was very valuable and needed to be protected. For TU Delft, this meant conducting more contract research for commercial partners, and patenting and marketing more inventions. The university had to market itself and showcase its research facilities to industry in order to entice entrepreneurs into participating in research projects. By transferring the ownership of the university buildings in 1992, the state increased the universities' autonomy, and with it the pressure to run the research facilities on a commercial basis.
The degree of collaboration in contract research between TU Delft and trade and industry varies per faculty. The Faculty of Chemical Engineering has for many years been working closely with chemical processing companies, including Unilever, AKU (later AKZO), Shell, and Hoogovens. The first patent corresponding to this was applied for on behalf of TU Delft by ICI on May 10, 1983. More patents soon followed, in particular as a result of the rise of biotechnology. The Faculty of Applied Physics had its inventions patented by the TPD (*Technisch Physische Dienst* TNO-THD, 1941), but after its merger in 1996 with Chemical Technology and Material Sciences, it followed its own patent policy.
Managing and marketing patents is also a task of STW, the Technological Sciences Foundation. Innovations from TU Delft that were successfully marketed by STW include a suction system to improve the stability of motorcars – currently under development at Actiflow, a TU Delft spin-off company – and a directional hearing aid fitted into a pair of eyeglasses, which Varibel marketed in 2006.
Researchers took a while to get used to this more commercial attitude. They were cautioned not to publish too quickly, as well as to first contact a contract manager to see whether an invention could be patented, and whether publication could be postponed until a patent had been granted. One of the first patents sold by TU Delft was for a more efficient and environmentally-friendly method for cleaning ships' tanks. The system had been developed in 1985 by researcher Ir. Verbeek and was sold to a Danish company. In 1993, a bundle of three patents (together with STW) covering new membrane technology (the separation of xylenes for the production of polyesters) were sold to Exxon for 665 thousand Dutch guilders (approx. 350 thousand euro).

It is an illusion to think patents can make a university rich

Ownership

In the early 1990s, the Dutch Parliament submitted a proposal for a legal status regulation: the regulation would give a university the patent rights to an invention made by someone employed by the university. The proposal lacked a sound legal basis, however, and was retracted. In trade and industry, such inventions had always become the property of the employer, and the Dutch Association of Universities (VSNU) wanted the same rule to apply to universities, in particular because it foresaw a ready source of income from patents and their commercial exploitation. Earlier, in 1985, a national regulation had been accepted: this regulation stipulated that trainee research assistants must waive any patent claims to the university, a development which considerably eroded the right of an individual to claim patents. When the National Patent Act was being considered in 1995, an amendment was accepted that would grant universities all the rights to inventions. In practice, the employer or university gains ownership only if the invention is connected with the inventor's position and field of expertise. The law awards the employee-inventor the right to reasonable compensation.
The emergence of TU Delft's patent policy was

Patent law

The curriculum of TU Delft (and formerly TH Delft Polytechnic) includes a range of legal subjects. Prior to 1940, the curriculum included courses in administrative law, trade law, industrial property law, and constitutional law, among other subjects. Some of these subjects were compulsory – trade law and constitutional law were compulsory as late as the 1950s. Industrial property law (taught by Professor Dr Ir. A.R. Veldman LL.M., and others) and patent law were never made part of the set curriculum. From 1977 to 2006, Ir. A. Rijlaarsdam LL.M., lectured on patent law and policy as an elective subject. As of 2006,. this subject is taught by P.A.C.E. van der Kooij LL.M., from Leiden University. The purpose of this course is to provide students with sufficient knowledge to enable them to understand the legal ramifications of inventions in a professional context.

a step-by-step process. In 1989, the university introduced its first remuneration policy. Starting from 1992, the net profit went to the faculty (minus 25 percent for the employer-inventor), up to a maximum of one million Dutch guilders (approx. 450 thousand euro). Most of the money went to the central university administration. Many scientists did not claim their share, preferring to allocate it directly to their research group, thus avoiding taxation. In 1994, a strategy plan, 'Towards a new involvement' was published, in which TU Delft introduced a points system that included patents as production (output) that generated income for the faculty.

During the late 1980s, the management of patents shifted from the faculties to the central university administration. Ten years later the university set up a patent contract bureau for each faculty. Since 1991, TU Delft inventions have been reported to the central university administrative level. Within the university, the Valorisation Centre was established in 2006: the centre is responsible for the valorisation of knowledge and the marketing and application of generated knowledge. Ever since, the inventor, the faculty, and the university each receive one-third of the net profit.

In political circles, the patenting university was considered a mainstay of the innovative knowledge economy the Netherlands was to become. Expecting to be able to make its contribution, and profit from it, since 1995 TU Delft has repeatedly increased its budget for patent applications. It is an illusion to think that patents can make a university rich, however, as filing and maintaining patents is a costly business. Only one in ten inventions ever yields a profit, and the chances of hitting the jackpot are much lower.

The university realised that its intellectual property was very valuable and needed protection

Patenting is an attractive option for other reasons though; it enhances the image of the inventive, innovative university, supports the technological sciences, and makes the university an attractive partner for trade and industry to collaborate with. Morever, for young graduates, having a patent on their curriculum vitae is an advantage. In 2004, patent policy gained even greater weight when the Minister of Education, Maria Van der Hoeven, designated knowledge valorisation as the third core business of a university, in addition to education and research. This was in reaction to a comment made by the American economist, Michael Porter, who said the Netherlands was much less innovative than the United States because Dutch universities had very few patents to their names. In the US, all inventions made at a university become the university's property by law, with commercial parties then paying market prices for them. Companies in the Netherlands refused to play ball however, arguing that they didn't want to pay high taxes for nothing.

Risk-bearing party

It is important that a university actually markets every patent it acquires. Licensing is the preferred method, because this is more lucrative than simply selling patents. In addition, the application base can be expanded by allowing several companies to participate in the patented invention. Rather than policing the market for patent infringements and monitoring patent agreements itself, the university prefers to leave these matters wholly to the partnering company, since such activities are in the partnering company's interest.

Commercialising patents is a complicated, time-consuming business that involves considerable risks and costs, as well as opportunities. The main challenge is finding a risk-bearing party willing and able to undertake a development process that could take years. TU Delft stimulates this by making intellectual property available (under certain conditions) to investors and other market parties, and by extending a helping hand in the establishment of companies that will develop an invention into a useful product ready for manufacture. The success of these spin-off activities is mainly due to patent-protected inventions.

Most of these companies are currently housed at YES!Delft, an entrepreneurial incubator. Until a few years ago, patent marketing was left mainly to the employee-researchers themselves, but since they had other duties and responsibilities to attend to, many an invention never became a practical application.

The university also leaves patent marketing to external business developers that the Valorisation Centre commissions to scour the market for interested businesses.

In 2000, Delft established a limited liability company that was to manage and market all university patents, and generate income for the university. However, due to overly high ambitions and a fear of alienating the inventor's commitment, the project was cancelled. Today, the Valorisation Centre manages the marketing of patents, although the earlier limited company is set to be resurrected, charged with formalising and professionalising the handling of patents and other intellectual property. In its new role, the limited liability company will become an extension of the Valorisation Centre.

TU Delft will further develop and improve its patent policy in order to not only strengthen its image, but also to be a useful partner to trade and industry and to reinforce the knowledge economy.

TU Delft Valorisation Centre

The TU Delft Valorisation Centre (2006) is a project group which stimulates and supports projects funded by trade and industry, manages intellectual property, organises training courses on contract and project management, etc. It also handles patent management and commercialisation. The Centre collaborates with the Technosprint project (which identifies new knowledge within the context of TU Delft, assesses its commercial value, and transfers it to the market through contracts), YES!Delft (Young Entrepreneurs Society Delft, which helps set up technolgical start-up companies) and the Delft Centre for Entrepreneurship (which stimulates entrepreneurship among students and employees).

The Valorisation Centre has ten employees, four of whom work in the patent group. In addition, each faculty has a contract manager and a technology transfer officer, which – together with the patent group and external business developers – play a role in the application and commercialisation process.

Over the period of 1991–2000, TU Delft employees reported 274 inventions, with patent applications being made for 148 of those 274 inventions (1996, 1998 and 2000 were the peak years). In recent years the annual number of inventions reported to the Valorisation Centre stands at about 50, of which half result in a patent application. The number of current national patents is about 1,300, based on 204 inventions or patent families.

Photos: Sam Rentmeester/fmax

Prof. Ir. Jan Vambersky

"I'm convinced that you must give one another total freedom to go your own way and pursue subjects that appeal to you."

Passionate

Professor Jan Vambersky was born in what was then Czechoslovakia. In 1968, just before the Prague Spring, he came to TU Delft as an exchange student. While he was here, the Soviet Army invaded his home country. One day Vambersky wandered into the TU's international office and promptly fell in love with the young woman running the front desk. After returning to Prague to study for a year, Vambersky came back to Holland to be with her, and she became his wife. He then went to work for Corsmit Consulting Engineers, where he is now the managing director. Vambersky has been a professor of structural engineering at the Faculty of Civil Engineering and Geosciences since 1988. He recently assessed the structural integrity of the Museum Mesdag in The Hague.

Robert Visscher

How would you describe one another?

Vambersky: "Roel is a determined professional who loves his work."

Van de Straat: "Jan is very passionate about his profession, and he has a very personal way of instilling that passion into his students and colleagues. Despite his busy life as a professor and his work for Corsmit, Jan always manages to find time for students and colleagues."

What is distinctive about the other person?

Vambersky: "Having gained his Master's degree in civil engineering, Roel has chosen to continue with architecture. I like the fact that he has chosen to do something that appeals to him. Roel is always prepared to visit conferences, write articles and organise things. If only everybody could be like that. But unfortunately that's not the case."

Van de Straat: "He doesn't put himself centre stage, as you can see on field trips. When you arrive somewhere abroad, the reception committee always goes to meet him first, but Jan will say: 'No, I'm not the one you want.' He'll then point to the students and say: 'They're the ones who arranged this visit.' I like that very much. It helps students to speak up for themselves. He won't let you hide behind him."

What have you learned from one another?

Vambersky: "I've learned a lot from Roel's approach to genetic algorithms. This is a new development for calculating optimised structures and their design and structural functioning. What he had researched over a period of nine months for his dissertation, I was then handed on a plate. In this way, his research also becomes my intellectual property, which allows me to learn in a few days what otherwise would have taken six months. He also has an unconventional way of solving problems. He isn't burdened by any previous experiences. This is a major advantage and allows him to explore new avenues that I would not have considered based on my experience."

Van de Straat: "He taught me to pursue subjects you enjoy. He always says that you should enjoy your profession, as this helps you to work ten times harder."

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

Vambersky: "I'm convinced that you must give one another total freedom to go your own way and pursue subjects that appeal to you."

Van de Straat: "It starts with enthusiasm for the profession. You should also know what the other can do for you, and vice versa. And the teacher needs to take his student seriously. Vambersky does. He always keeps himself informed of what I'm doing, and this confirms that he has confidence and interest in me."

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

Ir. Roel van de Straat

"Architects increasingly use special types of structures in their designs. This makes it necessary for them to collaborate with civil engineers"

Determined

Ir. Roel van de Straat (1982) graduated as a civil engineer from Delft University of Technology in January 2007. The subject of his dissertation was the optimisation of transition structures in multi-purpose buildings. His research earned him the Students' STEEL Prize in the 'Academic level research' category. Van de Straat has held a teaching and research position at the Structural Design Lab since March 2007. Last September he embarked on a second Master's degree study in architecture at TU Delft's Faculty of Architecture.

Is your relationship more like that of a father and son, or like a married couple?

Vambersky: "More like colleagues. I don't consider myself at all a strict teacher, but I do tend to keep my distance. I'm from an Eastern European country where that is how people do things. I'm a reserved kind of person. I still find it difficult to be on first-name terms with people. It has to do with respect. Not many people address me by my first name, and although I don't have a problem with people who do, I do find it difficult to do the same myself. That's why I tend to be a little reserved with Roel. On the other hand, it also means that he has lots of freedom to do what he wants."

Van de Straat: "It's said that reserved colleagues are not interested in one another, but that is certainly not the case with us. He reinforces the ideas I've come up with and helps substantiate my views. He doesn't just go along with what I say, but rather weighs my ideas carefully, without guiding them. I consider that almost paternal."

Do you ever quarrel?

Vambersky: "No. We do argue on a professional level, but it's not in my nature to quarrel with people. I'm perfectly capable of doing so, but I don't go looking for it."

Van de Straat: "I cannot imagine us ever quarrelling."

Can you recall an incident of good or bad luck that stuck in your mind?

Vambersky: "It's a pity that such a good civil engineer as Roel is leaving our profession , now that he's studying to become an architect. Yet, at the same time, I appreciate his doing so. It shows that Roel also appreciates other disciplines, instead of just having a one-track mind focused on technology."

Van de Straat: "I was on the committee of the U-Student Society for a year, which Vambersky is a kind of patron of. He stimulated the committee and showed us the ropes. That's how I came to develop a personal relationship with him."

Do you socialise?

Vambersky: "No, but Roel would always be welcome. That said, I do believe a supervisor should keep his distance without becoming unfriendly. You sometimes need to be a bit business-like. One tends to be protective of friends, but that is not the best kind of working relationship. You must be able to be critical and strict."

Van de Straat: "No, and that's fine with me. Our relationship is strictly limited to our working environment. I don't think of him as reserved, but rather as simply behaving correctly. It has never entered my mind to visit him at home."

Name one another's best habit.

Vambersky: "Roel is a go-getter. He's very enterprising. He has extremely good communication skills, and moreover he's an excellent engineer." ▸▸

The Bouwhuis Zoetermeer, an example of a design in which civil engineers and architects worked closely together

Marital status
Vambersky: married, two sons
Van de Straat: single

Best book:
Vambersky: Richard Dawkins, *The God Delusion*
Van de Straat: Harry Mulisch, *Siegfried*

Favourite newspaper and magazine
Vambersky: none, *Intermediair*
Van de Straat: none, *Bouwen met Staal* and *de Architect*

Invention you'd like to be yours
Vambersky: none
Van de Straat: the mathematical formula behind the roof of the Great Court of the British Museum

VAN DE STRAAT: "His drive to communicate his love for the profession. He often shows projects of great civil engineering beauty. His lectures on high-rise buildings are wonderful; he really can demonstrate that the sky is the limit."

And the worst?

VAMBERSKY: "He is going to have to learn to be a bit less amenable. Everyone in the building industry protects their own interests. You don't want to fall victim to that, so you must push back just as hard."
VAN DE STRAAT (*thinks for a while*): "I simply can't think of anything."

What is the other person's significance in professional terms?

VAMBERSKY: "Roel has demonstrated that genetic algorithms are a viable application. This is a small step, but every major development progresses with small steps."
VAN DE STRAAT: "A few weeks ago I attended a reunion of the U-Student Society, and there were lots of engineers there who had graduated under Vambersky. They came from all walks of life, from high-level civil servants to successful builders. It just goes to show how much influence Vambersky has."

What is today's greatest challenge to civil engineering?

VAMBERSKY: "To increase the influx and output of students to such an extent that we can produce enough civil engineers for the market. We don't do so at the moment. Civil engineering at TU Delft provides a very high level of training, which makes engineers popular with all kinds of employers, including banks."
VAN DE STRAAT: "The relationship with architecture. Architects increasingly use special types of structures in their designs, such as sloping walls and lots of glass. This makes it necessary for civil engineers to collaborate with architects. It is too simple to say that architects view civil engineers as rigid technologists, while civil engineers regard architects as mere designers of shapes, but it happens just the same. This can be avoided."

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

On 24 May, education minister Plasterk presented 'living on water' expert Ir. **Ties Rijcken** from TU Delft with the Leonardo da Vinci Prize 'to stimulate his further development as an exceptionally gifted scientist and artist'. The prize is awarded annually by ten West European Rotary Clubs to a young, exceptionally gifted scientist or artist. The prize is worth ten thousand euro.

This spring two Delft professors were appointed as members of the Dutch Royal Academy of Science. They are **Professor Dr Ir. Sef Heijnen**, professor of bioprocess technology at the Faculty of Applied Physics, and **Professor Dr Theo Odijk**, professor of complex fluids, also of the same faculty. A total of 25 new members were appointed this year, of which two are female professors.

On 8 May 'Duck man' **Dr Ir. Jeroen Wackers**, who last year received his doctorate with honours, was awarded one of two prizes (each worth 2,000 euro) for the best thesis at the conference of Eccomas, the European community for numeric methods in applied sciences. Wackers' supervisor was Professor Dr Ir. Barry Koren of the Faculty of Aerospace Engineering. The title of the thesis is 'Surface capturing and multigrid for steady free-surface water flows'. Wackers devised a model to describe the behaviour of waves, which is what got him his nickname. He is now working on maritime engineering applications in Nantes.

Hanane Ouna has won the ECHO Award for the Most Excellent Foreign Student in Higher Education. The prize was presented to her on 3 April by education minister Plasterk. The student, in her fifth year at the faculty of Technology, Policy, and Management, hails from Morocco, and expects to graduate soon, having studied ICT infrastructures and services.
As part of her studies Ouna analysed the security measures of the Electronic Medication Dossier (EMD) and the Electronic Patients Dossier (EPD). She investigated why it is that large-scale projects so often go wrong, and what the effects are to those involved, in this case the patients. The ECHO Award winners are given the opportunity to attend a summer course at the University of California in Los Angeles.

The supervisory board of TU Delft, the body that monitors the Executive Board, is back to full strength again. **Drs. Maarten Schönfeld** was appointed a member on 1 April, raising the number of members to five. Schönfeld is vice-chairman of the board of directors of the Stork industrial company. Before that he held various financial positions at Shell. Schönfeld graduated as a business economist in 1974 from the University of Groningen, after which he spent two years in Malawi, working for the United Nations.

The fine dust reduction system devised by TU Delft and BAM has won the Intertraffic Innovation Award 2008. The award was presented on 1 April by the secretary-general of the Ministry of Transport and Public Works, W.J. Kuijken, in the RAI conference centre in Amsterdam. The fine dust reduction system is a patented invention by **Ir. Bob Ursem**, director of the botanical garden in Delft. The system uses high-voltage (30 kV) wires suspended along motorways to collect fine dust from the air by means of electrostatic deflection.

Half a million dollars is what innovation and geophysics **professor Dr Ir. Guus Berkhout** of the Saudi Aramco oil company was awarded. Berkhout supervises the Delphi consortium, which focuses on seismic research and innovation management. More than thirty engineering companies and oil companies, including Saudi Aramco, participate in the consortium. "This award is special in that I get to decide myself what to do with it," says Berkhout, who will use the money for innovation management and to develop a new geophysical imaging technique.

[HORA·EST]

Propositions

If the number of readers halves with each mathematical equation, as is said to be the case with commercial books, at the end of the dissertation no more than a single hair of a single reader will remain.
Arthur van Bilsen
Physicist

The more you pay for a placebo, the more efficient it is. This explains why the pharmaceutical industry spends twice as much on marketing as it does on research and development.
Margarida F. Temudo
Biotechnologist

Being fluent in more than one language enhances one's ability to analyse and formulate problems.
Maarten Zandvliet
Geotechnologist

It takes the Chinese longer to get used to Dutch food than to get used to the Dutch research culture.
Huizhao Tu
Civil engineer

While the Dutch expression says that 'stagnation means decline', on the stock market 'stagnation of growth means decline'.
Redouane Hallouzi
Mechanical engineer

Allowing negative grades for students' exams and reports would result in better graduates.
Datu Buyung Agusdinata
Policy researcher

If evolution had produced only engineers, we would now be sitting around perfect campfires in perfect caves.
Christian Peineke, nanotechnologist

[Sound]bites

"Women should decorate the baby's room in the first month of their pregnancy, rather than in the eighth. The new furniture, carpeting, and curtains all contain gases, plasticisers, formaldehyde, benzenes, and biocides. All that stuff needs months to evaporate before the baby arrives."
Dr Ir. Evert Hasselaar of the OTB Research Institute in DE TELEGRAAF

"One shouldn't lie still at night. When sleeping it's better to move a lot, so the blood is kept flowing to all parts of the body. That way the different parts all get a turn at providing support."
Ergonomist Dr Ir. Ruud Goossens in DE VOLKSKRANT

"The government has the right and the moral duty to scrutinise the lawfulness of social security benefits. House visits are a natural part of this. They should be conducted not only on suspicion of fraud, but as a standard procedure for any benefit request."
Management professor Dr Arre Zuurmond in NRC HANDELSBLAD

"Dutch agriculture produces 40 to 60 million tonnes of biomass each year. We eat about one quarter of that amount. The remainder, 30 to 45 million tonnes, is left over. On a worldwide basis, this means that the thousands of millions of tonnes of biomass that are currently left unused could be made available. Corn leaves, straw, wood chips. If we use these to make biofuel, the balance could never be negative."
Biotechnology professor Dr Ir. Luuk van der Wielen in TROUW


Photo: Sam Rentmeester/fmax

Proposition
The most important dish to come out of the (bio)nanotechnology kitchen is hot air. Research financiers however are currently more than satisfied with this product.

Defence
"People talk about nanotechnology as if it were a completely new type of technology that will improve our lives, yet there's nothing new about it. The Belgians have been using nanotechnology for more than a hundred years to make chocolate. Nanotechnology is a hype. It's just a general term for doing things on a nano-scale. But if you tell your financiers that you'll be doing something with nanotechnology, you stand a much greater chance of raising funds. Researchers adapt their research proposals accordingly. My colleagues have done this, even though nanotechnology is totally irrelevant to their field. They then proceed to conduct research that wasn't in their original proposal. And the Netherlands Organisation for Scientific Research doesn't even check this. All they want to see are the published results five years later."

Wouter van der Star
Biotechnologist

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

When I graduated as a civil engineer, I got a job with the Department of Public Works, where I got a taste of the 'real' side of civil engineering: we managed projects from the drawing board, through the tendering stage, and all the way to completion. The projects were big, appealing, and were of interest to both colleagues and administrators. This was when I discovered that I really enjoyed the processes needed to produce civil engineering works. Project management was also the area in which I was really able to hit my stride.

After some years with the Department of Public Works, where I managed both civil and hydraulic engineering projects, I switched to national work, closer to the political administration, which took me further away from the technological side of things, although my civil engineering knowledge was still called on from time to time when questions were asked in Parliament or when issues needed to be resolved within various sections of the department. Using my technological background to work on major initiatives was challenging and instructive. Always searching for the right balance between doing your work as best you can and not straying too far out of your depth.

Although I was still very much enjoying this work, I was given a great opportunity with the province of Zuid Holland: to manage the department in which practically all aspects of civil engineering and geodesics are combined in road construction, traffic technology, hydraulic engineering, public works, data collection, and geodesics, among other fields. Apart from the fact that this position was a natural choice, given my civil engineering background, the new job included the challenge of restoring confidence in the management of the Infrastructure Management Service and ensuring the work field was developed on a tactical level. In other words, our department developed a robust system for planned management and maintenance, underpinned the management and maintenance budgetary requirments, and gave the department, with its wealth of civil engineering and geodesics know-how, a valuable place in the organisation.

Now I'm about to embark on a new challenge. After twenty years of civil engineering (starting in my first-year of university), I'm now leaving the profession to work as a facilities manager. My first impression is that the knowledge and experience I've gained at university and in my professional career will also stand me in good stead in this job, despite the fact that it's in a different field altogether.

Marjorie van Breda studied civil engineering at TU Delft from 1988 to 1994. She is currently a department manager for the province of Zuid Holland. Marjorie passes the pen on to TU-alumnus in urban architecture Mireille Woortman.

Folding containers

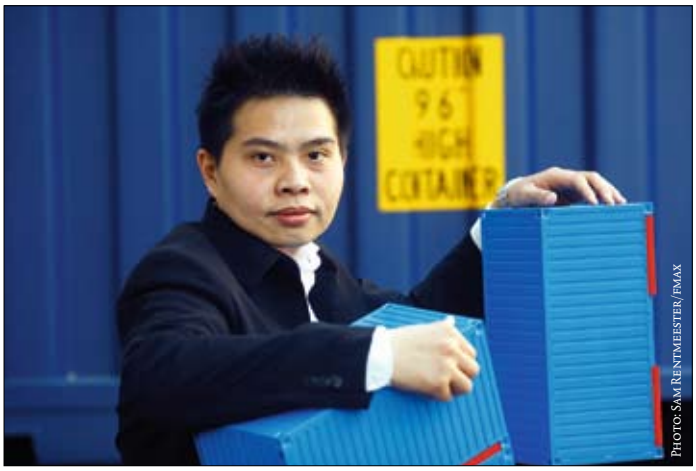

PHOTO: SAM RENTMEESTER/FMAX

Empty shipping containers waste a lot of space. The first concept for a collapsible container was launched in 1972. Failure quickly followed, however, because unfolding the container proved to be a laborious process. But now, with their patented modification, Ir. Gunawan Kusuma, and his supervisor, Dr Just Herder (Faculty of Mechanical, Maritime, and Materials Engineering), think they have finally found the solution.

ROBERT VISSCHER

Gunawan Kusuma was a bit let down by the initial reactions . 'Not again', the sceptics groaned. "I admit that I was disappointed," Kusuma says. "But then people became very curious, because a folding container is exactly what the industry needs. And as an engineer I want to make what's needed."

It takes guts to pick up an idea that several engineers have abandoned over the years. At the suggestion of his university lecturer, Dr Just Herder, Kusuma dusted off the old patent for a collapsible container. "It immediately grabbed me," he recalls. "That old patent was a rough diamond; all it needed was some re-cutting and polishing."

The old patent had failed primarily because the containers' sides were too heavy to fold. "The side of a forty-foot container weighs six hundred kilos. You don't just fold that up. Folding the containers also took too much time, and time is money in the shipping business."

Kusuma came up with an ingenious system for folding the containers that looks very simple. First, the long sides are folded inwards; then the roof is lifted, causing the ends to fold, after which the roof is lowered onto the collapsed parts. "The main reason it works so well is that we balance the long sides in the container, which makes it much easier to collapse such a heavy thing. It practically folds itself away."

According to Kusuma, the entire folding process takes one minute. "Four folded containers can now stand where a single empty unfolded container used to be. It also makes it much easier to transport empty containers. Rotterdam has a surplus of empty containers, because we import so much from Asia. A ship that is now fully loaded with 250 containers, will soon be able to carry a load of a thousand empty containers. This is what makes it such a good idea."

And the idea is fast gaining support. The initial scepticism has waned, and shipping companies are now enthusiastic, Kusuma is pleased to report. His company, Holland Container Innovation, a subsidiary of YES!Delft, has signed a contract to develop a prototype together with a large company that prefers to remain anonymous. Kusuma: "I'm certain my modifications will finally make the collapsible container a reality, after more than 35 years."

WHO & WHERE

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

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Central Library

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

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

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

Information

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

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

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

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

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

(Post Graduate) Courses

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

Institute for Biotechnology Studies Delft Leiden (BSDL)
Julianalaan 67
NL-2628 BC Delft
Telephone +31 15 278 2355

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