TO2MORROW

Magazine on results in the Open Innovation Network

2022

TO2 federatie

Organisations cooperating in applied research

MARIN

BETTER SHIPS, BLUE OCEANS

Deltares

nlr Dedicated to innovation in aerospace

WAGENINGEN UNIVERSITY & RESEARCH

TNO innovation for life

Contents

TO2: solutions for tomorrow as well as today

Dear reader,

We're living in the midst of many complex social issues. From economic uncertainty and historical developments in the energy market to global warming, from a health crisis to sustainability. The applied research organisations that form part of TO2 provide practical results for solving problems both for tomorrow as well as today. This includes the creation of innovative technologies that respond to these challenges and which are important for our future jobs and incomes. These TO2 institutes are the Maritime Research Institute Netherlands (MARIN), Deltares, the Netherlands Organisation for Applied Scienctific Research (TNO), Wageningen University and Research (WUR) and the Royal Netherlands Aerospace Centre (NLR).

This Impact Report shows concrete solutions found by TO2 institutes with their applied research. They have been categorised in the research groups 'energy transition and sustainability', 'agriculture, water and food', 'health and care', 'safety' and 'key technologies'. The results are invaluable to our society and are really worthwhile to be widely shared. In this way, civil society organisations, government authorities and companies can apply the knowledge.

The report reflects on 26 different examples, from 'organ-on-a-chip' technology to guardrails for sea-going vessels, from better methods of monitoring water levels to faster assessment of the safety of homes in the Groningen earthquake zone. I think it is wonderful to see what researchers in the Netherlands have achieved by working on this with such absolute dedication in using their know-how to arrive at real solutions.

The Netherlands has gained many years' worth of knowledge, experience and human resources in the field of innovation, of which applied research is an indispensable part. Thanks to all these efforts, the Netherlands is one of the most innovative countries in the world. That is something to be really proud of!

Minister Micky Adriaansens,
Ministry of Economic Affairs and Climate

Strategic choices for the coming years

Every four years we, the five TO2 institutions in the Netherlands, redefine our joint ambition. Knowledge development, application and dissemination continue to be our core tasks. We want to be the leading strategic knowledge partner for the national government, the business community and civil society organisations, to solve social issues together. We identify innovation needs, explore knowledge in more depth and expand its application in broad-based public private research programmes, aiming for an economically strong, resilient and future-proof Netherlands.

But, the environment is changing and that requires strategic choices so that we can fully support the needs of society with our research and innovation activities. The strategic framework describes our joint ambition for the period 2022–2025.

To force the technological breakthroughs that are needed, cross-pollination between various disciplines and expertise is a prerequisite. But working in an interdisciplinary or multidisciplinary manner, so too across national borders, is also a must. The TO2 organisations want to develop their cooperation even further in a programmatic approach on areas including the North Sea in the coming years.

In this publication several examples of a multidisciplinary approach are already visible.

Download the 2022–2015 Strategic Framework **here**

In the overview below, each of the institutions, who are part of the T02 federation, summarize their key areas of activity and the key technologies they develop and apply.

The T02 federation consists of:

Deltares

Deltares

Deltares is an independent knowledge institute for applied research in the field of water and subsoil. Based on a systematic approach, we work globally on smart innovations and applications for humans, the environment and society.
Deltares has a unique combination of highly qualified employees, innovative key technologies, unique experimental facilities and specialist open source software. As a knowledge institute for applied research, we are successful when our 'in-depth' knowledge is redeemed in and for society.
Together with our partners, we are going to tackle the social challenges of today and of the future. From a water and subgrade perspective including infrastructure, our work covers four perspectives: Future, Sustainable and Safe deltas, and Resilient infrastructure.
Deltares | Enabling Delta Life

MARIN
BETTER SHIPS, BLUE OCEANS

MARIN

The Maritime Research Institute Netherlands (MARIN) conducts research into hydrodynamics, maritime (zero-emission) technology and operations with simulations, model testing, true-size measurements and training. MARIN focuses on shipbuilding, shipping, offshore industry and public authorities. To this end, MARIN pays attention to the following social themes in the mission-driven innovation policy: energy transition and sustainability; agriculture, water and food; and safety. Key technologies that receive special attention are artificial intelligence and autonomy & decision support.

nlr Dedicated to innovation in aerospace

NLR

The Royal Netherlands Aerospace Centre (NLR) connects the sciences, business community and government authorities in the Netherlands and internationally. This knowledge organisation conducts applied scientific research within the market segments: industry, civil aviation, aerospace and defence. NLR's work covers the full spectrum of 'Research, Development, Test & Evaluation' (RDT&E). Within the mission-driven innovation policy, NLR's research focuses on social themes: energy transition, sustainability and safety. Examples of key technologies that receive special attention are artificial intelligence, augmented/virtual reality, digital twin and state-of-the-art materials (e.g. composites and 3D metal printing). ▶

Follow-up ▶

The T02 federation consists of:

TNO

The Netherlands Organisation for Applied Scientific Research (TNO) has a mission to connect people and knowledge to create innovations that boost the competitive strength of industry and the well-being of society in a sustainable way. TNO believes in the joint creation of value in economic as well as social terms and, together with partners, focuses on innovations in nine domains: the Building Industry, Infrastructure & Maritime; Circular Economy and the Environment; Defence, Safety and Security; Energy Transition; Healthy Living; Industry; Information & Communication Technology; Strategic Analysis & Policy; Traffic & Transport.

Development and making key technologies functional for application, is one of TNO's core activities within these domains. These include photonics, nano technology and quantum technology. But also new forms of production, material and chemical technology. Key technologies are characterised by a wide field of applications or scope in innovations and sectors. They will radically change the way we live, learn, innovate, work and produce. Key technologies are essential in resolving social challenges, such as safety, energy and care. Key technologies also enable groundbreaking innovations of processes, products and services, and provide a major contribution to the economy, to the emergence of new businesses and new markets, to an increased competitiveness and to bolstering job creation.

WUR

Wageningen University & Research is the joint venture between Wageningen University and Stichting Wageningen Research (a foundation). We have more than 6,800 employees and 12,900 students from over 100 countries working in the fields of healthy nutrition and the living environment across the globe, both for government authorities and for the business community. The mission of Wageningen University & Research is "To explore the potential of nature to improve the quality of life". Wageningen University & Research's strength not only lies in combining specialised research institutes and the university, but also in collaborations among various natural, technological and social science disciplines. As a result, scientific breakthroughs can quickly be translated into practice and into education. Wageningen Research is part of the T02 federation and consists of several research institutes who are active with the topics Food & Biobased Research, Bioveterinary Research, Livestock Research, Marine Research, Economic Research, Environmental Research, Plant Research and Food Safety Research. ■

Scaled Flight Demonstrator gives innovative aviation wings

Scale models allow cleaner and more economical aircraft to be developed faster and cheaper. This is what the team of engineers at NLR are hoping to prove in developing the Scaled Flight Demonstrator; a testing and validation method for scale-model aircraft. The team built an A320 in fine detail on a scale of 1:8.5 and developed high-quality measuring instruments. ▶

Floris Bremmers standing at the Scaled Flight Demonstrator, a scale model to develop new aircraft.

NLR

Problem: to be climate-neutral by 2050, we will have to fly less as well as develop more economical and cleaner aircraft. But the latter takes a lot of time and money.

T02 solution: the testing of scale models allows you to accelerate aircraft development at less cost and with fewer risks. The Royal Netherlands Aerospace Centre (NLR), together with European partners, is developing such a method, the Scaled Flight Testing Method. To validate this method, the team built an existing A320 exactly to scale in which the flight behaviour of this Scaled Flight Demonstrator (SFD) can be translated into a larger version. The team also operates the SFD on test flights and has developed proper measuring equipment and methods.

Impact: this testing method allows manufacturers to build and test radically new scale-model aircraft (with different wings or electrically driven) in addition to the design process and wind tunnel tests. This means the first prototypes need not be at their true size. This accelerates the much-needed innovation in aviation.

Reconstructing an aircraft as a model and experimenting with innovations. Why has the aerospace industry not done this before, when it is already known how much cheaper and faster it is to develop new aircraft using scale models? An important reason for this is that the aircraft and passenger aircraft we know today, the so-called tube-and-wing concept, will radically change with innovative propulsion concepts, materials and structures, driven by the need to fly more energy-efficiently and cleaner. It is precisely the dynamics of these new types of aircraft which can effectively be researched with scaled flight testing.
But producing such a scale model so that it behaves just like a full-scale version under the same conditions in the air – due to what is known as scaling effects – is a complex matter. For example, a large aircraft flies much faster than a mini version, causing the composition of the air to change and other forces to apply. And how do you measure and compare this so that the flying behaviour of large aircraft can be deduced from it?

Floris Bremmers: 'If these tests prove to be successful, there is a reliable validation method for scale models to develop cleaner and more economical aircraft.'

Small A320

These are solutions that are being sought by aviation engineer Floris Bremmers of NLR. As part of an international team, he is developing a reliable test method with a scale model, the Scaled Flight Demonstrator (SFD). NLR works in conjunction with aircraft manufacturer Airbus, the French research centre ONERA (validation and scaling) and the Italian CIRA (navigation and control system and remote Pilot Ground Station).
Together with the Dutch company Orange Aerospace (structural design and construction), the NLR team built an Airbus A320 (a medium-sized aircraft) on a scale of 1:8.5 in fine detail. This scale model has a wingspan of four metres and weighs about 140 kg. The

SFD reaches a speed of 85 knots, which is about 160 km per hour. NLR also developed the flight test instrumentation.
'A nice replica of an A320 can be bought on eBay for about €10,000', says Bremmers, who is responsible for the technical design and measurement methodology. 'But a scale model of a technically high standard has not been built by anyone yet.' Aside from being built to scale, the measuring method must also fulfil the highest requirements. ▶

NLR

Scaled Flight Demonstrator gives innovative aviation wings

▶ The technical features and the aircraft's behaviour were tested in wind tunnels and during test flights. The SFD has several sensors that gather information about more than 150 flight parameters for determining, among other things, the angles, forces and accelerations, speed and altitude.

Maiden flight

This SFD's technically high standard, combined with the precision of the advanced measuring instrumentation and method, makes this Scaled Flight Testing Method particularly special, says Bremmers. The way that NLR enables the scale model to fly is also unique. 'The SFD is controlled from a cockpit environment in a mobile ground station next to the runway using a camera and Head-Up Display (HUD), which projects information on a screen in front of the pilot's eyes.'

This type of control is complicated because a scale model is not designed for these specific speeds. With that in mind, the pilots have undergone a special training course. During the first flights the teams progressively tested functionalities, such as retracting the landing gear and moving the flaps (adjustable parts of a wing).

On 30 March 2022, the SFD was launched on its nine-minute maiden flight at Deelen airport. NLR's Jan-Willem van Dooren, the pilot in command and Jasper van der Vorst responsible for pilot monitoring, flew the aircraft to an altitude of 1000 feet (300 metres). 'A couple of hours for preparation, checking the landing gear, refuelling, and then the ground station's doors close. Having about one hundred components on board and notwithstanding the meticulous preparations and precautionary measures, something can always go wrong', Bremmers remembers the exciting moment.

'We often forget how fast technology is advancing.'

Flying wings

In the autumn, mission flight tests will take place at Puglia Airport with CIRA, our partner in Italy. This will cover the testing method as a whole. If these tests prove to be successful, the outcome will be a reliable validation method for scale models to develop cleaner and more economical aircraft. Bremmers: 'We are heading for a totally new kind of aircraft, with a comeback of propellers, batteries instead of fuel, or indeed hydrogen, and much bigger wings, which make the aircraft a sort of flying wing.' Whichever technology breaks through in aviation, will still have to be seen', says Bremmers, who is rather positive about meeting climate targets in aviation. 'We often forget how fast technology is advancing. But technology alone is not the solution. If possible, people should travel less often and shorter distances, or they should opt for a cleaner and more economical transportation alternative.' ■

Who: NLR, Orange Aerospace, ONERA, CIRA and Airbus.

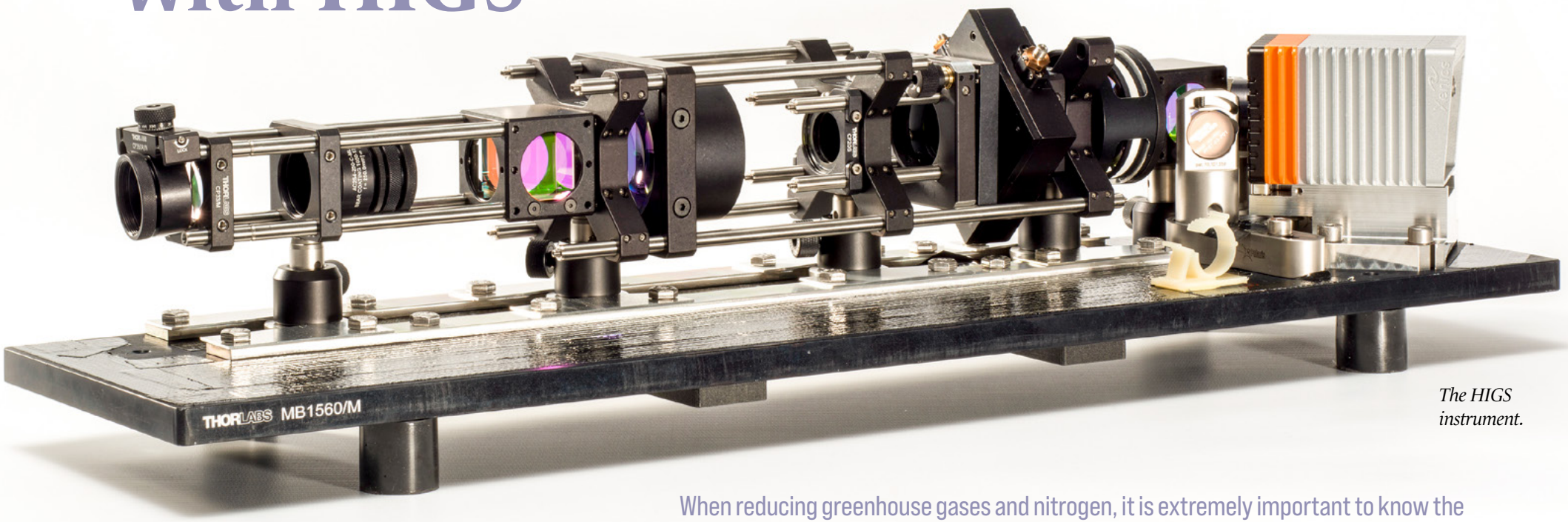
Duration: 2016–2023

Budget: €10 million. The project is part of the European Clean Sky 2 programme, co-financed by the European H2020 programme and the private sector.

Follow-up: a new prototype is being developed, the Distributed Electric Propulsion (DEP) SFD. For this purpose, the two gas turbines are replaced by six electrically driven propellers. Wind tunnel tests will soon be in place and the maiden flight is scheduled for early 2023. Alongside the other partners, TU Delft is also participating in this development.

View the video **here**

Breakthrough in emission monitoring with HIGS



The HIGS instrument.

When reducing greenhouse gases and nitrogen, it is extremely important to know the source of emissions as precisely as possible. Satellite instruments play a unique role in this emission monitoring. The latest HIGS technology can lead to a breakthrough in earth observation, atmospheric monitoring and the fight against climate change. ▶

TNO

Problem: in reducing greenhouse gases and nitrogen, it is extremely important to know the source of emissions as precisely as possible and how they spread. Satellite instruments are used for this, because they can carry out independent measurements across vast areas, but there is currently no instrument with sufficient resolution to identify small-scale greenhouse gas emissions.

TO2 solution: the HIGS instrument is being developed by TNO to significantly improve detection of small-scale emitters and greenhouse gases and to enable the identification of emissions from individual sources.

Impact: in the fight against climate change HIGS helps government authorities and industries to monitor their greenhouse gas emissions more accurately. Based on these satellite measurements, they can conduct scientific research as well as design and monitor effective policy.

For more than thirty years now, TNO has been developing satellite instruments for measuring and monitoring greenhouse gases and nitrogen in the atmosphere. Over the years, these techniques have increasingly been refined and improved. 'TNO has been involved in developing the satellite instrument Tropomi, which examines air quality more accurately than ever before and fully maps Earth's entire atmosphere in a single day', says Anton Leemhuis, Senior Business Developer Space at TNO. 'Previously, scientists had to combine a lot of data and could only see the largest sources of methane emissions. Tropomi is able to detect emissions on a smaller scale and to identify pollutant sources.'

Leaks

That is simply not enough to tackle one of the largest global challenges: climate change. Internationally, there is still an absence of measuring data of greenhouse gases and nitrogen, and climate scientists often still work with estimates. Whereas, when reducing greenhouse gas emissions, it is extremely important to know the source of emissions as precisely as possible and how they spread. Leemhuis: 'Current instruments can detect large 'leaks' of a greenhouse gas from the atmosphere' (of thousands of kilograms per hour), such as methane emanating from a large garbage dump or a leak in a gas pipeline. The latest generations of satellites that are going into orbit will have to measure several hundreds of kilograms and by using HIGS, we want to take a huge step towards further reducing this.' To this end, TNO is already developing more sensitive instruments using spectrometer technology.

HIGS

HIGS, (named after Huib Visser, the progenitor of the Tropomi instrument, and creator of HIGS: Huib's Innovative Gas Sensor) is the latest development and part of TNO's R&D programmes. Current research should reveal what the detection limit is. The initial HIGS studies have now been completed and the follow-up is to test the equipment by measuring emissions from the ground (atmospheric testing is not possible). Atmospheric testing already takes place when measuring from the ground'. In time we may be flying an aircraft and then, just like a satellite, you can also look at Earth. Testing from outer space, however, is too expensive: your prototype there would also be your first real instrument. 'HIGS uses newer techniques. Where spectrometers scan the earth, HIGS focuses a camera onto an area, allowing for even sharper two-dimensional images. 'You would even be able to trace smoke plumes.'
This new technology can help government authorities and industries to monitor and tackle climate change. Leemhuis: 'If you prepare policy that has a major economic impact, then estimates are not good enough. Policy makers really want to know the exact volume of emissions. The Tropomi instruments have already measured emissions from Australian coal mines. These measurements indicated that a small proportion of the mines accounted for three quarters of the emissions from the coal mining industry.
The Australian government has responded to the findings and satellite data helps them better understand the emissions there.
The European Union has developed a strategy to reduce emissions of the greenhouse gas methane. In doing so, satellites with accurate measuring instruments are of vital importance.' ■

Anton Leemhuis: 'HIGS can help government authorities and industries monitor and tackle climate change'

Who: TNO, Leiden University.

Budget: financing from TNO's R&D programme and financial support from NWO for a PhD student at Leiden University.

Duration: TNO has been working continuously for more than five years on the development of this new technology.

Follow-up: TNO works with the European space agency, ESA, on a study of this technology's potential for new satellite instruments.

Air bubble curtains protect seals against noise

North Sea offshore wind energy is becoming the most important source of energy for the Netherlands. Wind energy is clean and never runs out, except there are disadvantages for the animals in and above the sea, says Josien Steenbergen of Wageningen Marine Research. 'We are studying the risks and how to reduce them.' ▶

Josien Steenbergen.

WUR, TNO

Problem: wind energy is clean and contributes to the climate objectives, though for birds, bats and marine mammals wind turbines have disadvantages.

TO2 solution: to identify the effect of offshore wind farms in the North Sea on various species and determine which measures and innovations are possible to reduce their adverse effects.

Impact: fewer adverse effects for animals in and above the sea.

Many wind farms will be constructed in the North Sea in the years ahead. The Netherlands Environmental Assessment Agency (PBL) expects that by 2050, possibly a quarter of the Netherlands' wind farms will be offshore in the North Sea. The sea will look very different when seen from below and above the water's surface. This scaling-up does entail necessary risks, says Josien Steenbergen, research coordinator for offshore wind energy. Commissioned by the government and wind energy sector, Wageningen Marine Research conducts research into the consequences of offshore wind farms for animal species. This knowledge will help government authorities determine which locations are suitable and less suitable for wind farms and in which seasons offshore pile driving activities can best be carried out.

Bat migration

Direct effects include birds and bats flying against the blades, says Steenbergen. 'Some don't survive the impact.' But there are also long-term consequences: there are species of birds that have no problems with wind farms, e.g. the cormorant, whereas the northern gannet, a large seabird, circumnavigates wind farms in a really wide arc. 'Maybe those were places where they usually sought food or a place to rest. This may have an effect on the numbers.'
Earlier research by Wageningen Marine Research showed that not only several bird species, but bats (Nathusius' pipistrelle (Pipistrellus nathusii)) migrate back and forth across the North Sea. Researchers found that bats fly with a tailwind: in the autumn they fly from the Netherlands to England with an easterly wind and they return in the spring with a westerly wind. Thanks to this research, nowadays wind farm operators bring their turbines to a standstill at those times.

Prevent hearing impairment

Even underwater, wind turbines have all kinds of effects on animals. Current research into the effects of offshore wind farms on porpoises and seals, focuses on the impact of pile driving during construction of the wind farms. 'They have highly sensitive hearing with which they detect prey and communicate with each other', says Steenbergen. 'Because of the pile driving, their hearing can be impaired permanently, preventing them from searching for food.' Together with TNO, we also try to calculate the extent of the area where disruption takes place and the effects of such disruption. On the basis of this study, measures are taken to reduce the disruptions. An example is an innovation in which, in the process of pile driving activities, a curton of air bubbles are placed to protect the animals against much of the noise. ▶

Josien Steenbergen: 'The Netherlands Environmental Assessment Agency (PBL) expects that in 2050, 26 percent of the Netherlands' wind farms will be offshore in the North Sea.'

WUR, TNO

▶ The study into the effects on underwater animals, once the wind farms are in place, is in full swing. This includes a study into the effects of electromagnetic fields on sharks and rays. A study has also been launched into the impact of the large-scale roll-out of offshore wind energy on the ecosystem. This study is jointly being undertaken by Deltares, Wageningen Marine Research and the NIOZ.

Positive consequences

Interestingly enough, the impact is not only negative. 'For example, rocks are placed on the seabed to ensure that the turbines do not topple (scour protection)', says Steenbergen. 'Shellfish and other species grow on them, which enrichens biodiversity. Together with industry, we study how best to shape these scour protection so that the animals benefit from it.'

There are also initiatives to reintroduce oyster reefs in wind farms. These had disappeared in the North Sea over the last century due to overfishing, diseases and pollution. The fishing-protected wind farms can also offer opportunities for commercial seaweed cultivation, shellfish farming and passive fishing.

A great deal of research is still needed, but according to Steenbergen, the Netherlands is on the right track. Until 2016, wind farm owners in the Netherlands had to estimate the ecological effects themselves. Now this is centrally-based via Rijkswaterstaat's 'Offshore wind ecological programme (Wozep), commissioned by the Ministry of Economic Affairs and Climate. On the other hand, wind farm owners now have to include an ecological programme in their tender procedures. 'Which was interesting as it suddenly gave our research a boost. Many wind farm owners are now asking us for advice or want to collaborate.'

Translation into policy

Wageningen Marine Research is involved in a massive ten-year research programme on the impact of wind farms on animal species and the ecology of the North Sea, which starts in early 2023. But before this MONS programme (Monitoring-Research-Nature improvement-Species protection) is completed, a huge number of wind turbines will be erected in the North Sea. 'I hope government authorities will provide some leeway to adapt plans, if this proves necessary on the basis of our research results', says Steenbergen. She is curious to know what this enormous upscaling means for the various species of animals. 'The years ahead are going to be very exciting. Will politicians put our knowledge to good use? Will sufficient measures be taken to confine (any) adverse effects for animals and the ecosystem?' ■

Who: the MONS programme (Monitoring-Research-Nature improvement-Species protection) will be implemented as part of the North Sea agreement and will be financed by various ministries (Ministry of Agriculture, Nature and Food Quality (LNV), Ministry of Infrastructure and Water Management (IenW), and Ministry of Economic Affairs and Climate (EZK)).

Duration: 2023–2033.

Budget: €55 million.

Follow-up: current research focuses on a limited number of vulnerable animal species. MONS will provide an insight into changes in the ecosystem, habitats and species of the North Sea as a result of the energy, food and nature transitions. In addition, more international research is needed (animals are unaware of borders) including research into the impact of onshore wind energy on animals.

Air bubble curtains protect seals against noise

More and more space for solar panels

Not simply a roof, window, façade or noise barrier, but one that produces energy. TNO is developing a production method that enables companies to make solar panels in all kinds of materials and in any form, suitable for various surfaces. ▶

Peter Toonssen of TNO is working on the next generation of solar technology.

TNO

Problem: solar panels play an important role in the energy transition, but they need a lot of surface area for placement. They are bound to a certain size, so they cannot yet be fully integrated into all surfaces.

TO2 solution: TNO developed a production method based on semi-finished products, enabling manufacturers to integrate solar power functions into all kinds of building materials and properties, such as roofs, façades, windows or vehicles.

Impact: by simply fitting solar panels into existing infrastructure and materials at acceptable cost and be visually appealing too, the potential for solar power production increases enormously. Contractors will be able to order complete roofs in which solar panels have already been integrated. Installation of separate solar panels will no longer be necessary.

Mass production of tailored products, or as they say at TNO: mass customisation. With this, TNO is working on the next generation of solar technology. This means that solar modules will no longer be bound to a certain size or shape, but will be easier to integrate into, for example, roofs, windows, noise barriers and façades. 'They will be semi-finished products that can be incorporated into finished products', says Peter Toonssen of TNO. 'Manufacturers of construction elements or car bodies, for example, can integrate this into their products without much adaptation in their production process.'
Toonssen thinks this might even include the creation of a whole new industry that can supply these semi-finished products to existing industry. 'This is a technology that ties in better with what the market wants and is also affordable because of mass production. There was not much willingness on the part of existing manufacturers to invest in this technology. Through a grant from the Ministry of Economic Affairs and Climate, TNO was able to develop a line of research with which to develop a blueprint for an industrially scalable production line. This is what the market can respond to and develop products for integrating the generation of solar power.'

Blueprint

At the TNO site on the High Tech Campus in Eindhoven, a line of research was initiated in producing the first semi-finished products.

'This allows for development of a blueprint for a factory where this technology can be applied', says Toonssen. 'We can offer this technology based on individual panels and foils. We are now going to further optimise the production line to produce semi-finished products faster, at lower cost and for wider applications. Our goal is to remain below the cost of alternative options at a system level. But we have not reached that point as yet. For example, we must first move towards producing vast quantities. That is when material prices will drop and we can produce at lower cost prices. The advantage of our production method is that there is no need to engage a separate installer for installation of solar panels on the roof, for example.'

Increased capacity

The impact of this technology is immense, says Toonssen. 'Solar energy plays an important role in the energy transition, but for its application, a lot of surface area is needed and that is rather lacking in the Netherlands. So, if you can install solar panels into the existing infrastructure, it increases capacity enormously.' Integrating solar panels into a noise barrier has already been possible for a while, but implementation was expensive. With the advent of this new technology, things will be different.
Toonssen expects that the first solar panels – using the TNO production method – will be lying on residential roofs within a few years. The first manufacturers of façade and roof products are going to use this technology to boost their production lines. 'Façades at present are functional and at best very nice. Soon, it will also be a major source of renewable energy', Toonssen concludes. ■

View the video **here**

Who: TNO in cooperation with developers/ manufacturers of materials and solar panels, equipment developers, manufacturers of building parts and installation companies.

Duration: 6 years.
Follow-up: in addition to the line of research, TNO has introduced a new solar power integration lab to study how complete solar panels and solar laminates can further be integrated into various end products. In addition, it is also possible to determine the energy yield of products and to conduct research into service life, reliability and safety.

How can farmers adapt to climate change?

The impact of climate change on agriculture is considerable. The Climate Stress Test maps the risks for each farm. Daan Verstand, a climate researcher: 'We want farmers to be more aware of the problem and know how they can reduce the risks.' ▶

Daan Verstand of WUR.

WUR

Problem: due to climate change, temperatures are rising, rainfall occurs more often in a short space of time and there are longer spells of drought in the Netherlands. At the same time, soil quality deteriorates and all this is extremely detrimental to agriculture.

T02 solution: develop knowledge, models and scenarios for farmers, insurers and other companies, like the Climate Stress Test, which is part of the Climate Change Adaptation project for Open Cultivation.

Impact: this raises awareness of the problem for farmers and allows farms to adapt to climate change.

The Climate Stress Test is a method by which researchers can identify the risks of climate change for a specific farm. 'The aim is to make farmers more aware of the problem and to give them advice on what they can do', says Daan Verstand at Wageningen University & Research, who deals with the effects of climate change on agriculture in the Netherlands.

Two climate scenarios

In the test, the Netherlands is divided into five regions. For example, temperature inland is often higher and extreme precipitation occurs more often along the coast. The test examines two of the four climate scenarios developed by the Royal Netherlands Meteorological Institute (KNMI) for 2050: 1) the most extreme and 2) the most moderate. 'The consequences for farmers are therefore dependent on how extreme climate is going to change', Verstand explains. The test focuses on recognisable cropping schemesfor those five regions where many crops are cultivated, such as potatoes, sugar beet, root vegetables, cereals and onions, and shows how vulnerable they are to extreme weather conditions. Onions and potatoes, for example, are vulnerable to droughts; cereals much less. In the years ahead, researchers will also add other crops to the test, such as kidney beans, broad beans and soy.

Other crops

At present the test is still a tool that researchers execute themselves, but they are also working on developing an app that farmers can use for themselves. Aside from arable farmers, insurers were also involved in the research. 'It is also worthwhile for them to know how farms can reduce their vulnerability, because if they increasingly have to compensate for extreme weather damages, the premiums will rise tremendously.'

Using water more economically

'The test not only involves the risks, but also offers tips to arable farmers on how to adapt to climate change', Verstand emphasizes. For example, there are ways to use water more economically during dry spells and to improve soil quality so that farmers can better deal with

Daan Verstand: 'We offer tips to farmers on how to reduce the risks of climate change'

extreme weather conditions. Farmers can adapt their management to the changing climate, by for example improve the water holding capacity of the soil and reduce soil compaction (the soil is compressed by heavy machinery which prevents the roots from reaching deeper water). Farmers also share their experiences and can learn from each other. 'If these adaptations don't work, the farmers could consider switching to crops that are better suited to extreme weather conditions.' ■

View the video here

Who: public-private partnership on climate adaptation research project Open Cultivation: Wageningen Environmental Research, together with BO-Akkerbouw, Agrifirm, SPNA and Delphy, commissioned by the Ministry of Agriculture, Nature and Food Quality; KANO, a knowledge transfer project: WUR Open Cultivation, together with LTO-DAW, Agrifirm and the Dutch Association of Insurers.

Duration: Climate Adaptation Open Cultivation: January 2020–December 2023; KANO: June 2020–June 2022.

Budget: Climate Adaptation Open Cultivation: €1.4 million; KANO: €200,000.

Follow-up: in the next year and a half, to develop the Climate Stress Test into an app that farmers and consultants can use in kitchen-table discussions.

Fewer greenhouse gases through sustainable agriculture and forestry

Sustainable agriculture and forestry play an important role in solving climate change. Gert-Jan Nabuurs, a professor of European forest resources, writes about this in the latest IPCC report. 'We contribute to global talks on climate, but it is also important to look at what we can do in the Netherlands.' ▶

In a forest in Venray a mix of other tree species have been planted in grow tubes to reinforce this somewhat ageing forest in becoming a mixed forest; it enables a better capturing of carbon dioxide, for wood production and biodiversity.

WUR

Problem: unsustainable forms of agriculture and deforestation create greenhouse gases such as carbon dioxide and methane, which accelerates climate change.

T02 solution: global awareness and actions have been set in motion as a result of the IPCC report, which emphasizes the importance of more sustainable forms of agriculture, forestry and timber construction to help solve the climate problem.

Impact: supporting global negotiations on climate targets that result in reduced climate change and therefore fewer extreme weather conditions and a curtailed sea-level rise.

Agriculture, forestry and farm animals are responsible for emissions ranging between 13% and 20% of greenhouse gases that cause global warming. Due to deforestation, there are fewer trees that can absorb carbon dioxide and livestock emit greenhouse gases methane and nitrous oxide. 'More sustainable agriculture and better forest management, including more planting and timber construction, reduce greenhouse gas emissions and raise the capture of carbon dioxide', Gert-Jan Nabuurs explains. The scientist from Wageningen writes about this in the most recent report by the United Nations' Intergovernmental Panel on Climate Change (IPCC).

'Meanwhile, everyone wants to go green and plant more forests'

Take action faster

This was already the sixth time that he co-authored an IPCC report, but this time as the lead author of the chapter on Land Use and Agriculture. 'The main message is: emissions continue to rise, so we need to take action even faster.' The IPCC report concludes that almost one third of the solutions can be found in a broad-based set of measures in agriculture and forestry.
We also test and implement this locally within the EU, says Nabuurs. The Vegetation, Forest and Landscape Ecology Team, of which he is a member, collaborates in a European context. For example, the European Forest Institute has an EU-sponsored project, SUPERB, which restores thousands of hectares of forest in Europe and plants more varied species, but above all, it also learns from the particularly difficult processes to achieve this.

Climate-smart forests

Nabuurs considers it essential to see what we can do nearby. For example, Wageningen University & Research was commissioned by the Ministry of Agriculture, Nature and Food Quality to work on another project about Climate-Smart Forestry and Nature Management. In pilot studies, researchers examine how best to adapt our forests to climate change. Some tree species like the Norway spruce, for example, have been found to suffer a great deal from climate change and others less so, for example the maple. These and other deciduous tree species are now being planted more often. Forestry can also play a role in the supply of construction materials, Nabuurs emphasizes. 'The use of timber as a construction material ensures the prolonged capture of carbon dioxide.'

Firmly on the up

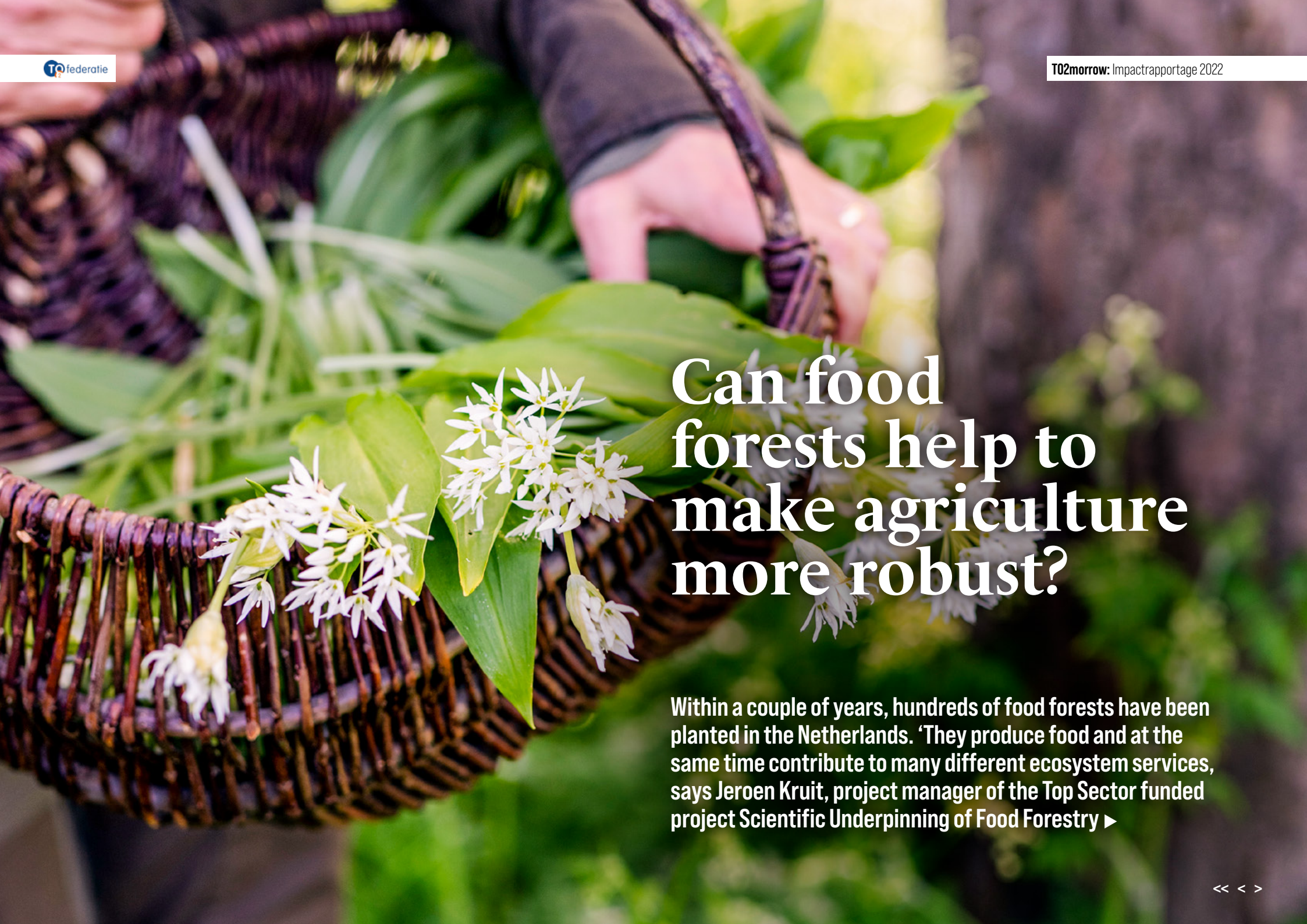
The Netherlands must also reduce the energy consumption of greenhouses, for example, by using LED lighting. Agriculture, which of course featured prominently in the news recently, has been tasked to reduce the amount of methane – particularly the volume emitted by livestock – for example, by way of a different feed or other livestock breeds. Nabuurs knows that it is not so easy to change things in the agricultural sector around the world. 'There are millions of landowners with all kinds of conflicting preferences. What's more, the world's population is growing and food production must therefore increase.' Before the 2015 Climate Conference in Paris, his team consisted of only five staff, nowadays there are twenty. 'At that time we launched the idea of climate-smart forests and we have since been firmly on the up and have noticed that this also has an impact in common practice. Meanwhile, companies and major financial institutions are forced to go green and plant more forests. These trends will continue and, together with public funds and implementing organisations, this will lead to the much-needed additional capture of carbon dioxide.' ■

Who: Wageningen Environmental Research: co-authored the chapter on Land Use and Agriculture in the IPCC report.

Duration: 2018 – April 2022.

Budget: €20,000 per year.

Follow-up: the next IPCC report will be published in 5 years' time.



Can food forests help to make agriculture more robust?

Within a couple of years, hundreds of food forests have been planted in the Netherlands. ‘They produce food and at the same time contribute to many different ecosystem services, says Jeroen Kruit, project manager of the Top Sector funded project Scientific Underpinning of Food Forestry ▶

WUR

Problem: how to improve the robustness of agriculture for weather extremes caused by climate change with more diversity and less monoculture?

T02 solution: the research project Scientific Underpinning of Food Forestry studies to what extent food forests can contribute to sustainable agriculture.

Impact: a more sustainable, environmentally-friendly and climate-friendly agricultural system.

But, to what extent do food forests contribute to major agricultural issues, such as climate change, the nitrogen problem, biodiversity restauration, as well as water retention and buffering? And is there a revenue model for the farmer? Kruit and his colleagues are seeking answers to these questions in their research project.

Annuals vs perennials

The government is convinced of the advantages: the ambition is to have realized 25,000 hectares of agroforestry of which a 1,000 hectares of food forests in the Netherlands by 2030. Farmers mostly grow annual crops. Agroforestry combines annual crops with perennials, for example, by planting rows of trees between fields of grain. Kruit: 'Those trees have positive effects on the annual crops because they provide shade and root deeper. That helps with the provision of water in droughts and drainage in events of heavy rainfall. Food forestry goes a step further. These multi-layered perennial systems mimic a forest ecosystem, growing many different species that produce edible fruits, nuts, leaves, roots, herbs and seeds. -

Food forests are a new phenomenon in the Netherlands: the best known food forest Ketelbroek was only planted in 2009. Meanwhile, hundreds of small initiatives, initiated by enthusiasts, have started. Slowly on also lager scale commercial food forest of 5 hectares and more are starting off.

Challenging alternative for farmers

Kruit thinks the government's aim is ambitious but promising, because it is linked to the objective of planting more forests in the Netherlands anyway. 'To meet the ambitions through planting trees on arable land farmers will have to be seduced to integrate trees in their agricultural system.' In a food forest, the most complex agroforestry system, the earning model is possibly most challenging, the researcher explains: 'Return on investments will take (a lot) more time compared to annual crop agricultural systems. Although a food forest will in time produce in abundance it will approximately take up to 7 years before a food forest starts producing serious volumes. At the same time there is no need for crop protection products and (chemical) fertilizer and no seasonal preparing the soil with heavy machinery for ploughing and sowing.'

Harvesting methods researched

What's more, harvesting in food forests is done by hand and often with volunteers. The food forests in Almere and Schijndel were developed with a research ambition in mind. The planting scheme was designed as such that future machine harvesting is possible. Developing these machines is one of the fields of research right now.

Kruit emphasizes: 'Although food forests will not provide us with potatoes and grain, they have a potentially important role to play in making the overall agricultural system more robust. This project teaches us to what level food forests can contribute to food production, biodiversity, climate mitigation (carbon sequestration) and climate adaptation (adapting to the effects of climate change).' ■

Who: Wageningen Environmental Research, in cooperation with a large number of partners.

Duration: 2020–2025.

Budget: €1 million.

Follow-up: additional research is necessary to make well-founded statements. More time is needed because a forest does not grow very fast.

Jointly being smarter with vital water

Water for agriculture is scarce during periods of drought. Grow with the Flow helps farmers manage the available water more efficiently and to plan their farming operations better. At the same time, this project provides water authorities with more insight into local water needs and enables researchers to improve their models and knowledge. ▶

Edwin Snippen of Deltares was involved in the development of Grow with the Flow.

Deltares, WUR

Problem: water shortages and waterlogging are becoming more common as a result of climate change. This calls for efficient water management by water boards and water usage by farmers; so too in view of securing our long-term food supply.

T02 solution: Deltares and Wageningen University & Research (WUR), together with water boards and private parties, developed Grow with the Flow, a digital platform that monitors and predicts data on water availability at plot level.

Impact: Grow with the Flow's data and predictions enable farmers to optimise their farming operations. At the same time, the platform provides water boards with a better understanding of the water needs in their area and allows researchers to refine their models using the data obtained.

The idea for Grow with the Flow once originated at a Christmas dinner. Between courses and over drinks, a Deltares expert chatted to an ICT specialist who was involved in automated monitoring of crop growth on farms. While they were chatting, they questioned whether any kind of unique cross pollination was possible; by matching up different data and models and making them available to farmers at plot level? More questions were posed like: what can we then find out about water availability; or whether there is drought stress or, by contrast, a water surplus, and what does it do with the crop? And if we add weather forecasts to such data, could we then jointly cope with the scarce water situation in a clever fashion?
They ventured well beyond small talk. After talking to all the relevant parties, a unique consortium emerged that dared to take on the challenge, consisting of researchers from Deltares and WUR, managers of various water boards, potato producers Lamb Weston/Meijer, ICT specialists from Capgemini and experts from the insurance company Achmea. 'A week before the Netherlands was subjected to its first lockdown, we had our kick-off meeting', project manager Edwin Snippen recalls. 'We immediately continued 'remotely' and that says a great deal about the commitment of all the parties in this project.'

Close to common practice

More than two years later, Grow with the Flow has grown into a functioning platform, running trials in two regions for its second growing season. Where some growers were sceptical initially, during the trials Snippen has managed to change that scepticism into enthusiasm. 'We provide supplemental knowledge and information to the data that farmers already get through apps like *Buienradar*. They can take advantage of this.'
The basis of Grow with the Flow consists of a combination of different calculation models aimed at water availability and crop development. Snippen: 'We use a groundwater model to calculate the regional groundwater flow. Another model uses this input to calculate the water availability, which allows us to predict the development of the crop.'
'So, on a regional level, we go from totally global to a plot level – to the crops growing there', Snippen continues. 'That results in detailed and practically usable information for each plot that the grower can

view in the app. He can add his own information too, for example the volume of water he has used for irrigation. This data is then included in the calculations, so that the data is always up-to-date and close to common practice.'
In this way, app users get a clear overview of which plots most urgently require water. Snippen: 'Some growers have dozens of plots that are sometimes quite far apart. Irrigation costs fuel and relocating the hose reel is time consuming. In brief, planning is an important issue, especially in times of drought, when water must be dealt with as efficiently as possible.'

Reference measuring points

Grow with the Flow, however, does far more than merely provide an insight into the development of moisture content of plots in the near future. 'We can also calculate whether a plot is not too saturated to drive on it. Here too, we provide an indication for more than a week ahead via the app', says Snippen. 'In this way the farmer can weigh up when to use heavy equipment on the land. This helps to prevent soil structure damage. And that is good for the water system: a good soil loses fewer nutrients and is better able to retain water or allow it to penetrate. Similarly, the choice for a particular crop or the control of small (local) weirs, have an influence on the overall water balance and can be included in the app. In the final analysis, Grow with the Flow must develop into an app that will help farmers to plan ahead and to use the available water as efficiently as possible in their country.' ▶

Deltares, WUR

Not only do farmers benefit from the insights gained by Grow with the Flow, but water authorities too. Snippen: 'Water boards use this information to gain a far better and more detailed overview of water availability, from plots to the entire river basin, and in the process, also the impact of water management in an area. This can be calculated by using models, as you now have a number of reference measuring points in your area where the model can be tested.' These measuring points can of course be used again in prediction models. 'This enables the water board to provide better customisation. By showing what the current and expected situation is regarding the moisture content of the soil and then comparing it with the bandwidth of a long-term average, it is easier to substantiate where and when water needs to be retained or discharged.' What do the researchers themselves gain from this? 'We get to learn how our models best fit into practice so that we can refine them further.'

Available nationwide

The current project mainly focuses on dairy and potato farms. Snippen: 'To keep things clear and organised, we have limited the scope in the first phase to a number of common crops: grass, maize and potatoes. The next step is to increase the number of crop types so that more farmers are able to participate. The ultimate goal is to achieve national access.'

Looking back, Snippen considers the collaboration between such varying organisations to be one of the greatest merits of the project. 'It was nice to see how confidence gradually grew, which made growers also want to share information. If you consider the tremendous task of water management, both in the short-term and in the long-term, you can only cope with it collectively. With that in mind, it was an worthwhile experience for us to bring about such a broad-based consortium. The closer we can bring our knowledge to the growers, the better. Of course, this project is not the ultimate solution, but it does contribute to more water awareness, which is a step in the right direction.' ■

Edwin Snippen: 'The tremendous task of water management can only be resolved collectively'

View the video here

Who: Deltares together with WUR, Vallei Veluwe water board, Aa and Maas water board, Capgemini, Achmea and Lamb Weston/Meijer. The project was subsidised by TKI Agri&Food/TKI Deltatechnologie with contributions by the project partners. The basis for the platform was developed by Milan Innovincy in collaboration with Capgemini.

Duration: the project started in 2020 and will run for three years.

Budget: €1.5 million.

Follow-up: in a follow-up project we want to add more crop types and upscale the platform to make this available to growers nationwide.

Jointly being smarter with vital water

The landscape of the future is green-blue

A continuous warding off of water in the river delta in which we live is not a preferred option to keep our feet dry in the decades ahead. Annemargreet de Leeuw at Deltares is working on a different approach and manner of thinking about water-safe landscapes. ▶

WUR, Deltares

Problem: the consequences of an ever-faster climate change makes the Netherlands – as a river delta – vulnerable.

TO2 solution: WUR and Deltares are jointly developing future scenarios with three pilot areas for landscapes becoming more sustainable, rich in values, abundant in water and water-safe. Not only for now (2030), but also for later (2050) and in the distant future (2120).

Impact: a comprehensive way of thinking about retaining and managing water, and for the creation of landscapes that are rich in value which require giant system leaps and a different way of thinking.

The dry summer of 2022 showed what the IPCC report had warned about: climate change is increasingly pressing upon us. Rising sea levels and tropical temperatures, extreme drought and heavy rainfall are putting our water system under pressure both in the near and in the distant future. Annemargreet de Leeuw, Flood Risk Programme Manager at Deltares, knows what future challenges we face. 'Our water management is aimed at warding off rising water levels. The question is whether we need to maximise this system or whether we should store water in the landscape in such a way that we can still live and work safely.' In posing the question, it has basically been answered already. 'We are working on the creation of sustainable landscapes in which we rather live with the water and enjoy it, and where water is fairly distributed.'

Sustainable until 2100

Deltares and WUR's specific area-focused approach to developing landscapes of the future is based on three pillars: they must be water-safe, abundant in water and rich in values. Annemargreet: 'Future water management is more focused on resilience rather than the power to ward off. We give water more space in the landscape and thus create added value for everyone. For instance, by aiming for the catchment and storage of water in the event of too much rainfall and flooding, and retention of water for times of drought. Discharging it is the last thing you should do. An example of this is ABC-Delfland, in which a clever combination of the storage of water in polders, space for water in the 'bosom' and sufficient pumping station capacity to discharge the water, helps to prevent waterlogging as happened in 1998.

What if

The emergence of such landscapes requires radical changes that interfere with our present approach, agreements and policies. The project works on concept development in three pilot areas: (1) at the top of North Holland, in the vicinity of Schagen and Den Helder, (2) in the area split by the Rhine, IJssel and Waal rivers at Spijk in Gelderland, and (3) the Frisian Wadden Sea coastline. Annemargreet: 'The soil in North Holland salinizes the soil, which is harmful for bulb cultivation. How sustainable is this cultivation in the future? Should there be more or less water in that area, what about the hinterland, what if there are extreme floods? What other earnings models are there for that area? We're going to have round-table discussions with officials and executives from municipalities and provinces, as well as drinking-water supply companies and nature organisations, and we'll be kicking off a dialogue with design studios.'

Raising awareness

At these round-table discussions, a complicated trade-off of interests in economics, nature, businesses, farmers and residents takes place. Deltares and WUR contribute their knowledge. 'We think in terms of 'blue', and Wageningen does so in terms of 'green'. Wageningen knows all about the natural base system and layout of the existing landscapes. They create new maps based on our input about climate change and the makeability of landscapes that are sustainable, abundant in water and water safe.' A cross-pollination that looks way ahead from many different angles, with necessary and far-reaching consequences for development of the landscape of the future. Take the housing challenge that is topical in many areas. Should we continue to build in polders that are situated way below the Amsterdam Ordnance Datum (NAP) as we have been doing for years? On this, Annemargreet says: 'In the Netherlands everything is well organised, 90% of the population think that raising dykes is enough to ward off the rising water level. But weather conditions are becoming more extreme and we are becoming increasingly vulnerable when we build in deep polders without making adaptations. Especially if those polders have trouble with soil subsidence. It is this awareness that must be raised.' ■

Who: Deltares and WUR working jointly with partners in test areas (municipalities, provinces, water boards, drinking-water companies and nature organisations), as well as partners from the business community.

Duration: since April 2022.

Budget: €1.7 million.

NLR

Test centre for autonomous transportation

Shall we take an air taxi from A to B for urban environments in future? Many parties see it as an extension to the current way of travelling. To enable rapid and special transportation possible, airspace offers an alternative. Except, it must of course work properly and safely.
Together with various partners, NLR, RDW and DNW are developing the Mobility and Infrastructure Test Centre (MITC) in Marknesse for smart mobility. The collaboration brings together a wide range of test facilities for research into autonomous and sustainable modes of transport.
Examples of new forms of mobility are self-steering cars, drones and even flying taxis. NLR has a Drone Centre where test flights are already taking place with drones. In addition, organisations and companies will be getting a simulated infrastructure in an urban environment (DigiCity), so that they can test the behaviour of autonomous vehicles in various situations. How do they behave the moment they move between buildings?
As soon as the zoning plan for the test centre has been approved, the tender procedure and actual implementation will take place. It is expected that RDW's new test track will be operational in the first quarter of 2025.
mitc-flevoland.nl

Deltares and MARIN

Research into the impact of propellers on the embankment

In future, ships will become bigger will have even more powerful engines than today. The propellers and bow thrusters of these ships generate strong currents in ports, which can lead to more damage to quay walls, the seabed or embankments if left unprotected.
In cooperation with the ports of Rotterdam and Antwerp, North Sea Port, construction company Holcim, Rijkswaterstaat, MARIN and several market parties, Deltares has carried out scale model tests to study the impact of bow thrusters and ship propellers in relation to seabed protection near quay walls. Deltares has built a physical scale model in one of its basins and uses advanced measuring techniques (Particle Image Velocimetry, PIV) to visualise and characterise the jet stream produced by propellers. The scale model tests are based on field measurements carried out at the port of Ghent in 2020. MARIN also provides assistance in this project and is developing the numerical simulations.
The results of this research could lead to major cost savings, as the design and extent of future seabed protection near quays and embankments, could be ascertained better.

TNO

Fewer hospital admissions and improved pre-admission care thanks to 5G real-time video

The use of real-time video and vital data significantly improves the assessment of medical emergencies compared to current audio-only communications. This was shown by a recently completed trial carried out by TNO, telemedicine company RedZinc and AmbulanceZorg Groningen (ambulance care). It examined to what extent a remotely-located patient can be assessed better using an audio-video connection and/or 5G vital signs monitoring.

Monitoring remotely
In some cases, the ambulance takes the patient to hospital whereas an in-situ treatment would be satisfactory. When the emergency medical technician (EMT) uses portable equipment using a link that shares real-time video, vital signs, or a patient's ultrasound, the hospital's medical manager for ambulance care can monitor remotely and ensure a faster diagnosis and decision-making.

TNO

Geological Survey of the Netherlands exposes wealth of information

The Netherlands is faced with major challenges such as climate adaptation, the energy transition and large-scale housing construction. The subsurface plays a crucial role in resolving these issues.
The *Geologische Dienst Nederland, GDN* [Geological Survey of the Netherlands], which is part of TNO, has been researching the subsurface of our country for more than a hundred years already.

The GDN is making the subsurface much more visible on its new website by using the Subsurface Key Register and 3D models. 3D models can be viewed via the site; copies of the subsurface. This will help planners and policy makers to understand what is possible and not possible above ground. This includes major infrastructure projects or the construction of wind farms. The subsurface also plays a role in the supply of drinking water and energy, such as geothermal heat. In doing so, the GDN works closely with other knowledge institutes. One of them is Deltares, which, through innovative (field and lab) measurements, models, data science and system knowledge, provides insight into the subsurface and groundwater system for studies, strategies and decision-making.
geologischedienst.nl

Deltares, MARIN and WUR

Digitisation of the North Sea

The Netherlands is digitising at a rapid pace, but in respect of the North Sea, data collection, display and modelling are still in their infancy. While there are realistic challenges in the North Sea, shipping is increasing and more wind turbines will be erected, there are also all kinds of existing activities such as fishing, military exercises, sand, gas and oil extraction. 'Everyone wants to do something at the North Sea. The Coastguard's task is to ensure the safety of the North Sea and, because of the pressure, they are confronted with new tasks', says researcher Yvonne Koldenhof of MARIN. Monitoring the North Sea (and Wadden Sea) ecosystem is one of the government's core tasks.

Complex system
Activities in the North Sea will increase considerably in forthcoming years. The crux of the problem is primarily to improve good mutual communications not only to ensure sound security, but also to serve economic and environmental interests. Deltares, MARIN and WUR are researching this as well as collecting data on how this can be created at the North Sea using new insights into ecosystems, technological possibilities and, in doing so, which risks could be involved. 'The North Sea is a complex system. There are economic, military and ecological interests. If this system has to be managed properly, not only are good data and models are necessary, but these would also need to be deployed and combined correctly across the boundaries of primary interests.' Spatial planning, ecological resilience and risk limitation are essential and are closely linked in a complex international legal context.

TNO

Clean factory of the future

Due to the oil and gas shortages, not only have the prices of gas and petrol increased, but also the price of plastic, medicines and cosmetics. To make us less dependent on fossil fuel resources and to combat climate change, the chemical industry must radically change.

Foundation
In recent years, TNO and TU Delft have laid the foundation for cleaner production processes for the chemical industry in their VoltaChem and e-Refinery programmes. Within the new partnership, e-Chem, they are taking the next step: to actually build a clean factory of the future. Together with other knowledge institutes and industry, e-Chem is going to build large-scale plants that will extract carbon dioxide from the air on an industrial scale and convert it into raw materials – using sustainably generated electricity – for the production of plastics and fuels, among other things.
The electrification of the chemical industry is necessary if this industry is to be climate neutral by 2050. Besides, electrification offers great opportunities for the Netherlands to develop into the leading supplier of high-end systems for the energy transition.

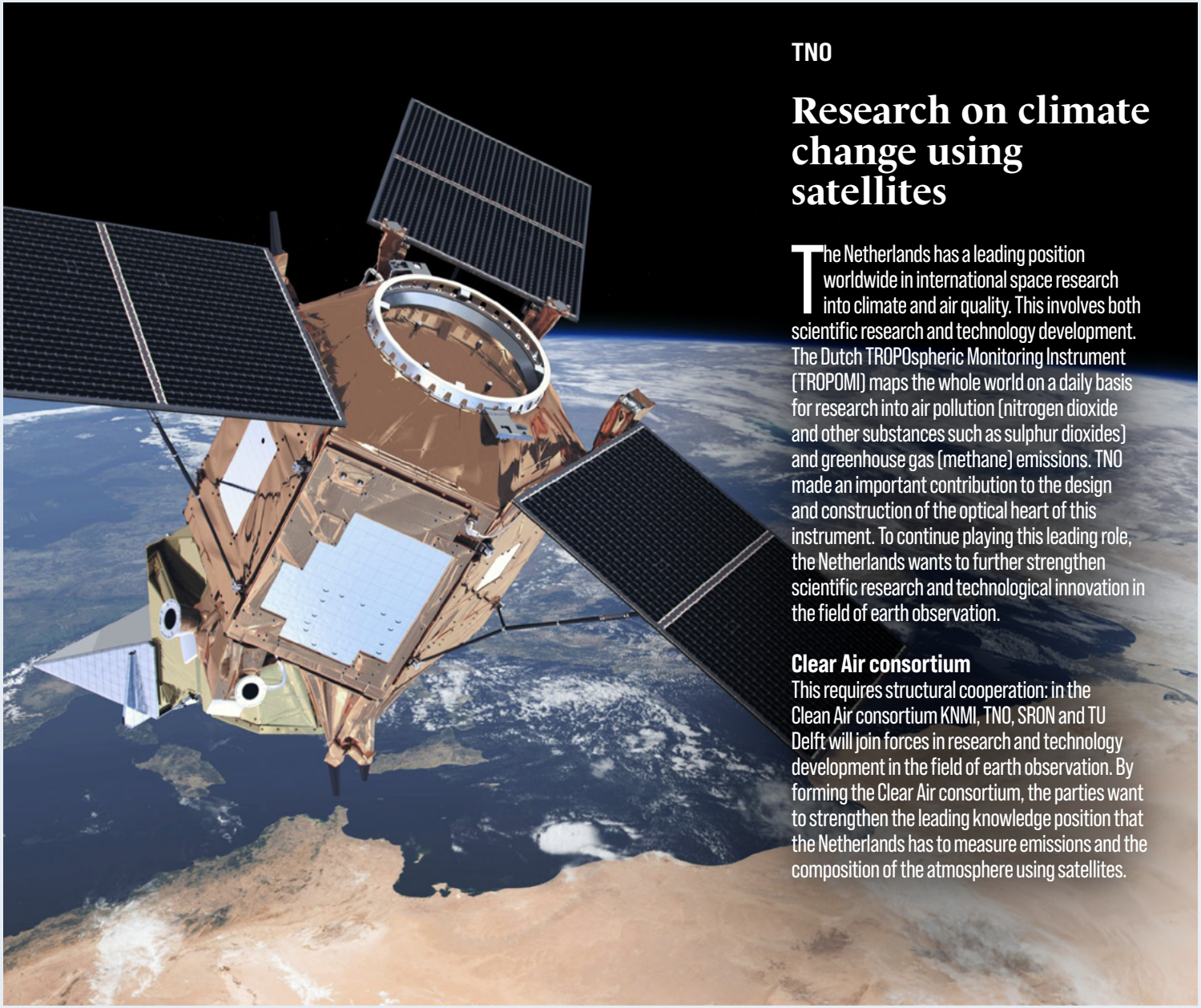
WUR

‘Digital twin’ for water management

Wageningen University & Research is working in conjunction with other parties on a digital twin in water management. A digital twin is the combination and interaction of a physical system (such as a factory) and a virtual representation of this system, often a computer model. Data streams feed the digital twin from the physical system, creating a virtual representation of the system. This digital copy, in turn, can communicate with the physical system to exercise control and to steer the system to a preferred state. A digital twin can also analyse virtually different scenarios.

Solutions

A digital twin for water management enables further integration and use of data, models, workflows and their implementation in the complex operational structures of water boards. A digital twin can contribute to modern water management solutions covering three different topics: water treatment plants, water quality and drought. The impact is massive for a broad-based consortium of partners: better management of water systems and easier testing of scenarios in the event of an increasing variety of climatological challenges.



TNO

Research on climate change using satellites

The Netherlands has a leading position worldwide in international space research into climate and air quality. This involves both scientific research and technology development. The Dutch TROPOspheric Monitoring Instrument (TROPOMI) maps the whole world on a daily basis for research into air pollution (nitrogen dioxide and other substances such as sulphur dioxides) and greenhouse gas (methane) emissions. TNO made an important contribution to the design and construction of the optical heart of this instrument. To continue playing this leading role, the Netherlands wants to further strengthen scientific research and technological innovation in the field of earth observation.

Clear Air consortium

This requires structural cooperation: in the Clean Air consortium KNMI, TNO, SRON and TU Delft will join forces in research and technology development in the field of earth observation. By forming the Clear Air consortium, the parties want to strengthen the leading knowledge position that the Netherlands has to measure emissions and the composition of the atmosphere using satellites.

WUR

Green = good for health

Contact with nature increases happiness and reduces stress. It is conducive to vitality and induces encounters between people. Researchers at Wageningen University & Research are therefore working on various 'green projects' for health. In Arnhem and Nijmegen, researchers examined how they, together with inhabitants, can get vulnerable neighbourhoods to go green, so that inhabitants are more into contact with green space and actively use it. This could be a neighbourhood vegetable garden, set up by residents themselves, where they work together and prepare meals with vegetables and herbs from their own garden. WUR wants to know the effect that this has on the health and well-being of the residents.
Green space also makes us feel comfortable on a warm summer day in the city. A good and scattered amount of city greenery combats urban heat. Wageningen University & Research researched the contribution of urban greenery to what is known as thermal comfort: how pleasant or unpleasant the interaction of temperature, wind, humidity and radiation feels. Climate change will increase the heat in cities, and thermal comfort will become more and more important in the design of outdoor spaces.

TNO

Up to 50 percent more yield by solar panels

Solar panels play an important role in the energy transition. There is a need for solutions to achieve greater efficiency per square metre of surface area used, for example by increasing the yield of solar panels to generate more solar power per surface area.
Researchers from TNO, TU Eindhoven and TU Delft are amongst the best in the world with their so-called four terminal tandem solar panels (two stacked solar panels that can convert more energy from the solar spectrum than a single solar panel). Last autumn, performances were achieved by further maximising the yield for tandem applications. And the end is not in sight yet. Yields could be up to 50 percent more as a result of the breakthroughs.

TNO's Robert Ostendorf helps developers of medicinal products to better mimic the conditions in preclinical studies.

Better prediction of the effectiveness of medicinal products

Developing new medicines is extremely time consuming. That process must be accelerated and become more effective, say researchers at TNO. One of the solutions in this process could be 'Organ-on-a-chip technology', which uses complex cell models to mimic human organ functions. ▶

TNO

Problem: the development of medicinal products takes too long and many medicines fail at a late stage of development: preclinical animal-based or cell-based studies are not good enough and do not provide sufficient insight into the effects and side effects of medicines.

TO2 solution: improved preclinical methodologies using 'Organ-on-a-chip (Ooc) technology'. This technology uses human tissue, stem cell-based organoids and advanced disease inductance capabilities. This enables TNO to help developers of medicinal products to better and precisely mimic the human conditions in preclinical studies.

Impact: Organ-on-a-chip technology sooner reveals the effects of interventions in humans and enables results to be interpreted better and/or faster to humans. This helps streamline clinical studies of medicinal product efficacy. In addition, it can play a role in personalised medicine and population-specific interventions by using patient-specific (stem) cells.

The most important reason for this development is the often disappointing results in clinical studies, according to TNO-business developer Robert Ostendorf. 'There is a huge need for a faster and more effective way to trial the efficacy of medicinal products. We have found this in the Organ-on-a-chip (Ooc) method, a technology that we are developing together with companies.' Researchers went in search of systems to test a substance in human cells and tissue, to approach reality as closely as possible. For this, TNO had to build a bridge between technology and biology. These specialist skills are both required for Organ on-a-chip technology. Ostendorf: 'It would be preferable to test developmental medicinal products directly in humans, but of course that is not possible, yet with Ooc technology we can try to mimic reality as far as possible.'

Mini organs

The researchers started to develop different methods to obtain suitable cultivation conditions for the different types of cells and to create mini organs. Ostendorf: 'That study entailed seeking certain functions, for example for the cell responsible for creating a particular protein. What happens there, and what does it do in combination with other cells? The cultivation conditions must make this possible. We also use the read-outs to find different methods to gain even better insights, including in combination with various electronic sensors and optical instruments and Ooc technology.'

Better predictions

The greatest gain of the Organ-on-a-chip system is that, among other things, by using human materials, better predictions can be made about what a medicine possibly does in humans and the time that it can save. Ostendorf: 'A study with animals is time consuming. They first have to be brought in and made sick before you can actually start the examination, after which the treatment will take several weeks.' All in all, this process takes a long time before results can be seen. Mini organs via Ooc sooner provide insight into the effect of new medicinal products. 'It is easier to access cell or tissue material that can be used almost immediately in the system.'

Robert Ostendorf: 'There is a huge need for a more effective way to trial the efficacy of medicinal products'

Trials of liver disease interventions

Various models are used, depending on the organ for which research is needed. 'At TNO the study first focused on the liver and the intestine. A great deal of biological knowledge is available on these topics. We developed a model for the liver to test the efficacy of medicinal products for fatty liver disease NASH (non-alcoholic steatohepatitis).

TNO

In our model we can also link the liver and the intestine through small tubes that mimic the circulatory system. This is used, for example, to test interventions for liver diseases that are administered orally and reach the liver through the intestine. This allows you to very carefully study different processes that play a role in this and you know much sooner whether new medicinal products have a chance of achieving the desired effects in humans.'
In addition, TNO is developing an intestine on-a-chip, which uses colon biopsies or stem cells derived from them, in order to study the absorption of medicines in the intestine. 'This research has been extended to a model in which we add intestinal bacteria to the system, to further study interaction between these bacteria and humans.'

Strive for uniformity

In the future, TNO will increasingly seek to work with this new technology in medicinal research. 'This is important', says Ostendorf. 'It now encompasses all activities to cultivate and test human cells. This should ultimately lead to a reduction in the use of laboratory animals in the development of medicinal products.'
He emphasizes the importance of standardisation: 'there is increasing potential and due to technology we are progressively able to measure more. The role of organs, which is the process within humans, can also be seen in Organ-on-a-chip models. By introducing this step-by-step, we get to know more and we can do more. In due time, we will need a platform that links all the studies to each other.'
The nice thing is that many companies are now building their own systems for Organ-on-a-chip, says Robert Ostendorf. 'At the same time, we have to conclude that this makes it difficult to arrive at a single system.' The aim is to achieve such a uniform system. Research companies can then work on a larger scale and technology will become cheaper. 'In addition, uniformity makes validation easier, and it is easier to link the new technology to it.' It is for this reason that TNO is collaborating with TU Twente and TU Eindhoven on a universal Ooc platform with integrated fluid streams and readout technologies.

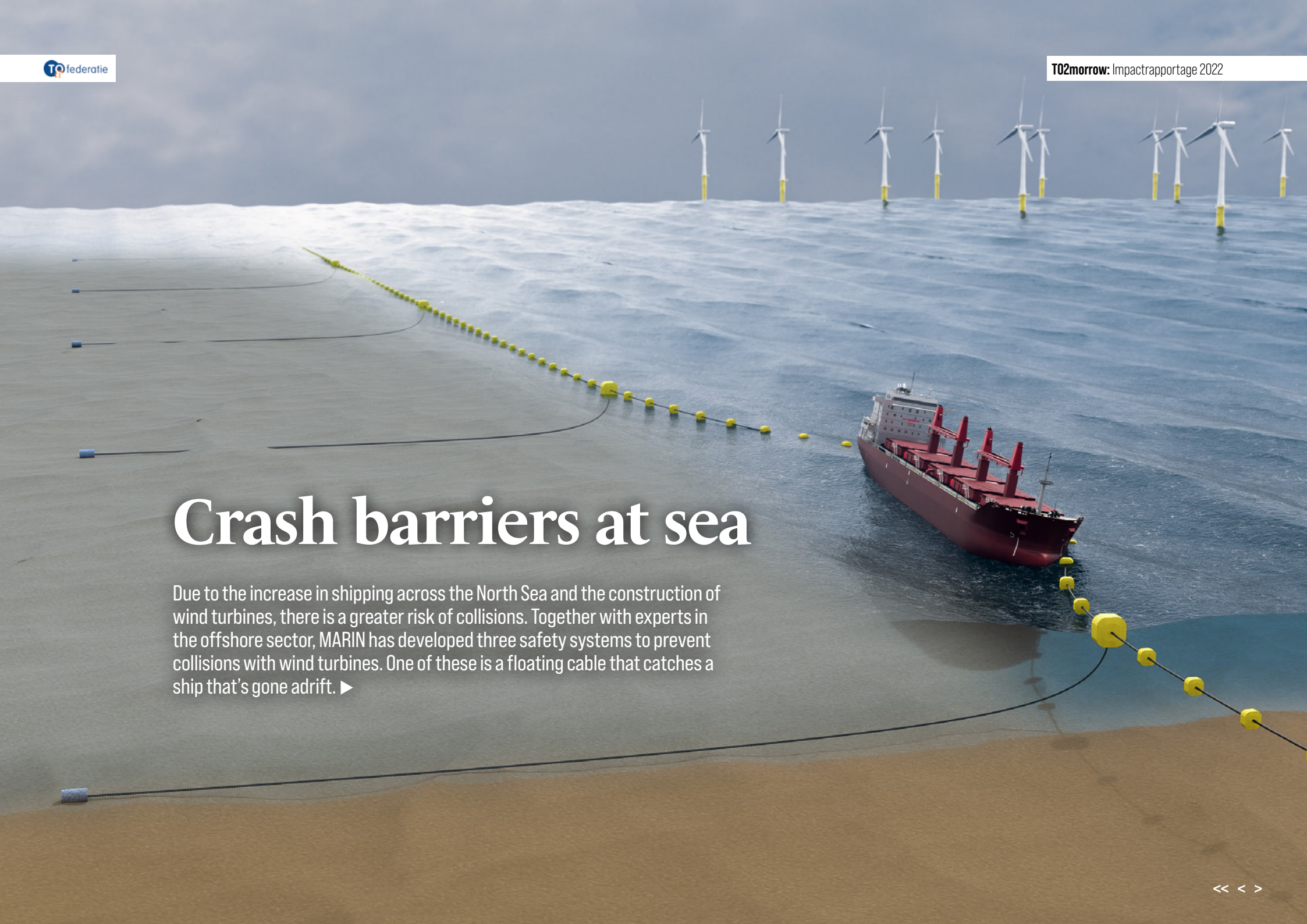
Growth Fund

Another example of cooperation is the NXTGEN Hightech Growth Fund project. This consortium comprises various universities, knowledge institutes and companies, where the entire chain is developed and scaled up, from materials to (stem) cell availability, and from models to their applications. Efforts are being made to link-up the liver and intestine, and onto a third organ, the kidney. Ostendorf: 'TNO's role is that of applicator and validator; input of our biological knowledge helps make the models feasible and reliable.' ■

Who: TNO, TU Twente, TU Eindhoven, and research groups at universities, (pharmaceutical and technological) companies, foundations and knowledge institutes.

Follow-up:
- further refinement of current models,
- platform linking all researches,
- growth fund: a consortium of universities, knowledge institutes and companies, in which the entire chain is developed and scaled up, and in which parties work on linking the liver and intestine, and onto a third organ, the kidney.

Better prediction of the effectiveness of medicinal products



Crash barriers at sea

Due to the increase in shipping across the North Sea and the construction of wind turbines, there is a greater risk of collisions. Together with experts in the offshore sector, MARIN has developed three safety systems to prevent collisions with wind turbines. One of these is a floating cable that catches a ship that's gone adrift. ▶

MARIN

Problem: the number of wind turbines in the North Sea will increase significantly in the coming years to meet the climate objectives. All the while, shipping is set to grow, increasing the risk of collisions with these wind turbines. Studies predict that a ship in the North Sea will collide with a wind turbine once or twice a year.

T02 solution: together with experts in the offshore sector, MARIN has developed a possible solution of 'crash barriers', to prevent ships that have gone adrift in the North Sea – about 80 per year – from colliding against wind turbines.

Impact: ships are already causing serious damage to wind farms. The Julietta D that went adrift this year mainly caused material damage, but a collision by a cruise ship or oil tanker with a wind turbine could have major consequences for humans and the environment. Crash barriers can improve shipping safety and prevent accidents and also economic and social damage.

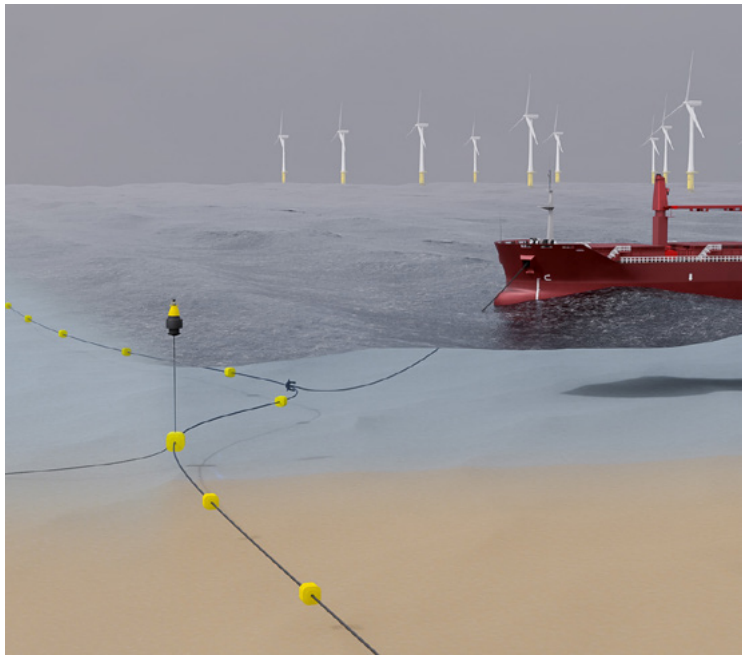
In 2022, the government decided to further raise the capacity of offshore wind energy to 21 gigawatts in 2030. This will result in some 700 additional wind turbines in the North Sea. Concurrently, the volume of seagoing vessels in the North Sea is getting worse and it is already cluttered. There are a quarter of a million ships per year, of which 50,000 sail to ports in the Netherlands. This increases the risk of accidents. MARIN's earlier researches already showed that a ship collides with a wind turbine or comes adrift about 1.5 to 2.5 times a year. This year, things went horribly wrong when, in blustery North Sea conditions, the sea-going vessel Julietta D damaged a transformer platform and the foundations of a wind turbine.

Julietta D

The Julietta D accident prompted MARIN to organise a solution-seeking day with twenty experts in the offshore sector. MARIN has been studying the safety of ships in the North Sea for a long time, which has already led to proposals for additional emergency towage vessels and intensive North Sea traffic management. 'We had had the idea for quite some time to develop concepts to prevent collisions with sea-going vessels at wind farms. The accident with the Julietta D vessel accelerated this expressed need for a meeting', says Yvonne Koldenhof, Traffic & Safety team leader at MARIN.
One month after the meeting, three systems were tested in MARIN's Offshore basin in Wageningen. The first system consists of a line with buoys, anchored to the seabed and acts like a kind of crash barrier, which prevents a ship from ending up amidst the wind turbines. The second method is an anchored underwater hook line to catch the anchor of the vessel that has gone adrift. The third concept consists of a suspended net between fixed poles that must stave off the vessel that has gone adrift.

Open innovation project

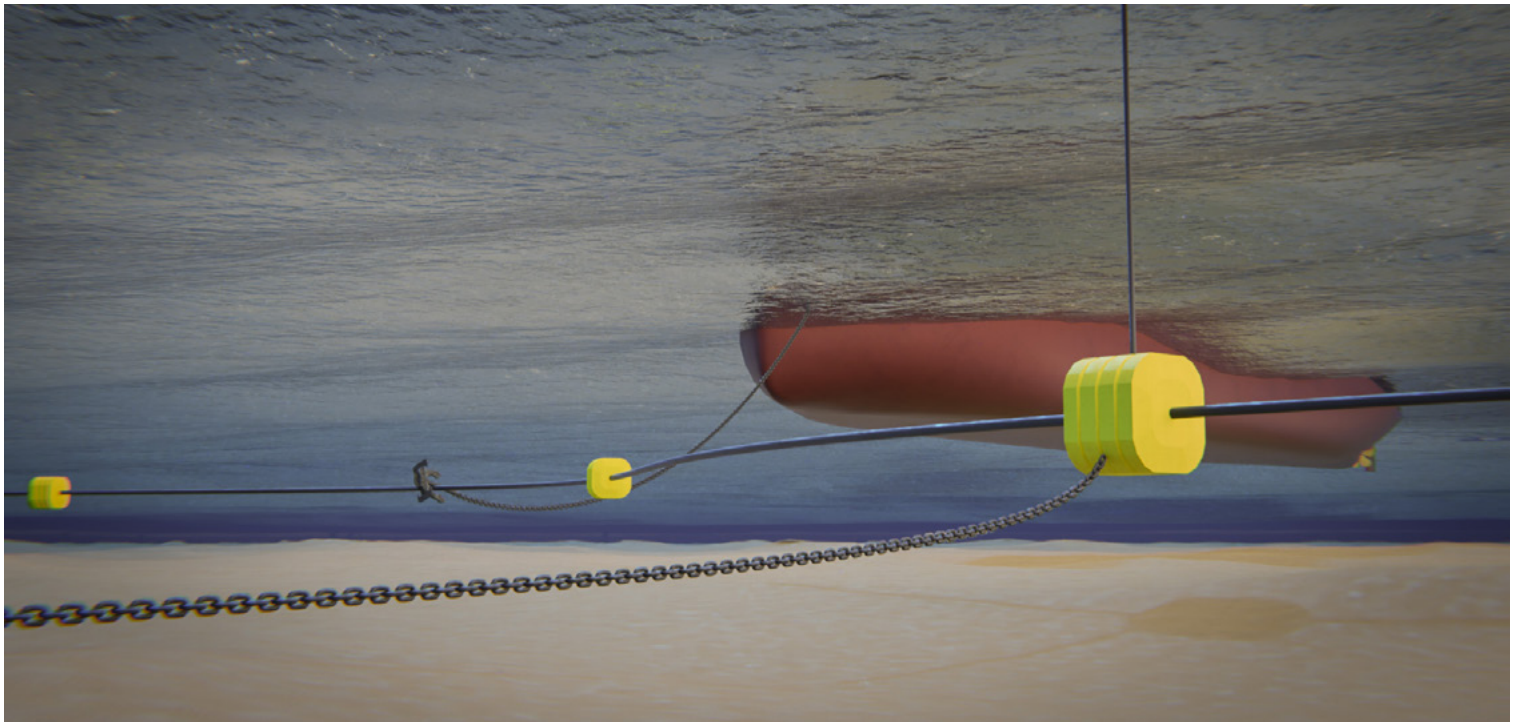
'All three concepts are capable of "catching" the ship', says William Otto, Offshore project manager at MARIN. 'The trailing anchors of the line of buoys gradually reduce the forces of the adrift vessel. The ship remains caught in the line perpendicular to the waves. At the underwater hook line, the ship turns naturally with the bow into the waves, finally leaving it barely rolling and remaining in place with relatively low forces. At first the netting had sagged too much, but after some fine-tuning we got this working too. We will share the results as an open innovation project and will then be able to develop the most promising concepts.'



Utility vessels

There are plenty of other matters to study, Koldenhof says. 'A wind farm cannot, for instance, be completely surrounded by a line of buoys. After all, utility vessels carrying out maintenance and control must continue to have access to the wind farm. We also calculate where the traffic flows lie, to establish where the highest risk of collision would be. Based on this, we can determine whether to only place crash barriers at positions where the risk is the greatest, for example where the navigational routes come close to the wind farms.'

MARIN



View the video here

The first study has been completed, but Koldenhof expects that the follow-up study will happen soon. "Now there is still enough space at sea, but with all these future wind farms under construction, there is an increasing risk of accidents. Damages were confined for the Julietta D, the vessel collided against only one wind turbine and a transformer platform and narrowly missed a few. As the wind turbine and platform were still under construction, the damage was still manageable. However, a cruise ship with thousands of passengers or an oil tanker with chemicals could also come adrift, which can lead to hazardous situations for the crew and the environment. Doing nothing is no longer an option, the risks are too real." ■

Who: MARIN in cooperation with Bluewater Energy Services, Mooreast, Vuyk Engineering, Heerema Marine Contractors, Boskalis, GustoMSC, KRVE (Rotterdam Boatmen), Pinkster Marine Hydrodynamics, Huisman Equipment, Orca Offshore and SBM Offshore.

Duration: 2022.

Budget: there are funds from our own research budget for this project.

Follow-up: the report was completed in the summer of 2022. There will be follow-up sessions as this was only a first step.

The concepts and results of all tests are shared as an open innovation project and the parties are elaborating those that are most promising.

Crash barriers at sea

Navigating safely in shallow waters

MARIN, in cooperation with Rijkswaterstaat, is conducting research into the behaviour and consequences of the 'squat' effect by inland water vessels in shallow waters. Especially now that skippers are more often faced with low water periods in the Dutch rivers due to the rising drought, it is important to have a better understanding of what 'squat' is for ships. ▶

Wytze de Boer of MARIN conducts research into navigational behaviour known as squat effect.

MARIN

Problem: where a ship has sufficient water below the keel in a stationary state, its bodily sinkage may increase by dozens of centimetres when in motion. This phenomenon is called a 'squat' effect. The degree of bodily sinkage varies due to the circumstances. In extreme conditions this can result in damages to the bow or rudder and propeller.

TO2 solution: MARIN conducts research into the navigational behaviour of ships and the squat effect in shallow water. The results make skippers aware that they need to reduce speed or they must allow for more margin in the shallowest parts on the waterway's route. In more extreme conditions, calculations also help to predict reality, so that waterway managers can arrive at better guidelines for widths and depths of navigable waterways.

Impact: gaining a better insight into the navigational behaviour of inland water vessels prevents skippers, shipping companies and shippers from wasting valuable time on delays or repairs, damage to waterways and engineering structures (locks, quays) and reduces traffic disruption on waterways by vessels that run aground. It improves the navigational guidelines for skippers and shipping agents in design guidelines for waterways and vessels.

Squat effect (roughly translated: bodily sinkage of the ship) is the loss of space below the keel of a ship in motion compared to when it is stationary. It is the hydrodynamic phenomenon causing vertical sinkage of a vessel (the 'bodily sinkage'), especially in narrow shallow waters. It is caused by the water velocity around the vessel, resulting in a reduction in pressure in the water. 'The water ahead of the bow is pushed away by a sailing ship and disappears next to and under the ship. This causes a reduced pressure in the water around and under the ship, causing some bodily sinkage of the ship', says Wytze de Boer, senior project manager for Inland Navigation at MARIN.

Interaction with ships

Interaction with passing ships similarly has an impact on the bodily sinkage. MARIN analysed a situation in which a loaded inland vessel of 110 m on the Amsterdam-Rhine Canal (depth of 6 m) passed a loaded tanker measuring 135 m. 'While passing, the 110 m vessel had a bodily sinkage of almost half a metre', says De Boer.
That difference could cause the ship to touch the bottom – or worse – to damage its rudder or keel. De Boer: 'Especially if there are stones on the bottom. If you then go over these stones with the stern of the ship, the rudder may get damaged. An incident is also known of leakage at the bow. In itself, the damage may not be so bad, but it may take days for the ship to be repaired at the shipyard. Ships that have run aground could also inhibit shipping traffic, which causes delays. As a consequence, skippers and shipping companies miss out on a lot of revenue.'
MARIN studied many aspects of the squat effect. For example, the bodily sinkage increases at a faster sailing speed or as a ship sails away from the middle of a river. The size and shape of the ship also influence the squat effect. For greater lengths, the squat effect will decrease slightly, and for greater widths the squat effect will increase.

Tightening the guidelines

Waterway managers also benefit from research. 'The results are increasingly likely to predict the reality on a canal or river in extremer conditions, so the waterway managers can produce better guidelines. The guidelines include waterway depths and widths and the waterway managers must ensure that skippers can sail on the basis of these navigable depths.'
The study's report will be completed by the end of 2022. The results make skippers aware of situations in which they have to allow for more margin in shallow sections of the navigable waterway. 'Our research has ensured that the squat effect concept is becoming more known to skippers and they know that they must allow for more margin in the shallow parts of low water or to reduce speed', De Boer concludes. ■

'The squat effect could cause the ship to touch the bottom and run aground – or worse – to damage its rudder or keel'

View the video **here:** Watch the video **here**: **Simulation of an overtaking manoeuvre of two 110 m loaded inland vessels.**

Who: MARIN and Rijkswaterstaat in collaboration with Platform Zero Incidents and VOF Shalimar/NPRC.

Duration: from 2018 until end 2022.

Budget: both MARIN and Rijkswaterstaat spend €150,000 annually on the project.

Follow-up: the details a follow-up study will be determined by late 2022. This could include the influence of upstream and downstream navigation and low-water conditions of the IJssel.

Marta Tojal Castro of NLR.

Fly drones safely in busy cities

Drones can help to find your way around a busy city quickly and safely. An automated air traffic control system must ensure that vehicles use urban airspace safely. Marta Tojal Castro, project leader at the Royal Netherlands Aerospace Centre (NLR) coordinates demonstrations of unmanned drones, where various scenarios are tested. ▶

NLR

Problem: busy cities with congested roads are offered the advantage of deploying drones to transport patients or to carry out reconnaissance flights in the event of disasters. But the skies are also getting busier. How do we ensure that all these vehicles share the airspace safely and communicate effectively with each other?

TO2 solution: as the leader of the European project AMU-LED, the Royal Netherlands Aerospace Centre (NLR) organises large-scale demonstrations with manned and unmanned drones. NLR tests various scenarios for efficient communications via a partially and fully automated air-traffic control.

Impact: demonstrations provide valuable information to improve air-traffic control protocols and systems. Moreover, they are a test case for the social acceptance of manned and unmanned drones. When the technology and ethos are ready for it, cities will become safer, more sustainable and smarter in future.

For many people this still seems to be science fiction, but it's almost reality. Perhaps in five years' time, drones will fly in the city skies to transport people or to assist in the event of disasters. This should be possible within five to ten years, says Marta Tojal Castro, a researcher and consultant at NLR. Tojal Castro is leading the European project Air Mobility Urban – Large Experimental Demonstrations (AMU-LED). This year, the consortium organised large-scale demonstrations with manned and unmanned drones in Amsterdam, Enschede and Rotterdam, amongst others. In doing so, they tested various scenarios for the automated air traffic control of drones, called U-space.

Advantages

Our cities are becoming busier and fuller. Deploying drones, for example for emergency services, offers many advantages, according to Tojal Castro. 'An unmanned drone can hover above a burning building and map the source of the fire or detect where humans are still present. This knowledge will help to safely send the fire brigade directly to the right place.' Drones are able to get to hard-to-reach places, such as accidents or floods. They can also transport crews efficiently to their ships. Additional advantage: they are electrically powered, so they don't create emissions. 'It is safer, faster and economically viable', according to Tojal Castro.

'Drones can hover above a burning building and map the source of the fire'

Safety

In order to achieve this vision of the future, it is important that flying with drones can be done safely. That is what Tojal Castro and her team tested extensively during the demonstrations. After all, there will soon be many more air traffic users who communicate in various ways. For example, there are scenarios where one drone enters the airspace of another. How does air traffic control solve this? 'U-space will send a fully automated 'alert' and instructions to remain hovering, to increase or to decrease in altitude.'

Society

Tojal Castro realises that there could possibly be resistance by society to flying with unmanned taxi-drones. "People might be a little scared of it", she says. That is why she and her team conducted research on the social impact of U-space during the demonstration in Amsterdam. A target group answered a series of questions in advance and afterwards to assess whether they had changed their minds about the use of drones.
In Enschede, the main issue was the social impact: "Here we want to show what U-space can do for the city of the future, especially for emergency services." In Rotterdam, the emphasis was on economic viability.
For example, the Port Authority of Rotterdam would like to test the transportation of a ship's crew with an unmanned drone. "This will be a demonstration of the city of the future."

Future

When we look towards the sky in the future, will we see thousands of hovering drones? Tojal Castro is quite certain about that, saying: "No, the public will not accept that. Besides, they fly at higher altitudes. You only see and hear them when they are really close by. So, not thousands of drones, but this could be a daily reality when you look skywards in ten years or so.' ■

Who: Airbus, AirHub, Altitude Angel, ANRA Technologies, Boeing Research & Technology-Europe, FADA-CATEC, Cranfield University, EHang, ENAIRE, NTT Data, Municipality of Amsterdam, INECO, ITG, Jeppesen, NLR, Space53 and Tecnalia.

Duration: 2020–2023.

Budget: €4 million via the Horizon2020 programme of the European Commission

Follow-up: long-term research and testing of shared airspace by all traffic using automated air traffic control.

Faster surety about safety in Groningen's earthquake zone

As a result of gas extraction, Groningen has been startled by earthquakes for many years. This has led to questions about the safety of its inhabitants. The National Coordinator Groningen (NCG) assesses the buildings on safety. The typology approach is to enable a faster assessment procedure, which is a solution developed by a team of researchers from TNO and TU Delft. This enables the safety of these houses to be assessed faster. ▸

Chris Geurts of TNO developed an approach to assess buildings in Groningen within three months.

TNO

Problem: gas extraction in Groningen has led to concerns about the safety of its inhabitants. The National Coordinator Groningen (NCG) assesses the buildings in Groningen on safety, but the existing assessment of the financial implications for each house takes six to nine months which is too long to guarantee safety for all those living in Groningen.

T02 solution: TNO and TU Delft have developed the typology approach which can be used to assess buildings in less than three months.

Impact: the new approach saves between 50% and 70% of the time needed for the assessment and provides surety to residents on the safety of their homes much faster. This sooner provides clarity on whether reinforcement measures are needed.

On 16 August 2012, the earthquake in Huizinge was considered a tipping point in the discussion about the risks of gas extraction. Since that time there have been concerns about safety. The question that had to be answered was: 'when is a building safe and how is that measurable?' Chris Geurts, as a specialist in building dynamics and principal consultant at TNO, is involved in the development and roll-out of this approach. This is done in a conventional manner based on advanced calculation models in which each building must individually be modelled and assessed. A long-term challenge, given the huge number of 27,000 addresses that form part of NCG's housing stockpile to be assessed.

Was it possible to do this faster? Chris and his colleagues at TNO already thought of an idea in 2017, the so-called typology approach: assessment of the influence of seismic forces on houses with similar structural properties. The testing of houses by using the typology approach, resulted in a faster processing time for the assessment. Instead of being assessed in nine months, this meant assessment of the buildings in Groningen could already be done within three months. This meant that residents sooner had assurance about the safety and/or reinforcement measures of their homes.

Baskets and density grid maps

The plan of action backing the typology approach started by collecting all the calculations that had already been made. Geurts: 'Together with TU Delft, we first mapped the stockpile of some 27,000 houses and then categorised the houses into 'baskets'. Categorisation was based on seven building and structural features, such as the type and material of the support structure, as well as the number of floors and the number of openings such as windows and doors. Eventually, thirty typologies emerged from this. 'We needed more than just this', Geurts knows, 'we also had to identify the vulnerability for these typologies.'

Chris Geurts: 'Residents of Groningen get assurance sooner about the safety of their homes'

This was defined by how the structure of a house responds to earthquake intensity. Another factor relevant for assessment was the location of the house. TNO and TU Delft developed sector maps that show for each typology where these typologies in Groningen do not meet the safety requirements, and where they are sufficiently safe. These maps are based on expected new earthquakes and the strength properties within the typology assessed.

Social impact

In the meanwhile, the NCG works with the typology approach and sector maps. At the moment, around 60% of the 27,000 buildings have already been assessed. The entire housing stockpile must be assessed by mid-2023. So, for those buildings that do not yet meet the safety standard, there was another follow-up in which reinforcement measures were designed and implemented.
Geurts and his team want to gain more than merely time. By using the approach and by giving the best advice, they especially hope to remove the uncertainty among both administrators as well as residents. 'It requires an effort that is highly laden with emotional and social impact. What we certainly do not want is to create more uncertainty. This is quite difficult, because even if you are not responsible, it does sometimes feel like that.' ■

Who: TNO, TU Delft and NCG.

Duration: 2019–2023.

Budget: approximately €3 million.

Follow-up: develop reinforcement measures that can be implemented quickly.

Combat cybercrime with universal cyber language

To combat cybercrime, it is important to have international cooperation among investigative services. The NFI was one of the initiators for a 'language' to make this possible. TNO is one of the parties who is further developing this CASE language to facilitate the exchange of information among international investigative systems. ▶

TNO

Problem: digital crime is not inhibited by national borders. International police forces need to cooperate closely to identify this type of cybercrime. The exchange of digital information is difficult because many international systems do not 'speak the same language'.

T02 solution: NFI uses the Hansken data platform to capture and analyse trace evidence. The problem was that this system was not yet able to speak 'CASE', a common cyber language to exchange data at an international level. TNO developed a module that allows Hansken to exchange data with other investigative systems in CASE language.

Impact: the further development of CASE enables investigators in various countries to exchange reliable data faster to be able to tackle international cybercrime.

The victim could be Dutch, the criminal could be Spanish, the software is made in the Czech Republic and runs on a Polish server. Cybercrime knows no boundaries. To combat this variant of crime, it is important to have international cooperation among investigative services, but that is difficult in practice. 'Cybercrime barely existed five years ago', says Freek Bomhof, Data Science business consultant for Safety & Security at TNO. 'It is a new form of crime, changes continuously and complicates collaboration. If Dutch detectives investigate a case together with other countries, there is often a language barrier. You resort to English, but nobody speaks it perfectly. And the definition of a wallet or hidden server is slightly different in the context of one country than that of another country, which can cause confusion of what is being meant.'

Series of arrangements

It may take months before another country honours a request for mutual legal assistance. To facilitate this international cooperation, the NFI, together with other partners, developed a universal cyber language: Cyberinvestigation Analysis Standard Expression (CASE). Bomhof: 'It is a computer language containing a series of mutual agreements concerning specific words and definitions. Like: if we use this term, then that is the exact definition. That is pertinent, because if you bring a case to court, it must be clear to everyone how the evidence has been established.'

Hansken

NFI uses the Hansken data platform to capture and analyse trace evidence. The problem was that this system did not speak CASE yet. In 2021, TNO created a module that allows Hansken to exchange data with other international investigative systems using CASE language. 'We have created a link within Hansken using CASE, so that Hansken can exchange data with other information systems.'

'Cybercrime is a new form of crime, it changes continuously and complicates collaboration'

CASE community

TNO has also contributed to the expansion of CASE's words and terms. 'In cooperation with INTERPOL, we have developed a glossary and definitions for cryptocurrency and underground market places', says Bomhof. TNO remains active in the CASE community and calls on other organisations that work with cybercrime data to join the community. 'At the annual event of our business unit it was nice to win the Impact Award with this Hansken project. We had achieved this in a short space of time and with very little budget, and that impressed everyone.' ■

Who: TNO in cooperation with NFI, INTERPOL and other parties.

Lead time: creating the CASE interface in Hansken took six months.
Budget: €50,000

Follow-up: TNO is working on creating CASE-proof tools that can identify fraud and money laundering in the 'DEFRAUDify' project.

Using simulations to be better prepared for peace missions

From small diplomatic missions to enormous mobilisations of military units; over the past decades the Netherlands has participated in dozens of peace missions. TNO develops simulations with new technology to prepare military personnel for the extreme circumstances which they face. ▶

TNO

Problem: peace missions are challenging and can lead to stressful and dangerous situations, because the military must perform their duties under extreme circumstances. How do we ensure proper preparation?

TO2 solution: TNO develops simulations with the latest technology to prepare military personnel for (dangerous) situations which they have to face. These could be true to life training courses in a virtual reality environment or in climate chambers where people can get used to extreme temperatures.

Impact: military personnel will be better prepared for their mission and risks can be reduced in dangerous situations. An increasing number of training courses at Defence make use of simulators, as it saves both time and money and it is safer.

The use of simulations in preparation for peace missions has already been done for years: in Afghanistan, Mali and more recently during the *"enhanced Forward Presence"* mission in Lithuania, where Dutch units performed various duties for NATO. Simulation technology, however, is developing at a rapid pace. This includes true to life situations in a virtual reality 3D environment, climate chambers where people can get used to extreme temperatures (which happened in Mali and Afghanistan, but also anti-piracy by the Navy off the coast of Africa), as well as ingenious technological solutions to support fighter pilots, UAV (drone) operators or naval personnel.

Virtual model

Simulations help participants prepare better for missions. 'By using simulations, far more practical situations can be practiced and mistakes can also be made safely, so that these occur less often in reality', says Wim Huiskamp, Chief Scientist Modelling & Simulation and Gaming at TNO.
Mission participants practice the procedures, operation of equipment and collaboration with all partners in a virtual environment. 'It is especially the collaboration that is important', says Huiskamp. 'On peace missions, you work in close alliance with NATO, other countries and civil organisations, such as NGOs and the local communities. To really understand such a world properly, we build virtual models with all the players in the field, including their roles, behaviour, movements, and we also map out the relevant infrastructure by collecting satellite data and aerial photos and making 3D terrain models. TNO uses the most up-to-date technology, such as artificial intelligence and machine learning. By using this technology, you can map out mission areas in a shorter space of time, accurately analyse the behaviour of opponents, and compute the various scenarios to be expected by the military. Once a mission has been completed, a simulation mission is analysed and you can learn from the mistakes.'

Training courses

Defence uses the most up-to-date technology to perfect their own

'Trainees use simulators in more and more Defence training courses'

simulators. Huiskamp knows that more and more use is being made of simulators in training courses given by Defence and other parties. 'In some courses, trainees already spend more than half their time practicing with simulators. This saves time, money and is safer and more flexible than live training. In a live training exercise, people could run greater risks than in a virtual environment, or the weather could prevent a scheduled training course. Flying in an F35 or practicing at sea with frigates is incredibly expensive. Those live training exercises continue to be important because of their realism, but those limited times and occasions must be used as effectively as possible.' TNO is also researching how Dutch simulation systems can integrate better with simulators from other countries, so that they can practice in a shared virtual world together with their various national systems. This research is being conducted in a NATO context under 'Mission Training through Distributed Simulation (MTDS)' and results in a permanent virtual training environment. ■

Watch the video here

Who: cooperation in various contexts. For example, Aeolus cooperating with the Air Force.

Duration: ongoing.

Budget: the research budget is derived from target funding by the Ministry of Defence. There are several projects; one of the ongoing research programmes concerns cloud-based simulation services.

Follow-up: in the coming time, TNO will conduct research into how Dutch simulation systems can better integrate with simulators of other countries, so that more exchange and cooperation is possible ("sharing and pooling").

Credits

TO2morrow is a publication by the collaborating applied research organisations, united in the TO2 federation. They create the link between knowledge and innovation for the benefit of the government, business community and society. © 2022.

More information:
www.to2-federatie.nl.

Text and editors:
TO2, the Ministry of Economic Affairs and
Climate (EZK) and Maters & Hermsen.

Final editing **and design:**
Maters & Hermsen

Images:
Deltares, MARIN, NLR,
TNO, WUR, TO2,
Niels Blekemolen and iStock.