TO2MORROW

Magazine on results in the Open Innovation Network

2024

TO2 federatie

De samenwerkende organisaties in toegepast onderzoek

WAGENINGEN UNIVERSITY & RESEARCH

nlr

TNO innovation for life

MARIN

BETTER SHIPS, BLUE OCEANS

Deltares

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Dear reader,

The Netherlands is known worldwide for its innovation prowess and ability to adapt to new challenges. Applied research institutes Deltares, MARIN, Netherlands Aerospace Centre (NLR), Netherlands Organisation for Applied Natural Science Research (TNO) and Wageningen University and Research (WUR) play a crucial role in our success story with their practical applications of scientific research.

By developing novel insights and technologies into solutions that actually impact society, these institutions are an important bridge between theory and practice. Their hard work produces applications that help businesses, government and society move forward, ranging from a multifunctional roadmap of the North Sea and sustainable solutions for making dairy farms profitable to technology for the early detection of eye disease. What's more, their work on new methods to reduce space waste and innovative solutions to foundation subsidence are helping to making our country future-proof.

Applied research institutions are strengthened and fueled by their ability to collaborate effectively with companies, universities and government, sharing knowledge widely and applying it quickly. These collaborations are key to our innovation prowess and make the Netherlands a frontrunner in technological progress and economic growth. In an increasingly fast-changing world, innovation is the key to staying ahead, and Dutch applied research institutes make a valuable contribution day in, day out. With their innovative solutions, these institutes help make the Netherlands a prosperous, innovative and sustainable country.

I am proud of the work done by applied research institutions and hope you enjoy reading this magazine, with its inspiring new insights into the power of collaboration and innovation.

Dirk Beljaarts
Minister of Economic Affairs

In the overview below, each of the institutes, who are part of the T02 federation, summarize their most relevant 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. We believe in the power of in-depth knowledge, in innovative solutions, and software, to keep delta regions all over the world liveable.

Our mission *"Enabling Delta Life"* focuses on the water and soil system. We focus on five moonshots to create an impact with our knowledge: habitable deltas, flood protection, healthy water and soil systems, greenhouse gas reduction, renewable energy, and resilient infrastructure.

Our 900 qualified employees are curious and passionate. In co-creation, we work in conjunction with universities, research institutes, the business community, NGOs and public authorities domestically and abroad and share our knowledge with the world ('dare to share').

MARIN
BETTER SHIPS, BLUE OCEANS

MARIN

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, the offshore industry and public authorities. To this end, MARIN pays attention to the following social themes in its 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 public authorities in the Netherlands as well as internationally. This knowledge organisation conducts applied scientific research in 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 jointly creating value in economic as well as social terms and, together with partners, focuses on innovations in six domains: Mobility and the Built Environment, Energy and Materials Transition, Defence and Safety, Healthy Living and Work, High-tech Industry; ICT, Strategy and Policy.

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, materials 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 healthcare. Key technologies also enable ground-breaking 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 7,600 employees and 13,100 students from over a hundred countries working in the fields of healthy nutrition and the living environment across the globe, both for public 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. ■

Roadmap for multifunctional use in the North Sea

The number of wind turbines in the North Sea is growing rapidly. That is good news for the energy transition, but the North Sea was already a bit full. Shipping, fishing and the extraction of fossil fuels also taking place there, while new users are already emerging: from floating solar parks to hydrogen production. Deltares, TNO and MARIN, together with interested parties, researched multifunctional usage, i.e. how they can make wind farms suitable for several users. ▶

Deltares, TNO, MARIN

Problem: wind farms of 70 gigawatt in the North Sea should be available by 2050, but space is limited, and there are other users too: shipping, fishing, and possibly floating solar parks in the future, the production of hydrogen, cultivation of seaweed or mussels, and other innovative activities. How can these various forms of usage best be combined?

TO2 Solution: an interdisciplinary roadmap indicates which administrative measures can incentivise and facilitate innovation and multifunctional use, and how to create synergy between users.

Impact: public authorities and companies now know which administrative and technological steps need to be taken to combine the energy transition in the North Sea with other usages.

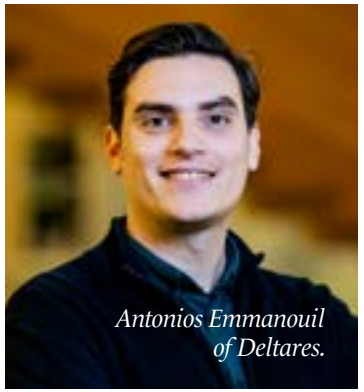
"The Dutch perspective on usage of the North Sea has tilted in recent years," says Antonios Emmanouil, researcher and adviser in the area of hydrodynamics and offshore technology at Deltares. "When the first wind farms were constructed in the North Sea, the fishing industry was compensated so that they could use that space exclusively." After all, the dragnets could easily damage electricity cables on the seabed, so a spatial separation of users seemed inevitable.

Seaweed as food

Now that the energy transition is gaining momentum, it is clear that a large portion of the Dutch part of the North Sea will be taken up by wind farms. "So there is space for a new paradigm," says Emmanouil. The big question is: how can we, alongside the wind turbines, make space for other uses of the North Sea? This could include other forms of fishing, the cultivation of seaweed as food, or new forms of energy generation: floating solar panels, or tidal and wave energy. Or it could include space for the restoration of nature itself, which is already under considerable pressure in the North Sea.

Roadmap

This multi-functional approach or "symbiosis" focuses on the Road2SID research project (Roadmap for technological advancements needed for Symbiosis Inclusive Design in offshore wind) that is coordinated by Deltares. The aim was to draw up a roadmap of the technological and administrative developments needed to combine 22 gigawatts of wind farms with other uses by 2030, in anticipation of the target of 70 gigawatts by 2050. Other participants were offshore installation companies Boskalis, Van Oord and Seaway7, energy companies Shell and RWE, and the grid operator TenneT. The roadmap they created distinguishes three categories of North Sea "users": energy, food, and nature, and makes recommendations such as clarifying and simplifying conditions for procurement (energy), promoting pilot projects (food), and incentivising open data, for example for ecological monitoring (nature). Willem Wagenaar thought the multidisciplinary project to be "very complex and ambitious". Wagenaar is a researcher and project manager for TNO. He has a background in physics. "It is quite unique that offshore wind farms are viewed from such a broad perspective. However, it is wise to broaden your gaze."


Antonios Emmanouil of Deltares.

"It is quite unique that offshore wind farms are viewed from such a broad perspective."


Floor Spaargaren of MARIN.


Willem Wagenaar of TNO.

Appreciation

"We had three teams for the three subjects", says fellow researcher Floor Spaargaren, shipbuilding engineer and project manager at MARIN, the maritime research institute. "Of course, every institute contributes its own specific knowledge. At MARIN, for example, we look at the technical feasibility of vessels and offshore structures, and then focus on how to make them installable so that they do not pose

Deltares, TNO, MARIN

any risks to shipping, and are able to last long in rugged offshore conditions." "Yet", she says, "the challenges were more often beyond the institute-specific know-how." "If you want to evaluate a seaweed farm, for example, you have to consider ecological aspects. That is where we really appreciate collaborations with other parties, such as Deltares, who knows all about underwater nutrient flows."

Brainstorm sessions

It has become clear that multifunctional use also brings about opportunities. For example, floating solar panels would be able to discharge their power using the same cables used by wind turbines. Or new underwater habitats could emerge, such as on the rocks that are dumped around the foundations of wind turbines to prevent currents from eroding sand around the poles. "We have noticed crabs, lobsters, starfish and other species heading towards those spots", says Emmanouil, "so you would be able to see how to design the rocks to create the optimum conditions for such a habitat, obviously taking the authenticity of the local ecosystem into account. On account of its intrinsic interdisciplinary character, the project was highly dependent on collaborations," he says. "Communication was therefore extremely important", says Emmanouil, "not only among the research institutes themselves, but also with the other stakeholders." For example, many brainstorm sessions and internal liaison preceded the identification of relevant topics and the formulation of interview questions for the stakeholders. "But this allowed us to ask the right questions and be able to involve external partners." Several workshops were held as part of the ongoing project of one and a half years, not only with project partners but also with other key parties, from environmental NGOs to government representatives, innovators and start-ups.

Business cases

"The involvement of business partners from the business community has surprised me in a positive sense", says TNO researcher Willem Wagenaar, "for example, they often employ specific people who are totally concerned with the ecological aspects of offshore wind." "An unexpected aspect of the study was the importance of governance and policy measures", says Emmanouil, looking back. "Initially we were focused on technology and innovation, but interestingly, we soon discovered that business cases and innovation are often highly dependent on policy. The requirements and goals that are set as a government, determine which technologies are stimulated."

Follow-up

This is also endorsed by Wagenaar with "regulation is extremely important. For example, if you put in a tender for offshore wind farms that the contractor must reduce negative impact on nature, or must perform monitoring, then that is what happens." Appropriate, public, standardised information systems are indispensable, as advocated by the roadmap. Wagenaar: "On the one hand you want to develop offshore wind energy quickly, but on the other hand you also want to know the ecological impact. So it is essential to keep a close eye on what is happening by monitoring exactly what happens." "A direct follow-up of the study has not yet been planned", says Emmanouil. "Once you create a roadmap, you are not going to create another one." But research into the follow-up steps for which the initiative now mainly lies with public authorities and companies, is certainly in the offing for the three institutes. "We are keeping in touch with several parties who will certainly approach us for new research or to exchange ideas. We are very curious to see what happens next." ■

"The requirements and goals that are set as a government, determine which technologies are stimulated."

More details about this project? Download the brochure.

Who: Deltares, MARIN, TNO, Boskalis, Van Oord, Seaway7, Shell, RWE, TenneT. The project was initiated through the GROW platform, a research programme for joint industrial projects to incentivise innovation and technology development for offshore wind farms.

Funding is derived from GROW as well as through the Netherlands Enterprise Agency (RVO), the Ministry of Economic Affairs and Climate (EZK) and TKI Offshore Energy.

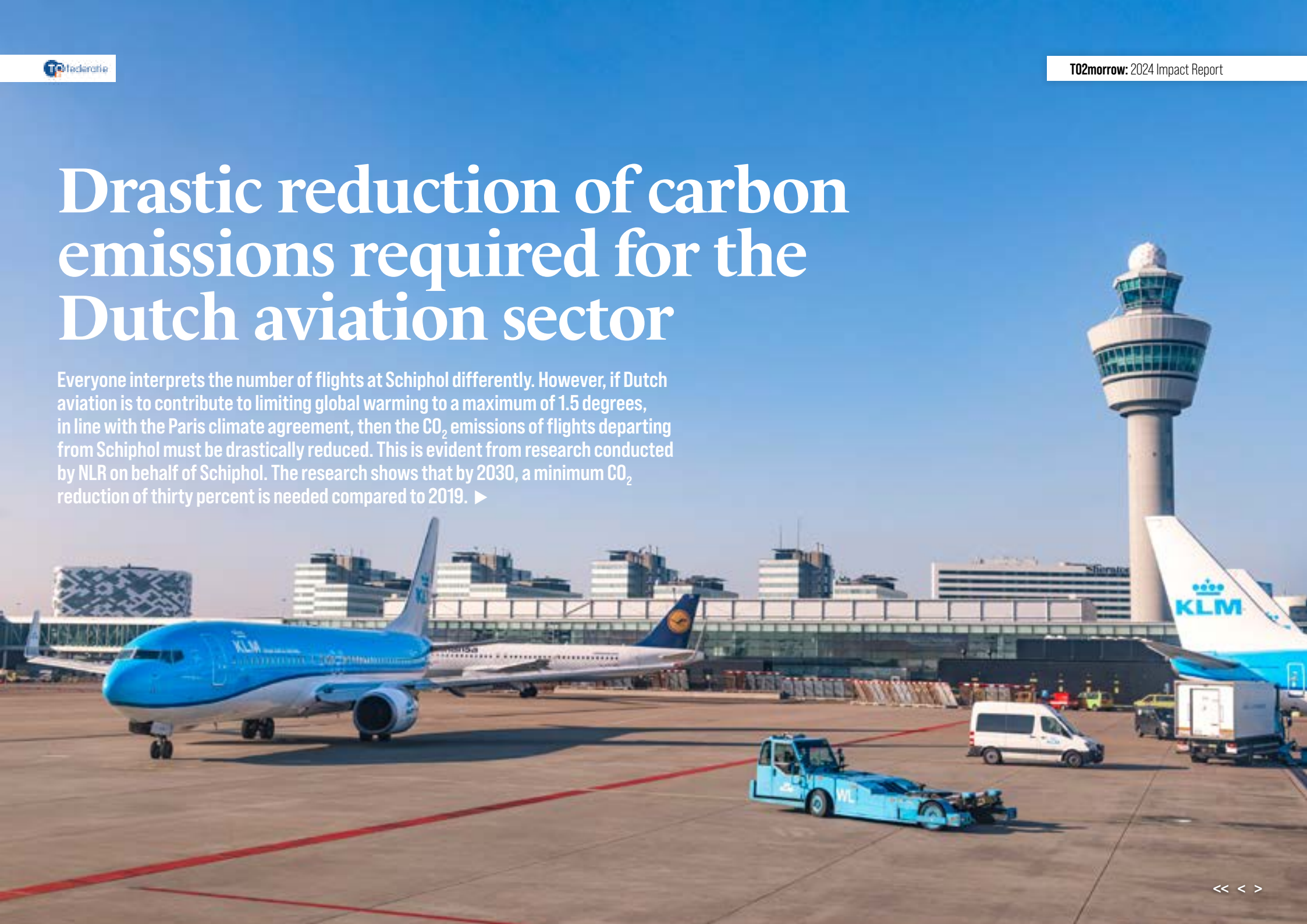
Duration: September 2021 – February 2023.

Budget: EUR 325,000.

Follow-up: the ball is now in the court of the companies and public authorities. Research institutes Deltares, MARIN and TNO follow developments and provide supplementary studies on partial aspects.

Drastic reduction of carbon emissions required for the Dutch aviation sector

Everyone interprets the number of flights at Schiphol differently. However, if Dutch aviation is to contribute to limiting global warming to a maximum of 1.5 degrees, in line with the Paris climate agreement, then the CO_2 emissions of flights departing from Schiphol must be drastically reduced. This is evident from research conducted by NLR on behalf of Schiphol. The research shows that by 2030, a minimum CO_2 reduction of thirty percent is needed compared to 2019. ▶



NLR

Problem: the aviation sector accounts for about six percent of carbon emissions in the Netherlands. This sounds modest, but nevertheless those carbon emissions must be reduced too. The national target is to reduce emissions to 2005 levels by 2030.

TO2 Solution: On commission for Amsterdam Airport Schiphol, NLR has studied what is needed to bring Schiphol's carbon emissions in line with the goal of a maximum of 1.5 °C warming in accordance with the Paris Climate Agreement. Research has shown that at least a thirty percent reduction in carbon emissions is needed by 2030. That is a considerably greater reduction than is currently planned.

Impact: the report sharpens the objective of the government and aviation sector for the airport with measures to accelerate the reduction of carbon emissions. In addition, based on the work, Schiphol has further expressed its support for strengthened national and international policies, such as raised flight taxes on long-haul flights, to use these revenues in helping to accelerate the discontinued usage of fossil fuels in the Dutch aviation sector.

The Dutch government and the aviation sector agreed in 2019 to reduce emissions of harmful greenhouse gases. In the Sustainable Aviation Agreement it was agreed that carbon emissions of flights departing from the Netherlands should be reduced to the levels of 2005 by 2030, a reduction of 9% in comparison to 2019. "Schiphol had called on us to enquire whether we wanted to research what is required to bring Schiphol's carbon emissions in line with the Paris Climate Agreement", says Bram Peerlings, NLR's aviation sustainability adviser. Simultaneously, Schiphol commissioned the research firm CE Delft to investigate this.

Cumulative emissions

In the Paris Climate Agreement it was agreed to limit warming to well below two degrees Celsius by 2050 and to aim for 1.5 degrees. In order to inhibit warming, net greenhouse gas emissions must be reduced to zero. Peerlings: "Many of the targets are about reducing or offsetting a certain amount of emissions in a specific year, such as aspiring for a net zero target by 2050. This, however, is not enough, because global warming is ultimately caused by cumulative greenhouse gas emissions: the emissions accumulated over a certain period of time. The IPCC, the UN's climate panel, has calculated how much we, as mankind may still emit until 2050: the global carbon emissions budget established for the period 2020 to 2050. That budget is either larger or smaller, depending on how much warming we want to accept, and how certain we want to be that we do not exceed it. However, these budgets only exist on a global scale and are not available for individual countries or sectors. That in particular, is exactly what we did in this research."

Technological breakthroughs

The researchers then compared a number of these budgets with the expected carbon emissions in the same period. The study showed that the expected cumulative carbon emissions are higher than Schiphol-specific carbon emission budgets which are in line with 1.5 degrees of warming. "If Dutch aviation wants to make its contribution, then carbon emissions must be reduced much faster. Within the target advocated by Schiphol, this means a reduction

Bram Peerlings of NLR.

"The only option left – unfortunately – is to reduce the number of flights."

NLR

of 30% by 2030 in comparison to 2019, as opposed to a government target of 9% less and an already expected reduction of 20%. The difficulty in achieving faster sustainability, unfortunately, is that major technological breakthroughs in reducing carbon emissions in aviation will still take a long time to achieve. Here and there, the aviation sector is focusing on biofuels and other more sustainable fuels, but many years will go by before they import them on a large scale. In the meantime, however, carbon emissions are still ongoing, despite the fact that air traffic is increasingly efficient and airlines are purchasing new aircraft. KLM, for example, has begun to phase in the Airbus A320neo for its European routes. This new type reduces carbon emissions by between 15% and 20% in comparison to older aircraft of the same size.

Short-haul and long-haul flights

"On the one hand, this is a nice improvement, but in relation to the total emissions of all flights departing from Schiphol, the expected impact is limited. This is due to major differences between short-haul and long-haul flights. About 75% of the flights departing from Schiphol have a destination within 2000 kilometres, mostly within Europe. Yet, these flights only account for 20% to 25% of carbon emissions. Conversely, this also means that 25% of the longest flights of over 2000 kilometres, cause 75% to 80% of the carbon emissions. In the example of this Airbus type, we are talking about only 20% of 20% – being fewer than 5% of the total carbon emissions. NLR came to such a sobering conclusion in its search for measures to align with the Paris Climate Agreement. "No matter how important fleet renewal is with more efficient aircraft, alternative fuels and more efficient routes, a great deal more is needed than merely improved technology", emphasises Peerlings. "The only option left – unfortunately – is to reduce the number of flights." This could be achieved by reducing airport capacity, but is also expected to happen if ticket prices rise – for example, by making airlines pay more for their carbon emissions, or by way of levies. "Given the large contribution of a relatively small portion of long-haul flights that emerged in our study, this segment is a logical focus area. In fact, more carbon emissions are reduced for each flight that is reduced."

"Long-haul flights are fewer in volume, but they are responsible for the bulk of carbon emissions."

Flight tax

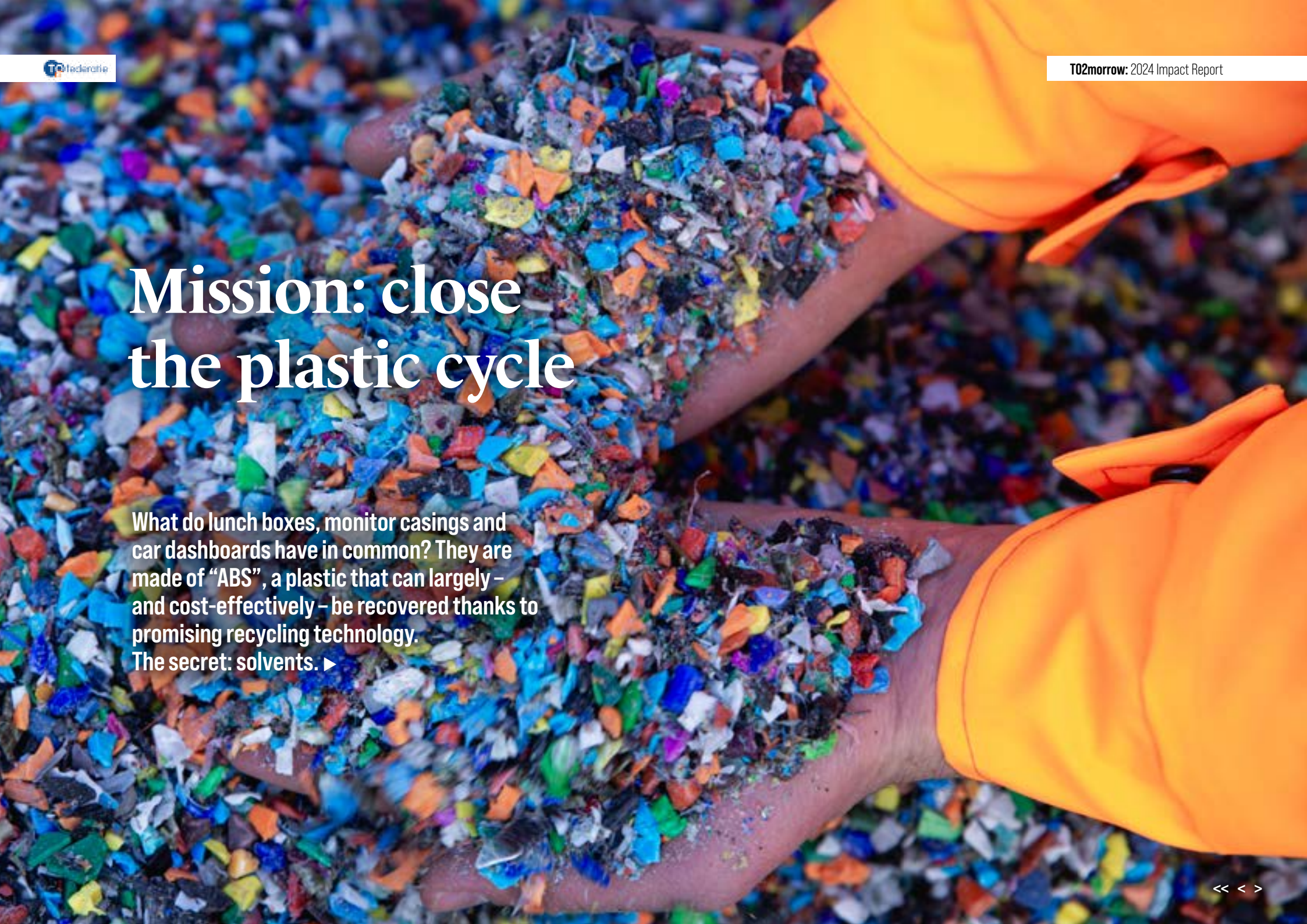
Amsterdam Airport Schiphol has used the report to further advocate policies and regulations to make aviation more sustainable. In that way, Schiphol has called for an increase in flight tax on long-haul flights, an intention taken over by the new Dutch government. In the process, they also want to invest that money in aviation. "At the moment, every passenger departing from Schiphol will pay EUR 29.05 in flight tax and it does not matter where you fly to, whether it be Vienna or Japan. By increasing the flight tax on these long-haul flights, these tickets will become more expensive and consequently fewer people will probably fly that far. It is therefore likely that it will contribute to reducing carbon emissions in aviation." If revenues from the flight tax are reinvested in the sector, the Dutch aviation sector may also be able to move away faster from fossil fuels, but that is not yet the case. "Whether these measures will continue depends to a large extent on the political decisions in that respect", concludes Peerlings. ■

Taking steps towards making the aviation industry more sustainable

Who: NLR and Schiphol.

Duration: **June** 2023 – January 2024.

Follow-up: working with cumulative measurements in the aviation sector is not yet common practise where the objectives often relate to a certain volume of carbon emissions in a given year. NLR is working on a scientific paper that makes this more widely known.



Mission: close the plastic cycle

What do lunch boxes, monitor casings and car dashboards have in common? They are made of "ABS", a plastic that can largely – and cost-effectively – be recovered thanks to promising recycling technology. The secret: solvents. ▶

TNO

Problem: plastic forms a large part of our mountain of waste, some of which is recycled. The reason: recycling of some plastics is technically difficult or not economically viable. However, we must reuse more plastics if we are to move towards a circular economy that is less dependent on carbon dioxide-intensive plastics production.

T02 Solution: TNO researchers have developed a promising recycling technology based on solvents (dissolution). This enables high-quality plastics to be recovered from plastics derived from waste electronics, among other things.

Impact: TNO's evaluation of field trials shows that this form of recycling is especially material and energy efficient, contributing to favourable processing costs. Above all, the polymer chains of the plastic remain intact while unwanted impurities are removed. The result is an end product of high quality polymer material, enabling the technology to create a circular usage production cycle.

Plastics are part and parcel of our modern world. They bring about many benefits, but at the same time they cause a mountain of waste. And as a result, the need for effective and economically viable recycling technologies grows, TNO researcher Mark Roelands has observed. "The reason is so that we are less dependent in the future on the carbon dioxide-intensive production of new plastics and work towards a circular economy."

Virgin plastics

Some of our plastics waste is recycled. The best-known examples are collected PET bottles. "They are processed through a shredder, get washed and sorted, and are then turned into clean plastic granules", explains Roelands. This is known as "mechanical" recycling and is an efficient method for uniform and fairly clean collected plastics. "A disadvantage is that the 'recyclate', which is what we call the final product, is of an increasingly poor quality." This is not the case for chemical recycling. In the process, the plastics are broken down into "monomers", their basic building blocks, which are reprocessed into "virgin plastics" (plastics that have not previously been used in a product). "However, this is an energy-intensive and complicated process, making it difficult to be economically viable." Yet, there is a third way to recycle plastics: by dissolution, or dissolving it, a specialism of process engineer Roelands: "In simple terms: we add solvents, after which a polymer mixture comes about. From this, we filter the contaminants and added substances, e.g. flame retardants. This results in a pure recyclate with which new products can be made, and completes a circular production process."

Washing machine door

Recycling by dissolution is not a new process. This technology was already conceived in the seventies of the last century. "What we wanted to study was whether this recycling technology can also be economically viable for real sorted plastic waste streams", says Roelands. Thus a collaboration came about between TNO and ELIX Polymers, a leading producer of Acrylonitrile-Butadiene-Styrene, abbreviated to ABS. In the Plast2beCleaned consortium, researchers created various test set-ups. The purpose: to recover raw materials

Mark Roelands of TNO.

"With this, we have shown that we are close to actually closing the cycle for plastics."

from sorted plastics derived from waste electronic equipment. Research institute Fraunhofer ICT was also involved. They are specialised in the removal of dissolved impurities. "The results are very encouraging", says Roelands enthusiastically. The researchers managed to produce clean ABS polymer recyclate using the dissolution process, plus two more useful raw materials: antimony trioxide and brominated flame retardants. "This enables the setting

▶

TNO

Test set-up for solvent recycling of waste plastics (dissolution).

up of a circular production cycle", concludes Roelands. To prove that, researchers partnered with Electrolux. This white goods manufacturer made inner rings for their washing machine doors with a large portion of the recovered polymer. "These are of the same quality as the inner rings of virgin plastics. This has shown that we are close to actually closing the cycle for plastics."

Sweet spot

Not only is the practical applicability of this recycling technology a reason for enthusiasm, its economic feasibility is that too. "By optimising processes, we were able to significantly reduce energy consumption. I think that with recycling by dissolution, we have found an optimum within the triangle of quality–economy–energy use." In order to substantiate this statement, experiments with dissolution will gradually be scaled up to a commercial level in the coming years, starting with a pilot installation in Rijswijk. "I envisage a future in which 80% to 90% of our plastics will be made in circular production chains. Recycling based on dissolution can play an important role in this – it is nice to be able to contribute to this." ■

Who: TNO in collaboration with manufacturer ELIX Polymers and Fraunhofer ICT research institute.

Duration: 2019 – 2024.

Budget: EU contribution EUR 4.5 million.

Follow-up: in collaboration with industrial partners, a further scale up of recycling by dissolution to – ultimately – reach a commercially viable level.

Koos Verloop, researcher of Agro Field Technology Innovations at Wageningen University & Research.

Sustainable as well as cost-effective: a dairy farmer's complicated puzzle

How can dairy farmers make their farms meet environmental standards of the future while keeping their business operations viable? This is a challenge for the government, the sector and in practice. Wageningen University & Research (WUR) provides support through the Cows & Opportunities project. ▶

WUR

Problem: the government wants to implement policies that allow dairy farmers to achieve integrated environmental goals in the areas of climate, biodiversity and circular agriculture while maintaining income. It is quite difficult for dairy farmers to meet all the requirements while remaining economically viable.

T02 Solution: Cows & Opportunities helps dairy farmers with practical know-how and effective solutions to meet the environmental requirements. It provides entrepreneurs with an insight into how different, and sometimes counteracting measures can best be applied at their specific dairy farm, so that emissions of methane and ammonia, and so too the leaching of nitrate, are as low as possible.

Impact: one of the solutions is to compose the rationing mixture for cows in such a way that emissions of ammonia and methane are reduced. Putting the cattle out to pasture more frequently also helps. The trick here is to undertake this in such a way that the amount of nitrate leaching into the groundwater is confined for business operations on sand. This often means that a dairy farmer must manage his livestock, rationing mixtures, and crops in such a way, that commodities supplied to the dairy farm (such as feed and fertilizers) are efficiently converted into products, without significant losses. This allows livestock farmers to save on their commodities and produce with fewer losses to the environment.

"Until the eighties, dairy farmers had relative freedom in their business operations", says researcher Koos Verloop. "Yet, it became increasingly clear that nature and the environment are seriously affected by carbon emissions in the sector." This initially became apparent mainly due to nitrate leaching into groundwater at dry sandy soils. Due to nitrate leaching, the suitability of groundwater for drinking water extraction was put under pressure. The problems with ammonia emissions were also clear at an early stage. Later on, the issue of greenhouse gas emissions was included as a point requiring attention. In fact, dairy farming goes hand in hand with emissions of the greenhouse gases methane and nitrous oxide, as well as carbon dioxide.

Reduced emissions per litre

Researchers, public authorities and dairy farmers, jointly launched the Cows & Opportunities project 25 years ago with the aim of establishing sustainable and viable farms with the help of smart solutions. "How that should be applied is a complicated puzzle for dairy farmers", says Verloop, who has been involved in this initiative since 2010 and offers support to dairy farmers through Wageningen University & Research (WUR). Currently, sixteen farmers across the Netherlands are participating in the project. Every year, the researchers together with the dairy farmers and their advisers, formulate "challenging but achievable" goals to reduce harmful emissions. "We study which strategies and measures they can apply", says Verloop. For example, dairy farmers can reduce the emission of ammonia by leaving the cows out to pasture more often. Manure and urine that end up in the same place in the barn, cause more ammonia emissions. However, leaving them out to pasture more often increases the risk of nitrate leaching into the groundwater. Verloop says: "We are therefore studying how to have cows left out to pasture without adversely affecting the water quality. We already know that good turf quality can help; this can be achieved by not allowing cows to graze on the same plot of land all the time. Good turf protects groundwater. In fact, plants absorb nitrate and as a result, less nitrate leaches into the soil and groundwater.

Less manure and environmental losses

The type of feed that cows are given, affects the amount of nitrogen and phosphate produced by manure. The researcher emphasises how relevant it is for dairy farmers to offer their cows the right feed. Of course feeds are provided to keep livestock healthy and to maintain the level of milk production, but it is also important that the resulting production of nitrogen and phosphate with manure does not become unnecessarily high. This is important because farmers are allowed to spread a limited amount of nitrogen and phosphate with manure across the land. This is stated in the Nitrates Directive, a European directive that regulates nitrogen in agriculture to prevent water pollution. Verloop explains: "Cows mainly eat grass, which is high in proteins and produces a great deal of milk, but if the protein content is too high, cows start producing unnecessarily high concentrations of nitrogen in manure. By feeding the dairy cattle with a specific amount of protein, dairy farmers reduce the amount of nitrogen in manure and thus the nitrogen emissions of their cows, without having to reduce the volume of milk." Methane emissions from cows can also be limited by controlling specific feed materials in the ration mixture. This, however, is a rather expensive approach, which is sometimes perceived by livestock farmers as being too artificial and therefore not suitable for every farm.

WUR

"A unique aspect of this project is that farmers, public authorities and researchers work together constructively to find concrete solutions."

Lower protein content

"By mowing the grass in a certain way and at a specific time, the protein content is reduced, although this can be at the expense of the energy value." That is why, aside from grass, dairy farmers additionally give cows maize, which contains less protein, or other types of feed concentrates with a lower protein content and more energy. "In the meantime, the optimum amount of protein that cows should get is quite well known", says Verloop, "but in practice it appears to be difficult to do that properly." To help farmers with this, WUR developed the "KringloopWijzer", which gives dairy farmers an insight into the environmental and climate performance of their dairy farms. These include emissions of nitrogen, ammonia and phosphate, which they can take into account. In the meanwhile, the "KringloopWijzer" has become the standard in the dairy sector and is used to calculate and reflect business performance. For example, the sustainability label "On the way to PlanetProof" is in line with this.

Herbal-rich grassland

Verloop and his colleagues are studying other "opportunities" for dairy farming to work towards fewer emissions, a more sustainable environment and social aspirations. This includes, for example, supporting biodiversity. On some farms there are opportunities to cultivate more herbal-rich grassland. There is a lot of experimentation with flower strips and hedgerows and collaborations with nature organisations. The impact on biodiversity is key, but it is also important to look for ways to make it viable, for which allowances are useful. Carbon capture in the soil has also been suggested to reduce greenhouse gas emissions. "Plants extract carbon dioxide from the air and those parts of plants can be preserved in the soil as organic substance", Verloop explains. He and his colleagues calculated the outcome of this solution; it seems possible to partially compensate for the emissions. In addition, organic substances in the soil contribute to soil fertility. So there is rather a lot of willingness and interest to look at this in practice.

Cycle

The puzzle is not entirely complete, but thanks to the insights gained in this research project, we have succeeded in reducing the amount of nitrate in the groundwater, and so too the emission of ammonia into the air. Farmers have also managed to make better use of nitrogen and phosphate in animal manure by recovering them through harvested crops. The circulation of these substances from feed to manure, to soil, to plants and back to feed has thus become a more closed circle. There are continuously fewer losses to the environment, and that is the cycle which is the subject of so much debate nowadays. Koos Verloop: "A unique aspect of this project is that farmers, public authorities, advisers and researchers work together constructively to find concrete solutions, to not only improve the situation for the environment but also for dairy farmers. And in doing so, we bring together the pieces of the puzzle."

More details on Cows & Opportunities

More recognition

It is also in the public interest to develop an approach that will enable dairy farmers to produce in an environmentally-friendly manner in a practical way. One of the development aspects is that it is still difficult for entrepreneurs to make their business performance visible with less environmental pressure. To this end, the "KringloopWijzer" is a powerful tool, which in principle, offers opportunities for public authorities and dairy farms to steer towards goals without imposing the "how". It is not coincidental that the Cows & Opportunities concept forms the basis for the "KringloopWijzer". However, the inclusion of this tool in government control could be much better. Collaboration between research, public authorities and the sector is also very important here. ■

More details on the "Kringloop-Wijzer"

Who: Wageningen University & Research.

Duration: the programme has already existed for 25 years over various research periods.

Follow-up: in the coming period, researchers want to focus on solutions for loss of the derogation, focusing on the goal, and applicability in policy and regulation.

By using new methods such as drones, biodiversity can be measured faster, more precisely and cheaper.

New ways to measure biodiversity better

Scientists, farmers and policy makers are striving for more biodiversity by applying nature-inclusive agriculture and other initiatives. Do new forms of agriculture such as food forests have the desired effect? This research project identifies the best methods for measuring biodiversity. ▶

WUR

Problem: there is insufficient understanding of the impact of ecological measures such as food forests and flower strips on biodiversity. This obstructs effective implementation and adaptation of these initiatives.

T02 Solution: a set of new methods, enabling biodiversity to be measured faster, more precisely, cheaper and on a larger scale. This will help to determine which measures will or will not work properly in nature-inclusive agriculture, for example.

Impact: if biodiversity is measured better, the initiatives to increase biodiversity can be applied more effectively.

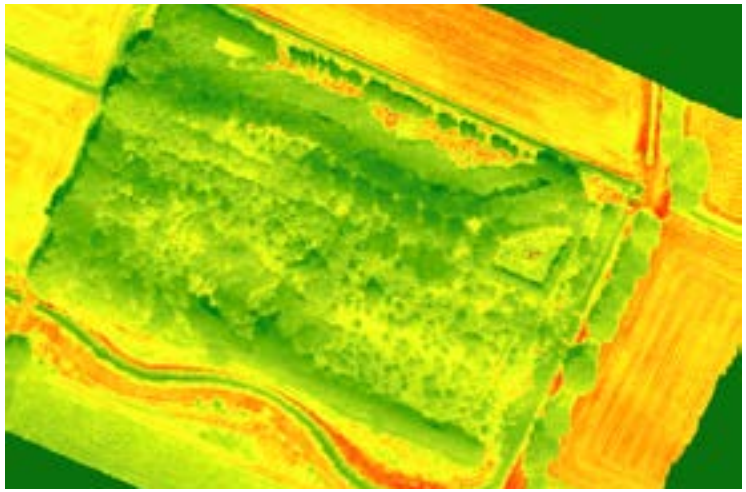
Promoting biodiversity is high on the agenda. "Many species are not doing well", explains Arjen de Groot, animal ecologist at Wageningen University & Research. He refers to the entire ecosystem of plants, animals, fungi and bacteria. As an animal ecologist, he predominantly focuses on animals. "Their numbers are decreasing or are even threatened with extinction, while these species are essential."

Pest controllers

Bees, for example. "If fewer flowers are pollinated, there will be deformed fruit or no fruit at all. This could cause considerable damage to the cultivation sector." Insects such as spiders, earwigs and hoverflies, also have useful functions for humans. "We can use them as pests controllers rather than chemical pesticides, but there must be enough insects. In the Netherlands we have been trying to work together more often with nature in recent years," says De Groot. Examples include green roofs in urban areas or flower strips to attract more insects. Nature-inclusive agricultural systems are also emerging. The new food forests, for example, in which the Dutch Ministry of Agriculture, Fisheries, Food Security and Nature (LVVN) is investing heavily. "But if we are to stem the tide, we must apply these new initiatives as effectively as possible", says the researcher. "And that is why we are investigating whether this type of new agriculture actually contributes to increasing biodiversity."

Drone photography

Measuring biodiversity is not a new phenomenon. Biodiversity has long been measured by birdwatchers with binoculars or listening ears, or by scientists who capture insects and identify them in the laboratory. De Groot: "Meticulous, specialised and time-consuming work." Researchers are therefore experimenting with new monitoring methods. They do so in Ketelbroek, the oldest food forest in the Netherlands. Drone photography, for example, clearly shows how healthy the plants are by using colours. "We are also investigating whether we can use the same light signals to recognise the species." By way of sound monitoring via small cabinets hanging in a tree, researchers are able to measure the



In drone photography colours clearly shows how healthy the plants are.

This equipment enables you to perform DNA analysis on hairs and animal skin cells present.

WUR

sounds of birds and bats. Other mammals are photographed when they pass a camera. By way of automatic image capture and sound recognition, a list is generated that shows the observed species. This makes it possible to collect information quickly and efficiently on the presence and identity of various animals or plants in a given area.

DNA via the air

Another state-of-the-art method is an analysis of DNA floating in the air. "This was first tested at the zoo in Copenhagen a few years ago", says De Groot. There was a device on the roof of the reception area that sucked up air. Its purpose was to perform a DNA analysis after a week of the hairs and skin cells present. The DNA of almost all the animals in the zoo was found to be present. "In Ketelbroek, we also saw how efficient and remarkably meticulous this is, which is quite an eye-opener." For example, this method appeared to identify almost all species that were found by both a bird watcher and the sound monitoring, plus a large number of extras. De Groot expects this technique to take off in a big way in the coming years. Research shows that these new measuring methods can measure biodiversity faster, more reliably, cheaper and on a larger scale. "Every technique has advantages and disadvantages, so it is important to combine the various methods. For each species and for each type of research question, we have to look at what works best," explains De Groot. WUR's Wageningen Data Competence Center helps to summarise and visualise all that data in graphs so that other scientists, farmers and policy makers can make use of it. The insights gained, help them to take the right measures, thereby increasing biodiversity. ■

"Every technique has advantages and disadvantages, so it is important to combine the various methods."

Who: Wageningen University & Research.

Duration: January 2023 until the end of 2024.

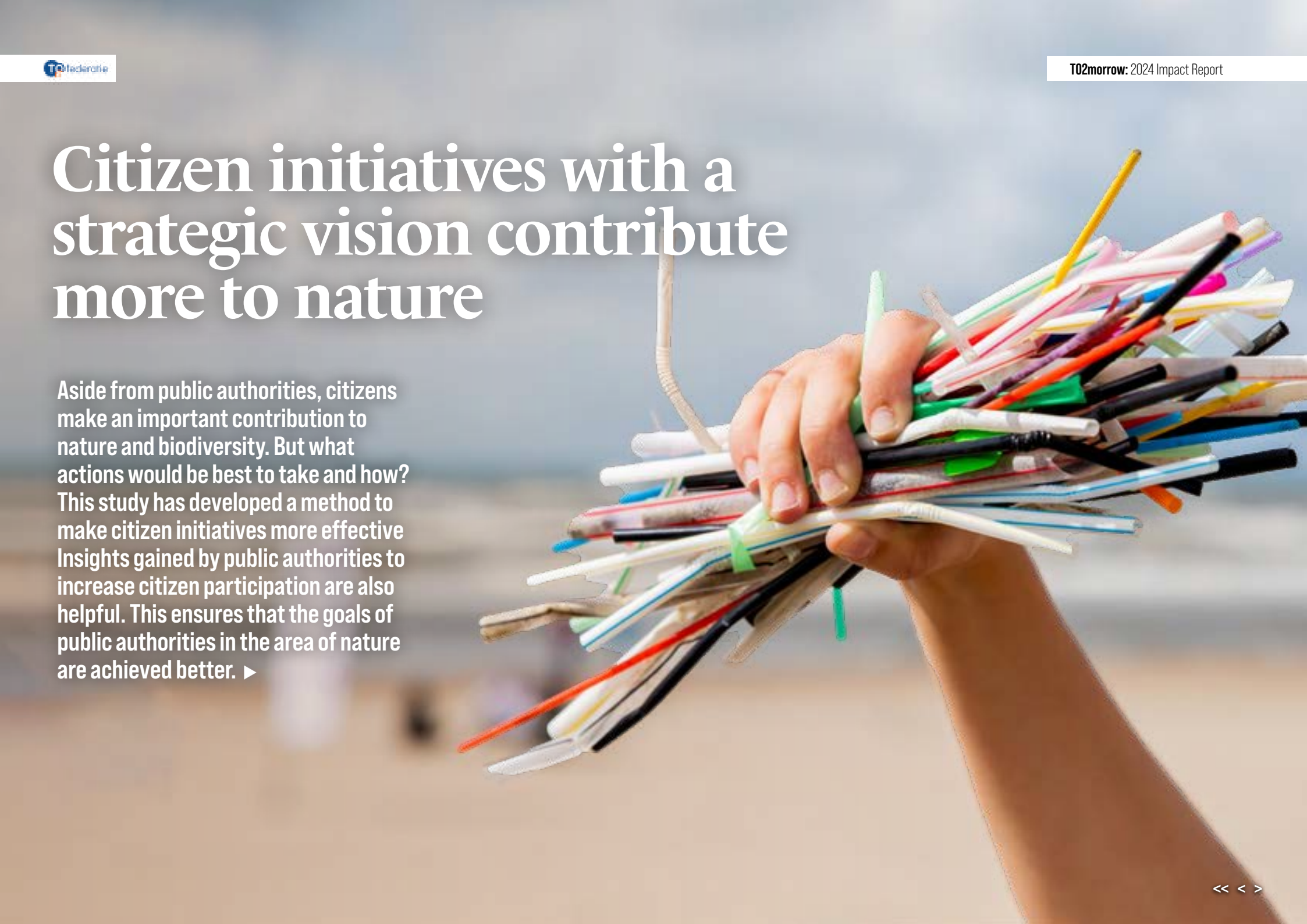
Follow-up: in a follow-up process, researchers want to measure the impact of the new set of monitoring methods in practice.

View the video **here**

By way of sound monitoring via small cabinets hanging in a tree, researchers are able to measure the sounds of birds and bats.

Citizen initiatives with a strategic vision contribute more to nature

Aside from public authorities, citizens make an important contribution to nature and biodiversity. But what actions would be best to take and how? This study has developed a method to make citizen initiatives more effective Insights gained by public authorities to increase citizen participation are also helpful. This ensures that the goals of public authorities in the area of nature are achieved better. ▶



WUR

Problem: which actions in citizens' initiatives are most effective to protect nature? How can the government increase citizen participation in nature?

T02 Solution: researchers have developed a method (roadmap) that helps to make citizens' initiatives more effective. Insights gained also help to increase citizen participation and to achieve the nature goals.

Impact: citizens' initiatives are more effective in encouraging the business community and public authorities to contribute to nature. Effective examples are citizens' initiatives to reduce litter and to improve biodiversity.

Aside from public authorities and businesses, citizens make a significant contribution to the development, conservation and protection of nature and biodiversity. "There are three ways in which citizens can contribute", explains Arjen Buijs, Associate Professor of Forest & Nature Conservation Policy and senior researcher at Wageningen University & Research (WUR). "By contributing to existing policy goals, by developing new ways of managing nature or food production, or by putting pressure on public authorities and industry to go green". But how can these actions be designed as effectively as possible, so that they make a greater contribution to nature conservation and nature policy? And how can public authorities and nature organisations increase citizen participation to facilitate the achievement of their environmental goals? Buijs and his colleagues first looked into the motivations of citizens to want to contribute. Their research showed that people are not only motivated to do something on their own accord, but also take action due to dissatisfaction with the role of businesses and the lack of effective government policies, for example to reduce the volumes of litter. Subsequently, together with the stakeholders, they studied two successful citizens' initiatives. The lessons learned from this were translated into a general method that other initiatives can apply to become more effective.

"Tiny Forest really makes villages and towns greener and increases biodiversity."

Successful citizens' initiatives

One of the initiatives they researched was Tiny Forest, an initiative by the Institute for Nature Education (IVN) to plant small forests with different trees in collaboration with schools and municipalities (there are 282 in the meanwhile). "This initiative not only helps to involve the residents with nature", says Buijs, "this actually helps to make villages and towns greener and increases biodiversity." Tiny Forest, for example, succeeded in building a community, jointly constructing the small forests, and providing education to schools, among other things. In addition, researchers studied a number of citizens' initiatives that together, clean up plastic waste from nature so that it does not end up in the rivers and oceans, such as the North Sea foundation and their actions for Clean Beaches. "Every year, such organisations publish for example, the most number of cans found of which beverage brand and share this with the media", explains Buijs. "This negative publicity puts pressure on businesses to change their policies and also on politicians to introduce a deposit system for small plastic bottles." In the meantime, deposits are indeed being levied on both cans and bottles, and seventy percent fewer cans and plastic bottles are ending up in nature. "So that really has been very effective."

Big plans

"If organisations or the government really want to bring about a transition with the help of citizens, they must think very strategically in advance which activities are meaningful", explains Buijs. "Together ▶

WUR

"Negative publicity puts pressure on businesses to change their policies."

with Tiny Forest and the North Sea foundation, we have studied how they achieve smart development with a clear goal in mind."

Based on these insights, the researchers then developed a method, a roadmap for "local initiatives with big plans" to develop a strategy. Citizens can work together to fill in a template to clarify their goal, exactly what activities they undertake, and what the results are in the short and long term. They can also discuss this in depth regarding any assumptions, opportunities, barriers and supplies. The method allows the citizens' initiative to flourish, professionalise, or to apply for a grant. Buijs: "This is where you can set out to make your citizens' initiative more effective. It is very useful to start a discussion as a citizens' initiative about what you want to achieve in the long term. With this method, citizens can make a greater contribution to the development and protection of nature. They may even have an impact on the development of policies which may lead to structural improvements. The gained insights also help public authorities and nature organisations to develop an effective policy theory on how best to involve citizens in nature policy. And that, in turn, could increase support for nature policy." ■

Who: Wageningen University & Research.

Duration: 2020 to 2023.

Follow-up: insights gained from this research are used in various other research programmes on citizen participation and citizens' initiatives.

Charting the subsidence and rotting piles of houses

It is estimated that around 425,000 houses in the Netherlands have, or will have to, deal with foundation problems, such as rotting timber piles or shallow foundations in subsiding soils. Consequence: cracks, subsidence and even risk of collapse. ▶

Mandy Korff (Deltares) and Chris Geurts (TNO) conducted research into the foundation problems of houses in the Netherlands.

Deltares, TNO

Problem: hundreds of thousands of houses in the Netherlands have, or will have foundation problems in the future, usually due to rotting timber piles or shallow foundations on subsiding soils. Without measures, the damage could be as high as EUR 54 billion.

T02 Solution: Deltares and TNO are combining all available knowledge with which the exact extent of the problem can be determined. Now, there is also a plan of action for further research and they have advised on measures on a nationwide scale.

Impact: by gathering existing knowledge, making an estimate of the extent of the problem, and proposing ways of addressing it, a major financial and social crisis can be avoided. This would occur if hundreds of thousands of home-owners encounter unaffordable construction problems.

"I also had a house with rotting piles," says Chris Geurts, structural engineer and researcher at TNO, "where, within a fairly short space of time, there were rather serious cracks in the walls. In an investigation, it appeared that timber piles gradually turn into "snot". I actually wrote it off when it was sold." Geurts is not merely an expert by experience. His employer TNO, in collaboration with Deltares, provided the technical section of a report by the Council for the Environment and Infrastructure (Rli), which advocates a vigorous and nationwide approach to this problem.

Nationwide problem

The problem has been known for decades, according to geotechnical engineer Mandy Korff of Deltares, "but everyone now realises that it is no longer merely a problem of individual home-owners. We see that it is a nationwide problem, so we want to do something about it nationwide." This has resulted in the two organisations being ask by the Rli to combine their existing knowledge, to draw up an estimate of the scope of the problem, and to present proposals for further analysing and addressing the problem. And to do so rather quickly. "The request was received in October 2023, and had to be ready to be sent to the new Dutch government in February", says Korff. This made the choice obvious for the duo TNO and Deltares on account of their field of expertise: "In 2021, we had jointly already broached this subject in a knowledge agenda."

"If you do nothing, the foundation problem only gets bigger."

Rough-to-fine approach

"The parties began working at breakneck speed", says Korff. "Most of the work depended on a good set-up: what are we actually talking about?" Specifically, the researchers substantiated the number of houses with foundation problems. "Until then, the number of one million houses had always been assumed. The Rli wanted to have that investigated in more detail." To find out which 425,000 houses were involved, the researchers advocated a rough-to-fine approach. "There are 6.5 million houses, which do not all need to be examined and cause stress for people. A more thorough examination was needed, especially for buildings of more than 50 years old, which were built on timber piles or have a shallow foundation. If there were already cracks in the building, there was a greater risk that the foundation was the cause."

Archives

"Further research can then be done based on archives", says Korff, "except, one of the major issues is that we do not have a centralised archive in which we document foundations. It is also one of our most important recommendations to the government: to create such an archive.
"The information is often there", adds Geurts, "but it is poorly accessible. "Once you realise that you're getting none the wiser, you look at the property itself." Only in extreme cases will you proceed with a time-consuming and costly inspection of the foundation, which requires excavation down to the piles.

Mandy Korff and Chris Geurts: "A more thorough examination is needed, especially for properties of more than 50 years old."

Deltares, TNO

In Utrecht, thousands of houses have inadequate foundations.

Any remedial work will have to be addressed. Sometimes the damage is mainly cosmetic: some cracks do not affect the safety or functioning of a building. But, sometimes the foundations also need to be restored, which is a far-reaching and expensive operation, although postponing it often leads to greater damage and repair costs. And sometimes demolition is the only solution, but usually the overall housing quality is unsatisfactory too. Also, if no action is taken, the number of houses with problems will continue to rise.

425 years

"Innovation, both in terms of inspection and repair work, is urgently needed", says Korff. "We are now renewing the foundations of a thousand houses a year, so there will be work for the next 425 years. We have to move faster." The Deltares researcher sees that the urgent challenge based on existing knowledge, did stir things up. "We are now developing models to refine and improve which properties are most at risk, and we must also take into account the consequences of climate change." "Follow-up studies with the same partners are already in the pipeline", says Geurts. "This will include even more specific scrutiny on where the problem manifests itself. Can we identify certain types of houses, and which action should we then tackle first? Because not everything be tackled at once." In addition to the technical aspects, the Rli also includes informative, administrative, and financial aspects, with an urgent recommendation to address this problem nationwide, rather than to wait and see. Otherwise, the number of problematic properties will increase and the volume of damage will only get bigger. Korff: "If you do nothing, the problem only gets bigger." ■

Who: Council for the Environment and Infrastructure (Rli), Deltares, TNO, Knowledge Centre for Addressing Foundation Problems (Kennis Centrum Aanpak Funderingsproblematiek, KCAF).

Duration: October 2023 to February 2024.

Budget: EUR 160,000.

Follow-up: follow-up research by TNO and Deltares, mapping out in more detail which buildings are at risk and which choices are needed to address the problem.

TNO

New insights into MASLD development

Excessive consumption of fats and sugar-rich foods can lead to obesity-related diseases, such as Metabolic Dysfunction-Associated Steatotic Liver Disease (MASLD). It is known that this disease affects multiple organs and processes, although the focus often lies on the liver, where the disease manifests itself. For example, most intervention studies are often focused on a single organ or disease process. In order to being about change in this situation, TNO has set up a joint venture called ProLiver with partners from the pharmaceutical and food industry, as well as diagnostic service providers. The aim was to gain new insights into the development of MASLD, to develop new methods and technologies, and to explore innovative treatment strategies.
The study has given the whole industry a better insight into the underlying disease processes in several organs during the development of MASLD. By intervening sooner with innovative treatment concepts that target multiple organs, the ProLiver team has shown that the development of MASLD can be inhibited.

More details on ProLiver:

DELTARES/TNO

DigiTwin: digital copy of a flood defence

How does one use information technology to make flood defences like dykes future-proof? One would preferably want to make a digital copy of it so that it can safely be examined under various conditions, such as storms or prolonged drought. In order to achieve such a digital copy, Deltares and TNO started the "DigiTwin flood defence and substrate" project together with the companies Geodan, Fugro, HKV and BZIM. This project developed and tested software on a number of cases. This helps water boards and public authorities to convert the data they collect in the management of their dykes and soil projects into useful information. The digital copy of "DigiTwin" combines geological, geotechnical and geophysical data and information with real-time earth observations and existing data from flood defences. For example, "DigiTwin" maps out the vulnerabilities of a flood defence. By simulating situations such as extremely high water or persistent drought in the digital model, there is a better understanding of the sensitivity to major failure mechanisms of dykes, such as piping, where water flows through or under the dyke. By using a DigiTwin, water authorities can predict the state of a dam, dyke or storm-surge barrier more accurately and design future flood defences better.

WUR

Seeds and stories on erfgoedrassen.nl website

Modern agriculture is based on a limited number of varieties, which has made many heritage varieties rare and at risk of disappearing. Take the grosse brune paresseuse, a type of butterhead lettuce that was cultivated in glass greenhouses in the 20th century. A small stove was simply placed in the middle of such a greenhouse, so people could already have something to eat in early spring too.

On the new website about heritage varieties, the Centre for Genetic Resources, the Netherlands (CGN) of Wageningen University & Research aims to preserve old Dutch vegetable varieties of the nineteenth and twentieth centuries, to bring them back into the limelight and make them accessible to hobby growers. The preservation of heritage varieties is important for the future of agriculture and food production on account of the enormous diversity in these materials. Moreover, heritage varieties can be distinguished by their taste and quality, as part of traditional dishes. There is also a webshop where hobby growers can order small quantities of seeds. More information about each variety is available on how it used to be grown and eaten.

erfgoedrassen.nl

More details:

TNO

AIKON Health for portable health monitoring

Heart failure is a common cause of death for many people. The risk of death is greatest immediately after being discharged from the hospital after surgery. More than fifty percent of patients with heart failure are re-admitted within six months of discharge from the hospital. Remote monitoring of signals indicative of heart failure can save lives because it allows early detection and intervention. TNO is launching the spin-off AIKON Health, aimed at portable biosensors that focus on care management, starting with heart monitoring. AIKON Health builds on technology that TNO has previously developed at Holst Centre, the centre of expertise in hybrid printed electronics and thin film electronics. Portable monitoring can reduce re-admissions by 25%. In addition, spin-offs such as AIKON Health create new businesses and jobs for the Netherlands.

What do customers think of TO2?

Riekelt Post, Director RapiD Engineering:
"Our collaboration with Wageningen University & Research (WUR) has helped us to improve our vision system for the fishing industry and fish processing. While we, as an engineering firm, take care of the practical development of this system, WUR brings about new theoretical insights. With their objective research approach and testing facilities, they lay the foundation for improvements that we can then apply in practice. The system automates quality checks, steers robots, and collects valuable data. This technology enables us to further promote automation and digitisation in the fishing industry and fish processing, thus contributing to an efficient and sustainable sector."

The conveyor belt used in fish processing with the "vision robot" that performs the measurements and collects data.

WUR

Consumers are positive about the Dutch agriculture and food sectors

For over a decade now, the "Agrifoodmonitor" published by Wageningen Economic Research on commission for the Topsector Agri & Food, has been providing unique insights into the social appreciation of the Dutch agriculture and food sectors. Furthermore, the 2024 edition also features a survey of more than 3,500 people in the Netherlands about their perception with climate and food security, and how consumers appreciate the voluntary commitment of the Agrifood sector to reduce climate impact.

As in previous years, consumers are positive about the Dutch agriculture and food sectors and are open to rewarding these sectors for their additional commitment in tackling climate change. In addition, the "Agrifoodmonitor" shows that there are more ways to reward than merely payment. They feel that climate change is currently impacting the agriculture and food sectors harder than themselves. And they do not expect food to become much scarcer (outlook towards 2030). Consumers do not seem to be very concerned about food security as yet.

Insights gained from the "Agrifoodmonitor" are used by policy makers, the business community, cooperating organisations and scientists to better understand why consumers make certain choices and demonstrate certain behaviours.

TNO

Methane emissions from ships are higher than regulations assume

The use of liquefied natural gas (LNG) as a marine fuel is growing rapidly. Methane emissions from LNG-propelled vessels, however, contribute to climate change. The FUMES project (Fugitive and Unburned Methane Emissions from Ships) measured that the actual methane slip (the part that escapes unburned from the engine into the atmosphere) in ships with a common engine type averaged 6.4%, whereas EU regulations currently assume a methane slip of 3.1%. TNO carried out measurements in the exhaust pipe of the engine room. The final report recommends that EU and IMO policy makers should consider raising the default value for the methane slip of LPDF (Low Pressure Dual Fuel) four-stroke engines to at least 6%. "Conventional measuring procedures, such as those for certification, are accurate but could possibly not be representative. Actual measurements can help to determine representative data for fact-based policy making," says Robin Vermeulen, senior researcher at TNO.

FUMES Report

MARIN

Safely leaving the ship's bridge unattended

For decades, the engine rooms of vessels have benefited from automation systems that allow technicians to leave the engine room unattended at night and during the quiet hours of the day. MARIN's Alert Joint Industry Project [JIP] is developing a similar approach to the ship's bridge, allowing its crew to leave it unattended for a certain period of time without compromising its safety.
Systems and processes continue to operate to alert watchkeepers when their presence is needed.
Alert JIP is also investigating whether it can improve the safety as well as the working and living conditions for the crew on the ship's bridge. Crews often face irregular working and sleeping times and monotonous working conditions. Combined with periods of debilitating boredom, especially when the ship crosses large bodies of water like the oceans, and hectic, long working hours when the ship passes through busy shipping areas, fatigue is often the cause of (near) accidents and incidents.

More details:

Deltares/TNO

Investigation into failure of Princess Margriet Tunnel foundations

On 13 December 2022, a section of the Princess Margriet Tunnel along the A7 motorway near Sneek in Friesland lifted. Damage was caused to the roadway and the tunnel was immediately closed to traffic. Commissioned by Rijkswaterstaat, Deltares and TNO conducted an investigation. It appeared to be the pile foundations, which could not withstand the upward water pressure. The pile foundations consist of pre-stressed concrete tension piles. The investigation showed that the pre-stressed rods in the piles were broken, probably as a result of stress corrosion. Stress corrosion causes a gradual reduction in the diameter of the rod at some points, ultimately preventing the pre-stressed rod from bearing the tension present and suddenly breaking. As a result, the number of piles that have to bear the water pressure decreases slowly but surely. Based on the investigation, knowledge institutes suspect that stress corrosion may be caused by a combination of deficiencies in the wrapping of pre-stressing rods.
The deep part of the tunnel is currently undergoing completely new foundations. This is expected to be ready by the end of 2025.

NLR

Steering with electric propulsion

In 2024, a scale version of a large electric propulsion passenger aircraft has already made several test flights in Italy. This was carried out by the Royal Netherlands Aerospace Centre (NLR), where the aircraft was controlled remotely. The aircraft, which has a span of four metres, a weight of more than 160 kilograms, and a cruising speed of 100 knots, is equipped with six propellers. The distributed electric propulsion (DEP) makes it possible to control the aircraft using the motors. DEP technology allows large passenger aircraft to use less energy.
As acceleration of more air is more efficient and by being able to individually run the motors faster or slower, less use is made of the control surfaces. This reduces aerodynamic drag and helps to improve flight efficiency. This study is a follow-up to the article "The Scaled Flight Demonstrator gives innovative aviation wings" featured in the 2022 Impact Report.

View the video **here**

What do customers think of TO2?

Joris Stok of the Council for the Environment and Infrastructure talks about the foundations problem project (see p. 24-26): "Together with TNO, in no-time Deltares was able to draw up a complete overview of the scientific knowledge available in the area of foundation problems." They were also able to translate them into useful plans and models for consultancy support. Deltares proactively sought solutions to remaining knowledge questions and how to resolve them. By critically scrutinizing the draft recommendations, Deltares further reinforced the applicability of their study and intensified its recommendations."

Secure data sharing in the healthcare sector

“It would really be a huge step forward if we had a learning healthcare system”, says Jildau Bouwman, “in which, what is happening to your patient today leads directly to insights that can lead to improvements in the healthcare sector.” ▶

Jildau Bouwman and André Boorsma, researchers at TNO.

TNO

Problem: hospitals, general practitioners and other institutions have medical data on patients that, together, provide useful insights for other patients or for medical studies. Except, that data is fragmented across many institutions, it is contained in various systems in different formats, and sharing is not always possible because of privacy and medical confidentiality.

TO2 Solution: TNO collaborates with twelve parties on HERACLES, a combination of technology and organisational measures that merges various data sets without compromising privacy, initially in the area of two types of cancer. For this, the system works with privacy-enhancing technologies (PETs), but efforts are also being undertaken on systems of arrangements on the organisational and administrative side of data sharing.

Impact: HERACLES provides a useful concept for privacy-friendly data sharing in the healthcare sector, and highlights issues, frictions, and opportunities in setting up data sharing. The ultimate goal is a "learning healthcare system", in which insights gained immediately or through scientific research, leads to improvements in healthcare.

Bouwman is a systems biologist at TNO, Leiden location. Together with her colleague André Boorsma, who is also a systems biologist, she explains why HERACLES was created: a collaboration between thirteen parties that should bring the learning healthcare system a step closer, by improving the care treatment of two types of cancer as an example. "Look at the travel industry, social media or webshops like Amazon, which already work totally data driven," says Boorsma, "in this respect the healthcare sector is seriously lagging behind." A learning healthcare system would not only provide a wealth of insights for scientific research, but also for individual patients.

Medical confidentiality

However, unethical practices by internet giants have shown that you cannot always simply release all data, especially in the healthcare sector. For example, virtually all patient data is protected by medical confidentiality. "The great thing is that there are new ICT technologies that can still enable access", says Bouwman, "you can 'prompt questions' about the data, without having to share them physically." "Federated learning" for example, is such a technique, in which the answer to a research question is spread among the various parties that have data, rather than bringing the data together. Bouwman: "It can be compared to a train. You place a data model of what you want to learn on the train, and it travels along every data station – that could be a hospital or the Integrated Cancer Centre Netherlands (IKNL) – and it extracts data on site on what can be learned about the research question." At the last station, all the data is combined but remains untraceable to individuals.

Mathematical techniques

Another privacy-protection technique is "Partially or Fully Homomorphic Encryption", where several parties supply data but in encrypted form: by using mathematical techniques the data is translated into an unreadable numerical string. However, more advanced computer techniques can perform calculations on this encrypted data. The answer can then be decrypted again, without any individual data being revealed. Both techniques have advantages

"As an independent party with its own ICT expertise, by definition TNO can fulfil an orchestrating role here."

TNO

and disadvantages. "It is quite imaginable that in "federated learning" more has to be secured, because the data itself is indeed accessed physically. Partially or Fully Homomorphic Encryption is safer, but it is difficult to run really complex models with it," says Bouwman.

Fragmented

A hands-on issue is also that healthcare data, especially in the Netherlands, are highly fragmented. "There is data all over the place", says TNO colleague André Boorsma, "general practitioners have data, and institutes like IKNL and hospitals have different data, and even within hospitals there are often different systems and conventions." The quality of data must also be in good order, even more so than in "ordinary" research. Boorsma: "Normally, a researcher can first view the data and get a bit of a feeling for it: are there duplicates or missing fields?" But with privacy-protection techniques it is more difficult to control, so standardisation and good data management are extremely important. HERACLES is a pilot project, in which this data sharing is set up for a defined group: patients with lung cancer and patients with ovarian cancer. "The question with lung cancer is: can this be diagnosed sooner?", says Bouwman. "The diagnosis is often established at a late stage, which means that the treatment is not optimum. For ovarian cancer, the question is how consistently are various treatments applied to different subgroups?"

"Parties like to keep control of their data. There is some resistance and that is understandable."

Governance

For some data it is not just about technology, but also about organisational and governance aspects: sound arrangements not only in a legal sense but also in a practical sense. Boorsma: "Here, it not only concerns which party can use which data and under what conditions, but also clear definitions: are the same terms used with the same meaning? For example, are the same standards used for lab values?" There is some diplomacy involved in setting up such multilateral convention systems, in other words "Data Spaces". Bouwman: "Parties like to keep control of their data. There is some resistance and that is understandable." Hospitals are cautious when allowing access to their business operations, and scientists have an interest to initially extract publications from their data. That means positive incentives are also needed, although with the European Health Data Space (EHDS), there will also be legislation which will impose more obligations in this area.

Real data

To test the data collection in practice, the HERACLES system is tested with real data from the various parties. Bouwman: "The architecture is specified, and parts of the software are already running. But the test also includes that you first map out which data can be found where, and what the quality is." Results are expected in the course of 2025. Bouwman: "This is a difficult project, with many different parties and interests. However, as an independent party with its own ICT expertise, by definition TNO can fulfil an orchestrating role here." ■

Who: TNO, IKNL (Integrated Cancer Centre Netherlands), Radboud UMC, UMC Groningen, AstraZeneca, Janssen-Clilag, Roche Netherlands, Almende, Linksight, Pharmo Institute, SURF, CZ Zorgverzekeringen, Stichting Olijf.

Duration: 2022 – mid 2025.

Budget: EUR 4 million, largely derived from Health Holland.

Follow-up: the knowledge gained will be used for implementation of Health-RI and Cumuluz; two initiatives for setting up data sharing in the healthcare sector and the associated infrastructure.

View the video here

Treat diabetes with lifestyle interventions

Iris de Hoogh is specialised in research at the cutting edge of nutrition and health at TNO and the Leiden University Medical Centre.

Millions of people in the Netherlands do not exercise enough, eat unhealthily, are overweight and are therefore at risk of developing type 2 diabetes. The good news: thanks to targeted lifestyle interventions, this disease can often be treated effectively and – better still – it can be prevented. ▶

TNO

Problem: diabetes is one of the most common chronic diseases in the Netherlands. In diabetes, the regulation of sugar content in the blood (sugar level) is disrupted. More than 1.2 million people in the Netherlands have diabetes, of which more than 90% have type 2, mostly due to overweight, have too much abdominal fat and/or an unhealthy lifestyle, in conjunction with a genetic predisposition.

TO2 Solution: lifestyle has a major influence on the development and course of type 2 diabetes. However, the precise effect of nutrition, exercise and sleep on the sugar level varies from person to person. In the TNO-led study called "Gluco Insight", 41 people with type 2 diabetes were monitored in the area of nutrition and exercise. The effect of different diets and prescribed exercises were measured.

Impact: the knowledge gained from Gluco Insight enables effective treatment with a personal lifestyle recommendation for type 2 and early type 2 diabetes. Nutritional interventions, in particular, have proven to be highly effective. For example, the effect of a very low-carbohydrate menu on the average sugar level after four days is just as much as treatment with a commonly used antidiabetic medicine (metformin).

What is diabetes mellitus, commonly known as "diabetes"? People with diabetes have a chronically increased amount of sugar (glucose) in the blood. This happens when their body does not make any or almost makes no insulin (type 1 diabetes) or too little (type 2), or because their body has become more immune to insulin (type 2). This is dangerous, because insulin causes the body cells to absorb glucose (and thus be supplied with fuel). In the treatment of type 1 diabetes, insulin (in the form of injections or by means of a pump) inevitably plays a role, but in type 2 diabetes, especially in the early stages, there is also a lot of health gain through an improved lifestyle. In other words, exercise more and eat differently. "We increasingly understand the effect of nutrition, exercise and sleep on the origin and course of type 2 diabetes", says Iris De Hoogh, at TNO and the Leiden University Medical Centre specialized in research at the cutting edge of nutrition and health. "Thanks to these new insights, lifestyle interventions become a real alternative to medicines." That is good news, because more than 1.1 million people in the Netherlands have type 2 diabetes. It is therefore one of the most common chronic diseases in our country.

Healthy nutrition

Type 2 diabetes is often caused by lack of exercise, an unhealthy diet and overweight, as well as old age and a genetic predisposition. The fact that an active lifestyle, healthy diet and more sleep can inhibit and sometimes even reverse the course of this disease, is already known. "But we also suspected that there are individual differences in the effectiveness of certain lifestyle interventions. We have analysed this in our study." For this study (Gluco Insight), 41 people with type 2 diabetes were equipped with a glucose sensor, which was applied to the upper arm and measured "continuously" for ten days (a reading every 5 minutes). Each time the study subjects were prescribed different lifestyles requirements. This included taking a walk after every meal, to exercise intensively for a short while every hour, and two different diets: a Mediterranean diet and a very low-carbohydrate diet. The study subjects were given a sports watch to measure their movement and sleeping behaviour and an app to track their dietary intake. De Hoogh: "This resulted in a wealth of

Iris de Hoogh: "Thanks to these new insights lifestyle interventions become a real alternative to medicines."

TNO

data. We were able to follow exactly what effect food intake had on the glucose levels and its interaction with movement and sleep."

Active for fifteen minutes

"This is how the study team arrived at some important insights", says De Hoogh. "First of all, there are indeed major individual differences in the effect of nutrition on blood sugar levels. In one case, the sugar level shoots up immediately after eating carbohydrates, while in another case hardly anything happens. The effects of movement is also determined individually. For one group it proved beneficial to be active for fifteen minutes before eating and for another group it was immediately afterwards." Another eye-opener was the impact of nutrition: the very low-carbohydrate menu on average had an equally positive effect on blood sugar after four days as a widely used diabetes medicine. "Pretty spectacular", concludes De Hoogh.

Lifestyle recommendation

The knowledge and insights exist; the next step is to translate them into an effective treatment of type 2 diabetes. "Nowadays, patients are given a lifestyle recommendation. That is often rather non-binding, usually without intensive individual coaching and, if it has no effect after three months, the doctor often prescribes medication." The study team is therefore working on a follow-up project with the aim of making the new insights more applicable in a practical treatment programme. "We are working on a model that predicts the best lifestyle intervention for an individual patient. This will help people with type 2 diabetes better without or with fewer medicines. That would be highly beneficial." ■

"Over 1.2 million people in the Netherlands have diabetes."

Who: TNO, Leiden University Medical Centre, Roche Diabetes Care Nederland BV, Reinier Haga Medical Diagnostics Centre and Ekomenu.

Duration: 2019 – 2023.

Budget: EUR 1.4 million.

Follow-up: a new study project to apply the insights gained in a practical treatment of patients.

Using the eye to view our health

TNO is working on retinal cameras that can detect eye diseases sooner. Early detection of tissue changes in the retina can lead to better treatment of eye diseases and savings in healthcare costs. ▶

TNO

Problem: a third of the more than one million diabetic patients suffer from retinal degradation: damage in the eye's blood vessels that lead to impaired vision. Failure to detect this condition quickly can lead to poor vision or even blindness.

T02 Solution: TNO is working on innovative retinal cameras that measure oxygen distribution in the retina with different colours of light. This allows clinicians to obtain earlier and more accurate diagnostic information about the health of the retina.

Impact: several eye diseases are likely to be detected sooner by these innovative retinal cameras. Early diagnosis ensures treatment in good time, avoids costly treatments and improves the patient's quality of life. TNO is researching whether this technology can also show cardiovascular diseases and brain disorders.

About a year ago, a client enquired whether TNO could develop a compact retinal camera. "It was an opportunity for us to apply the knowledge we had developed, in this respect", says Arjen Amelink, Principal Scientist at TNO and Endowed Professor at the Department of Physics at Vrije Universiteit Amsterdam in the area of light-tissue interactions. "The eye enables an interesting view to our health, a unique place that allows visual access to small blood vessels. Those vessels are the first to be affected by diseases, such as diabetes. But, cardiovascular diseases also have an effect on small blood vessels."

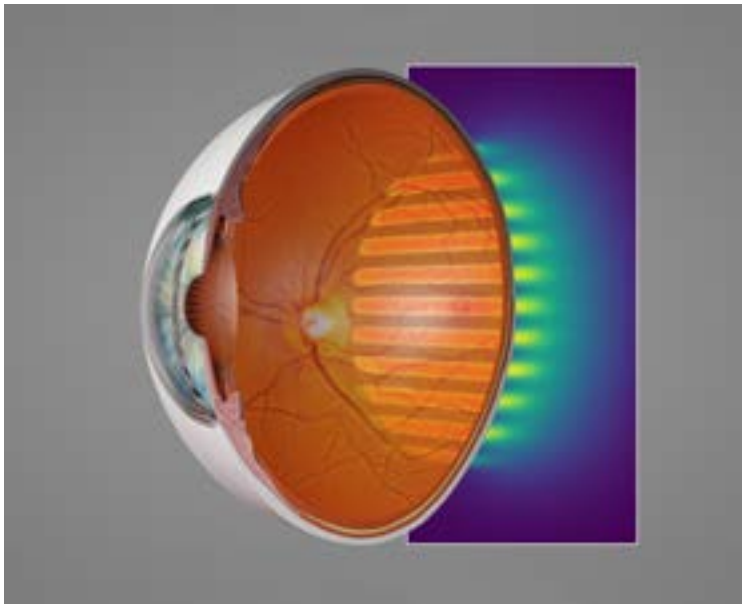
Diagnostic information

TNO has now developed and validated a new type of retinal camera together with the Rotterdam Ophthalmological Institute and the Leiden Centre for Human Drug Research. It illuminates the retina, the light-sensitive layer at the back of the eye, using different colours and patterns, and measures the returning light with a camera: Quantitative Retinal Imaging. From this, researchers can gain new diagnostic information about the oxygen distribution and perfusion of the retina. Together with the Vrije Universiteit Amsterdam and the company Heidelberg Engineering, TNO is also developing a device which measures the oxygen content in the retina's blood vessels with a scanning laser. As a result, eye diseases with retinal degradation (loss of vision) are likely to be detected sooner and medical specialists can intervene more quickly and with smaller interventions to minimise eye damage.
The technology is still under development. Michiel Oderwald, Senior Business Developer Medical Devices: "We are adding new features to the current retinal cameras and providing doctors with diagnostic information that they did not previously have available. We're having discussions with doctors about measuring oxygen

"The eye is a unique place that allows visual access to small blood vessels."

The Quantitative Retinal Imaging device.

TNO



Cross section of a 3D eye model.

distribution in the retina. Some patients with diabetic retinopathy are treated with medicinal injections directly into the eye. By measuring the level of oxygen in the retina, we may be able to determine that one person needs a follow-up injection after three weeks, while another person may only need this until after six weeks, for example. Nowadays everyone gets an injection after the same period."

Applications for other diseases

Another possible application is assessment of the risk of cardiovascular diseases in women, where the signs of disease are different from those in men and are often not well recognised. "In the study, the physician uses a catheter to enter via the groin to assess the condition of the heart. If the condition of the blood vessels in the retina would help you to assess the cardiovascular risk, it might be possible to make a pre-selection of who should or should not need to undergo radical catheterization. Here further research is still needed", Oderwald emphasises. "These are still hypotheses, but they certainly are very interesting developments to research." And that is not the end of the story. "The eye is a direct outcrop of the brain and this may offer opportunities to sooner detect neurological diseases such as Alzheimer's and Parkinson's disease", says Amelink. The first clinical trials in patients with eye diseases and brain disorders will start at the end of this year.

"This gives us the opportunity to test oxygen measuring in the retina properly."

Artificial eye

For validation of the retina cameras, TNO is developing model eyes. One of them even features a miniature heart-lung machine where human blood flows through an artificial blood vessel into a simulated retina of a real eye. "This gives us the opportunity to test the oxygen level in the retina properly, because this would be too complex on a human eye as well as ethically irresponsible", says Oderwald. When the first results with the prototypes of the retina cameras prove to be successful, larger clinical trials will be harnessed for the various diseases. Due to prolonged clinical research, it will certainly take several more years before hospitals or general practitioners start using it. ■

View the video **here**

Who: TNO, Rotterdams Ophthalmological Institue, Centre for Human Drug Research, Vrije Universiteit Amsterdam and Heidelberg Engineering.

Lead time: 2015 – present.

Budget: various projects are funded by a Top Consortium for Knowledge and Innovation (TKI). The two ongoing TKI projects jointly amount to EUR 1,400,000.

Sea of the future in the SOSc

How will autonomous vessels operate in busy waterways in the future? How can we best support human beings when sailing in confusing situations. In MARIN's new Seven Oceans Simulator centre (SOSc), the simulators emulate situations with several vessels operating under difficult conditions at sea or in ports. ▶

Large Motion Simulator.

MARIN

Problem: maritime operations are becoming more and more complex due to increasing maritime traffic, even bigger container ships, as well as the development of wind farms. This is causing greater risks of accidents, such as a collision between vessels or a collision against wind turbines.

TO2 Solution: MARIN's research facility, the Seven Oceans Simulator centre (SOSc), makes maritime operations safer and more efficient by realistically simulating interactions between maritime structures, shipping vessels, the environment, and human beings.

Impact: the simulators enable designers and users to work together to make ships more sustainable, better and safer in operational conditions before they are built. In addition, the simulators play a role in practising operations. This is how MARIN contributes to a clean, smart and safe shipping industry.

Things are getting busier and busier in the North Sea. In addition to more and larger vessels, the number of wind farms is increasing. Less offshore space means more risk of accidents, such as collisions between vessels. Analyses have shown that accidents are often the result of human behaviour, or that there has been insufficient response to emergencies. This has been confirmed by the report "Negotiating with space" (Schipperen met ruimte) published by the Dutch Safety Board in 2024. The report warns that there are no guarantees for safe shipping, with potentially serious consequences for people and the environment. The question then is: how can we support the crew onboard and ashore to perform theirs tasks safe and efficient? How do we design ships, support systems and infrastructure involving these crews using their operational knowledge and experience?

360 degree visibility

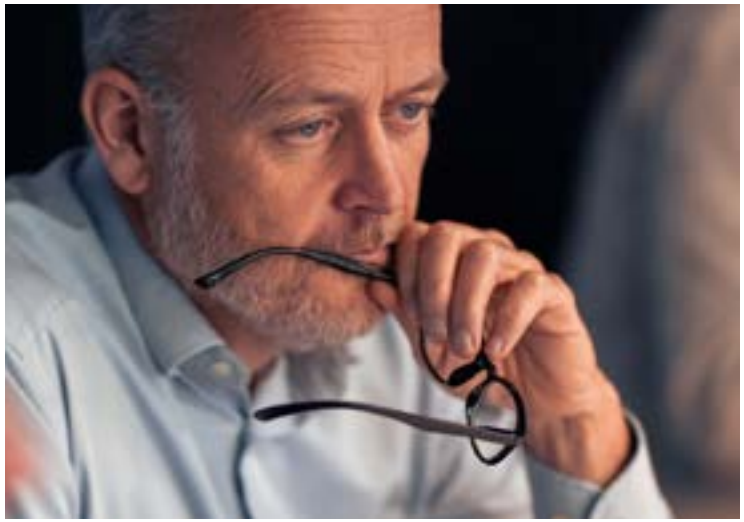
"Maritime operations are becoming more and more complex", says Dimitri van Heel, Maritime Operations team leader at MARIN. He is one of the "creators" of the new Seven Oceans Simulator centre (SOSc), the test facility that can realistically simulate reality at sea, including motion platforms and spherical simulators with 360 degrees of visibility. "At MARIN we have been working with simulators since the seventies, but the simulators were already 25 years old. They needed to be replaced and we wanted to introduce new techniques." The SOSc consists of various simulators. For example, the Full Mission Bridge emulates the bridge of a large ship and Traffic and Mission Control simulates a traffic control centre for shipping where maritime parties can practice. "All simulators have been set up modular. This means that the set-up in a simulator room is easy to adapt, from the layout of a large cruise ship to a one-man bridge set-up of a modern frigate."

Large Motion Simulator

One of the flagships, the Large Motion Simulator (LMS), was already put into practice shortly after its official opening by King Willem-Alexander in May 2024. "We are working on the TopTier project, in which we conduct parametric roll oscillation tests. These motions of the ship could cause stacked containers to topple from the deck into the sea. We have incorporated the motions recorded in our water basins into motions in the simulator and can thus investigate whether a crew is able to see any upcoming parametric oscillation." The LMS is spherical with full visibility topside and bottom, along port and starboard, as well as fore and aft. As many as thirty projectors link realistic images of the sea to each other. "This 360 degree view is necessary when a ship passes by, because the crew then has a good view of what is happening along port as well as starboard." The LMS is located on a motion platform and can tilt up to angles of thirty degrees. "In this way we can simulate how to turn a ship in a storm without capsizing. For example, we study the capsizing of fishing vessels, as this unfortunately still happens too often. We can also emulate wave impact or the vibrations of a ship colliding with an ice floe. The engineers and crew can jointly experience and improve ships in operational conditions before they are built."

Multifunctional simulators

For smaller vessels, such as tug boats and barges, four multi-purpose simulators are available. They consist of a one-man bridge set-up with radar, ECDIS (Electronic Chart Display Information System;



Dimitri van Heel.

MARIN

Floor plan of the ground floor of the SOSc.

is a computer system that makes it possible to view electronic marine charts), command and alarm screens. Two of the multifunctional simulators are equipped with additional screens on the floor and ceiling, so that crane operations can be simulated, for example. All simulators in the SOSc can be linked to and operated from various control stations. This allows simulations to be performed in which a large vessel (e.g. on the LMS) is assisted by one to four tug boats, operated via the multifunctional simulators.

Disaster management

In Traffic and Mission Control, a mock up of a traffic control centre for shipping, parties like the coast guard can conduct disaster management drills. "Via T&MC, they can coordinate emergency control. At other simulators, they can conduct other parts of the operation. This varies from a ship that lists to lifeboats that come to the rescue. Anything that can go wrong, can be practiced here. The simulators offer unprecedented possibilities to simulate all aspects of operations at sea and give the human operator a central platform. Together, they experience situations with ships even before they are built." MARIN wants to use the new SOSc to fulfil its ambitions to make the "sea of the future" more sustainable and safer. "We will expand our use of modern techniques, such as virtual and augmented reality." In future, MARIN also wants to connect the simulators to other (vessel) simulators, both in the Netherlands and abroad. "This allows us to simulate even more complex scenarios, while clients can also participate in the simulations without having to travel to Wageningen."

The human factor

No matter how important technology is, the human factor remains crucial, so that has been given a lot of attention at SOSc. MARIN combines technology with research into human factors: how do crew members function and respond in difficult conditions? "We use eye trackers to see how they respond, and a heart rate monitor to see when tensions rise for the crew. We employ psychologists and behavioural scientists who analyse this. The focus of our efforts to contribute to a clean, smart and safe shipping does not lie in technology alone, but on a well designed combination of technology and humans.

"The engineers and crew can jointly experience and improve ships in operational conditions before they are built."

View the video **here**

Who: MARIN.

Lead time: 2014 – 2024.

Budget: the SOSc costs EUR 15.8 million, funded by MARIN and the Dutch Ministries of Infrastructure and Water Management, Defence and Economic Affairs.

Follow-up: the underwater kingdom is rarely covered in realistic simulations. In future, the SOSc wants to provide realistic visual presentations of the vessel's surroundings.

Working together in the airspace

With the advent of new aircraft, from drones to F-35 fighter jets, pressure on our scarce airspace is increasing. How can these "newcomers" be fitted in and made compatible with existing airspace users? The Safe and competitive operations seeks solutions. ▶

Programme Manager Nick van den Dungen of the Royal Netherlands Aerospace Centre (NLR).

NLR

Problem: Dutch airspace is becoming increasingly congested with passenger aeroplanes, helicopters, military aircraft and emerging aircraft such as drones. How can these existing and new users mutually make use of the airspace safely and efficiently while reducing their impact on the environment?

TO2 Solution: NLR's knowledge programme called Safe and Competitive Operation, studies how all users can make use of the airspace in a safe, sustainable and effective manner.

Impact: aviation is indispensable for the Netherlands, both economically and socially. The knowledge gained in NLR projects can be applied by airlines, airports, and air traffic control organisations to maintain their competitive position and, in consultation with airports, air traffic control, drone operators and the Ministry of Defence policy makers can incorporate it into their policies to ensure safe and sustainable aviation in a responsible social context.

Amsterdam Airport Schiphol in the Netherlands is one of the top three European airports, but we have a far smaller airspace than many other countries. "Our airspace is already quite congested," says Programme Manager Nick van den Dungen of the Royal Netherlands Aerospace Centre (NLR). "Drones need more and more flight space, and the Ministry of Defence, for example, has indicated that the F-35 fighter jet needs more airspace to practice than its predecessor, the F-16. In addition, we want to make air travel more sustainable and develop more efficient systems that make air traffic as compatible as possible. To manage this properly, a great deal of research is needed."

ITARO

It led to the knowledge programme Safe and Competitive Operation, which consists of several projects. One of those projects, where NLR was involved, was the European project ITARO, which focused on introducing more sustainable flight operations with fixed approach routes. As part of an optimum flight path, aircraft ▶

The flight crew after the test flight using "Interval Management"": flying two aeroplanes in calculated succession to descend continuously in landing as sustainably and efficiently as possible on a fixed approach route.

NLR

"Electric aircraft fly less fast and at a lower altitude than 'normal' passenger aircraft and are usually propeller driven."

▶ can descend continuously in their approach during landing, which requires less engine power and results in lower fuel consumption and noise pollution. "We have studied several scenarios with air traffic simulators to test these optimum routes. Additionally, by means of a test flight, we investigated the interval between aircraft in their approach to the airport, in order to reduce delays and to limit detours." For safety reasons it is important that aircraft do not get too close to each other. The investigation showed that the investigation's outcomes can be applied in practice. "It is now up to the airlines and air traffic control operations to put this into practice."

Electric aircraft

NLR also contributes to the Dutch government's airspace review programme to better classify the use of airspace and to enable more sustainable flight on a large scale. "NLR has gained a great deal of knowledge on aircraft systems and management and we have combined that knowledge in the programme." In addition, future research will increasingly focus on the integration of new aircraft in the airspace, propelled by electricity or hydrogen. "Electric aircraft fly less fast and at a lower altitude than 'normal' passenger aircraft and are usually propeller driven. Those propellers also produce noise. What does this mean for noise pollution in the areas over which they want to fly? Of course, this is an important factor, aside from limiting the climate impact. Fortunately, we also conduct a lot of research on this at NLR. ■

Nick van den Dungen of NLR.

Who: aside from NLR, many other parties were involved in the ITARO project such as the German DLR, EUROCONTROL, and the test flight was supported by LVNL and Groningen Airport Eelde.

Lead time: 2022 – 2025.

Budget: The entire ITARO project (of all partners, including NLR) is EUR 7.8 million.

Follow-up: the Safe and Competitive Operation programme is expected to continue with new projects after 2025.

View the video **here**

License plate for satellites in outer space

From public authorities to the European Space Agency, everyone is seeking solutions to the growing problem of space waste and the explosive growth rate of the number of satellites in outer space. TNO's solution to identify new satellites with the Satellite License Plate helps to reduce space debris. ▶

TNO

Problem: every year, thousands of new satellites are added to orbit Earth. Many of them can no longer be identified after being launched, due to their loss of contact with the earth. That could be hazardous for other satellites and spacecraft on account of a collision. After a collision, debris is released into space, which in turn could cause a new collision.

T02 Solution: TNO developed technology that provides satellites with a Satellite Licence Plate. This satellite license plate is a unique identification code that accurately maps out each satellite.

Impact: our lives are highly dependent on satellite navigation and satellite communications. A failing satellite can have serious consequences for society, such as the loss of internet or military intelligence.

Over a period of three years, the number of launched satellites has quadrupled. In 2023, the number of launches grew by more than 2500 satellites and spacecraft, and it is expected that 60,000 satellites will orbit above us by 2030. As a result, concerns about congestion in our airspace are growing. The European Space Agency (ESA) reported that it is estimated that there are some tens of thousands of objects floating in space that have not been identified. "If we do not know where these space objects or satellites are located, then there is a greater risk of accidents involving colliding satellites", says Fabrizio Silvestri, an Optics System Engineer at TNO when outlining the problem.

Measuring equipment for the Satellite License Plan.

Retroreflector

TNO has devised a solution for this, the Satellite License Plan (SLP), which can identify satellites. Together with various departments of TNO, Fabrizio and his team have managed to develop an optical set-up within a year. It is similar to the vehicle license plate system, but instead of a number plate, a satellite is given a unique identification code. The technology consists of a retroreflector that reflects incident radiation (light) in exactly the same direction as where it came from, irrespective of the angle of incidence. "A ground station on earth sends the laser beams to the satellite. The returning retroreflected signal ensures identification of that satellite." The advantage of this optical technology is that SLP does not add additional signals to the radio frequency range used by most satellites for internet or television, for example. Optical

TNO

technology also provides a higher resolution than radio waves, making the identification of satellites more accurate.

Satellite swarms

Silvestri expects that the introduction of an identification system will lead to more safety in space. "SLP can assist in identifying objects that are likely to collide with satellites. Or it could identify a satellite approaching its end-of-life." More and more companies are launching what is known as "satellite swarms". These are networks of sometimes thousands of small satellites, like those from Starlink by the American company SpaceX. SLP can quickly identify individual satellites in these swarms, for example if they do not work as expected. "Only when a satellite has been identified, are organisations able to work on its removal."

Space surveillance

The technology works, but when the market or public authorities will make use of this, according to Silvestri, is not yet known. "The European Commission is in the process of drawing up a strategy and legislation in the area of space surveillance and monitoring. We are going to establish contacts with European space agencies and other parties in the near future to jointly develop this further. We will make the technique possible, it is up to other parties to implement this technology." ■

Who: TNO teams Optica, Optomechatronica, Quantum Technology and Space System Engineering.

Lead time: summer 2021 – spring 2023.

Budget: EUR 250,000.

Follow-up: TNO continues the dialogue with parties to further develop technology in the optical ground stations.

“Talking” to satellites via laser beams

Connecting to a satellite that orbits at 28,000 km/h with a laser beam from the ground, and maintaining that connection: that is the technological challenge for laser-satellite communications! At TNO they have figured it out, thanks to sixty years’ worth of experience in aerospace instrumentation. ▶

Kees Buijsrogge, Director of Aerospace at TNO.

TNO, NLR

Problem: almost all current communication technology (Wi-Fi, Bluetooth, 5G) makes use of radio waves. Except, with our growing dataconsumption, the radio frequencyspectrum is getting congested and interferences arise. Moreover, the speed for data traffic by radio is limited and also susceptible to eavesdropping.

TO2 Solution: optical communication is a faster, more reliable, and safer alternative to radio traffic. However, we are also faced with technological challenges. TNO researchers have recently been successful in transmitting data from a satellite to a ground station on earth, using their proprietary laser communications system SmallCAT (Small Communications Active Terminal).

Impact: SmallCAT paves the way for faster and safer broadband connectivity for both the Netherlands and Europe within a strong NATO. This innovation also contributes to an emerging Dutch industry specialising in optical satellite communications.

Our data usage has exploded. From the 4K videos that we stream on our smartphones while travelling, to the endless data streams that we generate from sensors and cameras all over the place. Data that we recirculate in real time. Sometimes we do so via fibre optic cables, but mainly via the air, in other words, via radio waves, because, whether it is Wi-Fi, Bluetooth, 4G or 5G, all this communication technology makes use of the radio frequency spectrum. The result is predictable: the spectrum is gradually becoming overcrowded, which causes interference. "Compare it with the old-fashioned FM radio. When you used to turn the knob and you got too close to another station, the radio reception would begin to signal interference. This is currently the situation with our data traffic", explains Kees Buijsrogge, Director of Aerospace at TNO. There is another drawback: it is easy to eavesdrop on radio frequencies. "There are some outer space photographs on which, other than there being a communications satellite, a second object can be seen: that is an eavesdropping satellite that has secretly been placed there."

"We are talking about optical communications: fast, reliable and barely susceptible to eavesdropping."

Eiffel Tower

The good news is that alternative technology is being developed that has no difficulty with the disadvantages of radio communications. "We are talking about optical communications: fast, reliable and barely susceptible to eavesdropping", says Buijsrogge. However, from a technological point of view, laser communications presents us with the necessary challenges. Check it out: a satellite orbits at an altitude of five hundred kilometres at a speed of 28,000 kilometres per hour. To touch that from a ground station with a laser – that is like beaming a tiny target on the Eiffel Tower from the Texel lighthouse, while that lighthouse is in motion. Yet, that is what TNO, in collaboration with Airbus Netherlands among others, has achieved with the SmallCAT project. A laser connection has been established with an orbiting satellite from a ground station in The Hague in the Netherlands. It then transmitted the data signal by laser to a ground station in Tenerife in the Canary Islands. "A breakthrough", says Buijsrogge. "This has shown that this technology works in realistic conditions and is ready to be industrialised further."

Turbulence

For laser-satellite communications to work, unprecedented precision over long distances is required. TNO has this precise know-how. "We have been working on aerospace instrumentation for sixty years already", says Buijsrogge. "We develop high tech optical instruments to study the universe from Earth. And vice versa: to view our atmosphere from outer space, e.g. to monitor air quality and greenhouse gas emissions. As a result, we have gained a great deal of knowledge on optical system design. For example: if you look at the stars, you often see them twinkling due to turbulence in

TNO, NLR

the atmosphere. We have the technology to compensate for these interferences along the way. Technology that can also be used to touch and hold a tiny "target" five hundred kilometres away with a laser. "We call this active or adaptive optics", Buijsrogge explains. "Think of a mirror that can be moved rapidly and accurately so that it constantly remains connected to the satellite or to the ground station. In jargon: a fine steering mirror. A system measures interferences in the atmosphere. So-called "actuators" continually push against the back of that mirror and thus compensate for those interferences. What we do with that is truly world-class." In fact, the technology works so well that TNO is collaborating with Airbus Netherlands on laser satellite terminals suitable for aircraft. "This allows an aircraft at an altitude of ten kilometres to connect to a satellite 40,000 kilometres away. As far as we know, that is a world first."

IRIS2

By making use of the SmallCAT, TNO has shown that the technology works and is ready to be commercialised and industrialised on a large scale, and now is the right time. Europe is in the process of setting up its own constellation of satellites for secure communications called IRIS2 (partly motivated by the desire to no longer be dependent on, for example, Starlink owned by the American entrepreneur Elon Musk). "Our dream is to succeed in the development chain with Dutch companies. That dream now seems to be turning into reality", says Buijsrogge, who envisages a laser-satellite industry emerging in the Netherlands. "In the past, we were constantly in the lead as TNO. The roles are gradually being reversed, because nowadays there are projects in which we work as a subcontractor for a Dutch company. In short, the Netherlands is about to become commercially successful with this technology. This is just the way you want it to be."
"Yet, that is no reason to be complacent", Buijsrogge emphasises. "We are already working on the next generation: how can these laser-satellite terminals not only be even faster and better, but safer too?" For this purpose, TNO is working on the integration of quantum technology. "If you add a quantum key to the optical signal, then the messages are impossible to hack", says Buijsrogge. The next step: quantum-satellite communications that enable a worldwide quantum-internet network, which is endlessly much faster and safer than our current internet. "We want to help Dutch companies with this key technology as well, to build up a global leadership position," says Buijsrogge. "In short, we're just at the beginning." ■

"Nowadays there are projects in which we work as a subcontractor for a Dutch company."

TNO's laser communications terminal.

Who: SmallCAT was developed by a TNO-led consortium consisting of the Dutch company AAC Hyperion and the British company Gooch & Housego.

Duration: 2017 – 2024.

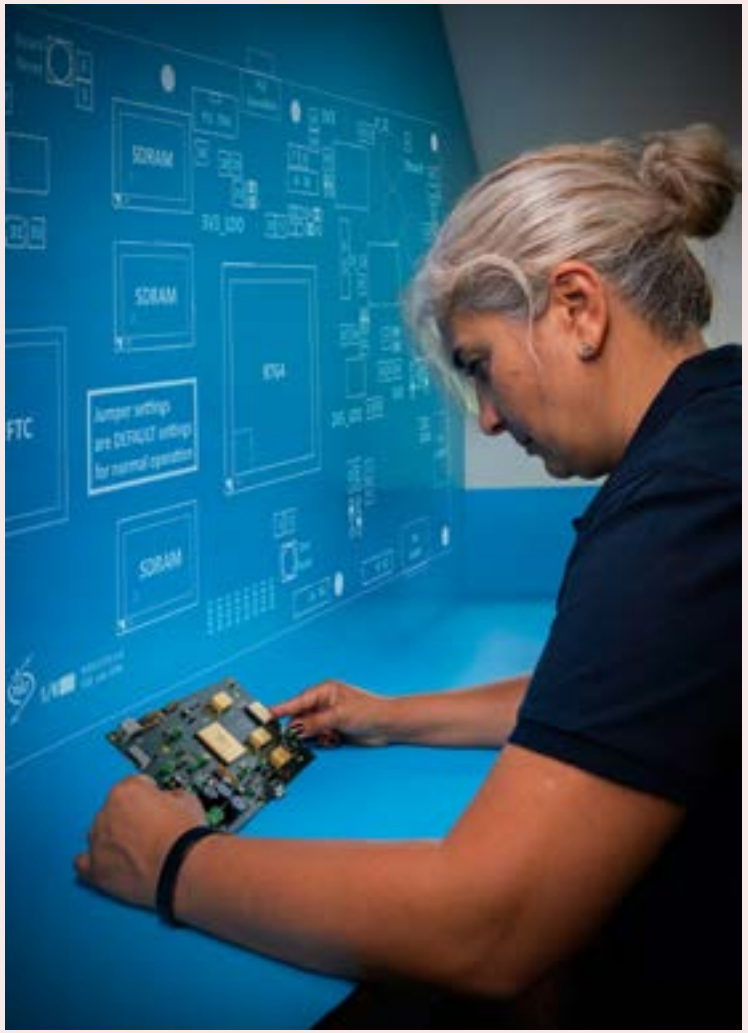
Budget: SmallCAT has been designed with financial support from the Netherlands Space Office (NSO) through the ARTES programme of the European Space Agency and from the innovationbudget of the Dutch Ministry of Defence. The programme has been co-financed by TNO.

Follow-up: the next generation of laser-satellite terminals is under development: faster, safer and, for example, suitable for quantum communications.

TNO, NLR

Dutch industry fully hooked up onto “satcom”

It is one thing to “beam” onto a satellite from earth with a laser, but an effective laser-satellite communication requires more than that: satellites also need to find each other. NLR is working with Dutch partners on the necessary “inter-satellite link”.



NLR is developing “high-speed modem” technology for aviation and aerospace.

Satellites travel at a rate of about 28,000 kilometres per hour through outer space. Although they orbit above the earth’s atmosphere, they are still relatively close to Earth, in what is known as a Low Earth Orbit (LEO). Such a satellite can therefore only cover a small part of the earth, which means that it has to wait for the ground station to be in view before data can be exchanged. “On average, the waiting time for these satellites is about an hour and a half”, says Oana van der Togt, Business Manager Space at NLR. We don’t want to wait for an hour and a half for our data, so a solution has been conceived. Although the satellite only sees part of the earth, it also has visual contact with other communication satellites. In this way, the data can be transmitted via a laser connection to a “friendly” satellite, and so on, until a satellite is reached that hovers above the required ground station. “Since laser communication operates at the speed of light, real-time data can be transmitted and received in this way”, says Van der Togt. “Concurrently, there do not have to be very many ground stations on earth, just as long as you have enough satellites in your network.”

“Concurrently, there do not have to be very many ground stations on earth, just as long as you have enough satellites in your network.”

Outer space conditions

However, those satellites must be able to find each other with their laser beams. Using extreme precision across a distance of several hundreds to thousands of kilometres away, while they are possibly

TNO, NLR

rotating on their axes too. "In order to enable this 'inter-satellite link' between satellites, a Dutch consortium is building a terminal that consists of all kinds of subsystems", says Van der Togt. For example, NLR is also involved in control electronics. This part allows two satellites to find each other, even if they rotate through outer space, for example. NLR is also developing a high-speed modem that encrypts and decrypts the data so that it can be transmitted and received via a laser beam. "The additional challenge is that all systems can withstand extreme outer space conditions, such as temperatures ranging from -40 to 120 degrees Celsius, as well as space radiation. Or, consider all the shocks and vibrations that the instrumentation is exposed to during the rocket launch. At NLR we have all the testing facilities to realistically recreate these kinds of conditions."

National Growth Fund

Within this development path, NLR sees itself as a significant knowledgepartner. Van der Togt: "We apply our knowledge and expertise to develop state-of-the-art technology that is important for the Netherlands and Europe. Ultimately, we want to transfer our knowledge and technology to Dutch industry that can market it as a product."
That also applies to the satellite communications terminal. "This type of project – funded by the National Growth Fund among others – offers the Netherlands an opportunity to secure a prominent role in the global laser-satellite communications market, and to maintain its competitive position in a rapidly developing market.
This is not only of economic importance, but also of strategic importance, because laser-satellite communication plays a role in an increasing number of areas. "This allows us to give people all over the world – including in remote places – fast access to the internet. So too for defence applications – consider real-time information exchange in a battlefield situation – where governments want to have access to their own laser-satellite network." The next technological hurdle is already in sight: quantum communications.

"As NLR, we are already gaining knowledge for development of this key technology, so that Dutch industry and public authorities are ready for the future." ■

"At NLR we have all the test facilities to realistically recreate these conditions."

Can an Optimist boat learn to sail by itself using AI?

The Optimist boat floats in a large basin measuring 45 m × 36 m at MARIN's marine research institute in Wageningen, where fans emulate the blowing wind. When the rectangular sail catches the wind, the small boat tilts to starboard, and is set in motion. ▶

Fanny Rebiffé, researcher at MARIN, developed a data-driven artificial intelligent method to steer an Optimist sailing boat.

MARIN

Problem: maritime prediction methods are often based on physics computer models. There is less experience with data-driven artificial intelligence (AI).

T02 Solution: MARIN developed a data-driven artificially intelligent method to control an Optimist sailing boat, in which the model explicitly does not know explicitly the physics, but implicitly is contained in the data. The philosophy is: if children can learn to sail without explicit physical knowledge, an AI algorithm should be able to do so too.

Impact: the self-learning Optimist paves the way to use AI and data-driven methods in more serious and demanding maritime applications, such as an autonomous docking of ships, more efficient sailing with fast vessels, or the rapid and safe installation of offshore structures.

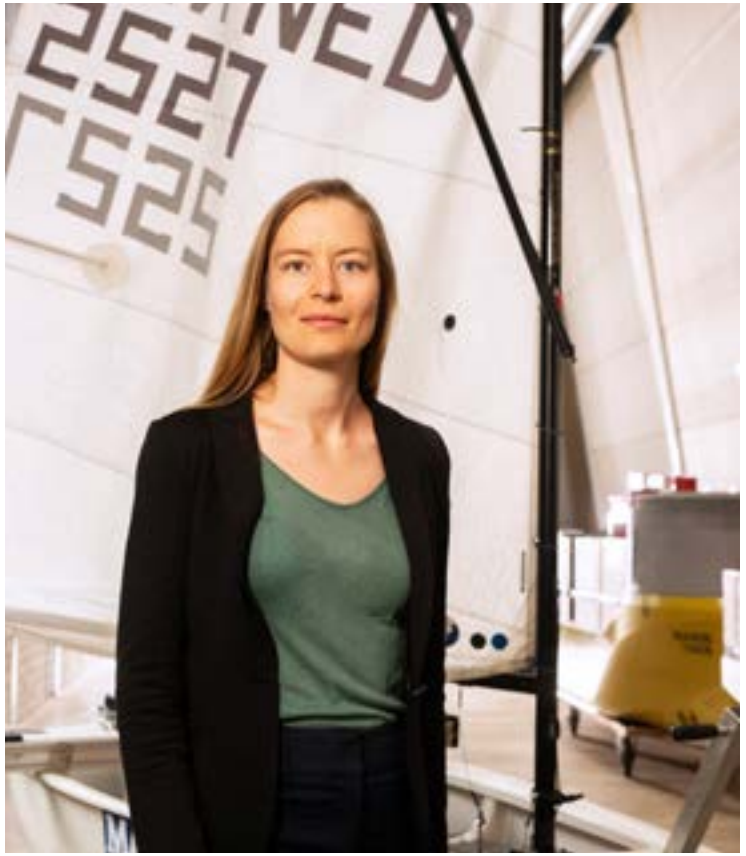
There is no child on board, only a computer. It controls the rudder position and the position of the sail, and – in the absence of a child – moves a weight of 42 kilograms from starboard to port. Children learn to sail in an Optimist boat without knowing too much theory about wind and forces on the sail. At MARIN they thought that should be possible too with artificial intelligence, or AI. "We wanted to explore the possibilities and limitations of AI for maritime purposes", says Fanny Rebiffé, an AI Sail research team member. "An Optimist boat was a rather intuitive example: a sailing boat for children, which is relatively easy to steer, it is easy to interpret what is happening and how AI responds."

Desired behaviour

While making use of the AI technique Reinforcement Learning, Rebiffé's system was able to learn tacking independently: sailing some sections at an angle against the wind and occasionally to change direction by tack. "In this technique, neural networks, inspired by the operation of brain cells, are trained by rewarding the desired behaviour", Rebiffé explains. "At the beginning, the AI system knows nothing. The system tries things at random, and if it happens to do something right, a reward follows." Doing something right is, for example, sailing a short distance in the right direction. Such rewards push the parameters of the network a little in the right direction. Trial and error enables the system to progress gradually, initially within a computer simulation. But when AI Sail had its first sailing lessons, it was allowed to move to the real world in the water basin. During training, Rebiffé tried to give as few explicit instructions as possible. "For example, we were not going to instruct the boat to tack, nor that it should not rock." "Rocking" is the movement of the rudder to move forward, which requires a lot of energy and is prohibited during competitions.

Autonomous Optimist

The Reinforcement Learning system will only be rewarded if it makes progress towards the final goal: the opposite end of the basin. However, there were penalties – a negative reward – for poor seamanship, such as sailing against the edge of the basin, or tilting at such an angle that water flows into the boat. Rebiffé: "That happened once, at the beginning." AI Sail soon mastered the sailing. "We started in May 2023, and by November we had an autonomous Optimist." That is not bad for a task which some experts expected that AI couldn't accomplish. The self-steering children's boat is now a regular ▶



Fanny Rebiffé of MARIN.

"For example, we were not going to instruct the boat to tack, nor that it should not rock."

MARIN

By using AI, the Optimist learned to sail independently in MARIN's water basin.

feature at MARIN's open days and working visits. "But the end goal is not an autonomous Optimist", says Rebiffé, "what we learn can be used for other maritime AI projects, such as autonomous docking (shutting down at a certain position) of vessels, or reducing 'slamming': hitting too hard onto the waves of fast-sailing ships."

Submarines

Other applications are autonomous inspection systems. "There are underwater drones for taking measurements or conducting underwater inspections, but if you want to inspect the pole of a wind turbine, for example, it can be difficult because of the waves or turbulence in the wake of the pole. We are now trying to achieve this with AI and other data-driven techniques." In fact, Rebiffé, who comes from France, still has to master sailing. "My father once took me sailing as a child, but then the boom hit me on my head, so I didn't want to go anymore. But nowadays, I am curious. I'm going to make another attempt." ■

Who: MARIN and TU Delft. Workshops were held with the shipbuilders Allseas, Feadship, Wagenborg, Damen and Oossanen.

Duration: 2023 – 2024.

Budget: EUR 600,000 from an internal budget, intended for AI and collaborations with industrial partners.

Follow-up: experience with AI, especially Reinforcement Learning, can be applied to autonomous maritime control systems for docking, inspecting underwater structures in difficult current-flow conditions, and for more efficient sailing with swift vessels.

View the video **here**

Using a combination of techniques, to remove medicine residues from effluent

More and more medicine residues end up in nature, especially in waterways such as rivers. The long-term consequences for our health are unknown. Wageningen University & Research investigates how advanced purification technologies can be combined to effectively monitor and extract medicine residues from the water. They simultaneously remove bacteria that are resistant to commonly used antibiotics. ▶

Tania Mubita Zambrano of Wageningen University & Research: "A single technology is not enough to remove medicine residues."

WUR

Problem: conventional treatment methods do not remove all medicine residues and potentially harmful bacteria from the effluent, which means that they end up in the surface water and accumulate in the living environment.

T02 Solution: WUR is developing advanced purification technologies for the removal and monitoring of medicine residues in effluent at the source.

Impact: decentralisation of sewage purification is of vital importance. The combination of advanced technologies can more effectively remove resistant contaminants than current purification methods. Together with online monitoring, these technologies can detect and remove contaminants in effluent directly, preventing the accumulation in the environment and negative effects on humans, animals and nature.

More and more pharmaceutical waste and residues of the medicines we use, end up via our urine and faeces in effluent. "Regular treatment methods cannot remove all these medicine residues", explains researcher Tania Mubita Zambrano of Wageningen University & Research. This contaminated water flows through the sewage purification plants to ditches, rivers and lakes, which are also the sources of our potable water. "Some chemicals are extremely persistent. These remain in the water even after purification processes and eventually accumulate in the environment", says Mubita Zambrano.

Medicine residues more often

The water boards are increasingly discovering medicine residues in the water, even after treatment in the sewage purification plants where the effluent is purified. These include residues of various types of antibiotics, the commonly used pain relievers Ibuprofen and Carbamazepine, a medicine for epilepsy and manic-depressive symptoms. The precise effects on human and animal health of medicine residues in effluent are still unknown, although research has shown that some medicines residues disrupt the reproduction of fish and change their behaviour. "What exactly happens when the fish are then eaten by other animals or humans, is unclear. Perhaps these substances are not harmful to us, but then again, perhaps they are. We simply do not know the long-term effects. That is why it is all the more important to extract these substances from the water", Mubita Zambrano emphasises.

Research in practice

With her colleagues, she jointly conducts research into the effectiveness of three innovative technologies, in conjunction with a water board, a pharmaceutical company, and technology suppliers. The technologies remove medicine residues as well as harmful bacteria that are now resistant to certain commonly used antibiotics. "This will enable us to work simultaneously on reducing antibiotic resistance in the water", explains Mubita Zambrano. The researchers focus on thirteen medicines and have taken samples of the effluent from four hospitals and two healthcare institutes spread across the

Tania Mubita Zambrano of WUR.

"The use of a combination of different technologies can be very effective."

WUR

(From left to right) Researchers Ruben Massop, Tania Mubita Zambrano, Mahmoud Alkhalid and Truus de Vrije who are working on various technologies, which remove medicine residues and bacteria from effluent.

Netherlands. "Hospitals and healthcare institutes are ideally suited locations for testing, as they are a source of emissions of large quantities of medicine residues into the sewerage system", says Mubita Zambrano. In the laboratory, the researchers study the effectiveness of the three different technologies to remove the medicine residues and bacteria. Together with the HAN University of Applied Sciences, the researchers are also working on measuring systems that can be placed in the effluent at hospitals to continuously detect and monitor concentrations of specific medicine residues and antibiotic-resistant bacteria.

Purification technologies

The first technology, nanofiltration, uses a porous barrier that allows water to pass through and retains some medicine residues. The second technology, UV light in combination with hydrogen peroxide, tackles the substances that pass through the barrier anyway. This technique breaks down the substances into smaller molecules, which can then undergo further degradation processes, possibly reducing their impact on the environment. The third technology, plasma water, breaks down the residues using electricity and without the addition of chemicals. Research has shown that the combination of these technologies is more effective than the purification methods currently in use. Mubita Zambrano: "A single technology is not enough to remove the medicine residues. The use of a combination of different technologies can be very effective. However, the methods require considerable investments and energy." She continues: "I hope that public authorities will invest in introducing these technological solutions. Treating effluent at its source is one way of reducing the spread of persistent waste substances in water sources. It is just as important to make people aware of the fact that all the medicines we take, end up in our waste water. If this is not treated properly, it can accumulate in our living environment. ■

Who: WUR.

Duration: From April 2023 to March 2026.

Credits

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