TO2MORROW

Magazine on results in the Open Innovation Network

2023

TO2 federatie
De samenwerkende organisaties in toegepast onderzoek

TNO innovation for life

MARIN
BETTER SHIPS, BLUE OCEANS

nlr Dedicated to innovation in aerospace

WAGENINGEN
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Dear reader,

What innovative solutions can help achieve a sustainable, clean and safe future for the Netherlands? And how can businesses continue to grow and innovate so that the Netherlands continues to prosper? You can find answers to these and other questions in this eighth edition of TO2MORROW, the annual impact report of applied research organisations, referred to as TO2 institutes.

Allow yourself to be inspired by great examples, such as the acceleration of emission-free construction to reduce CO_2 emissions. Or the development of high-quality crop seeds to increase food production worldwide.

I am immensely proud of all the work our TO2 institutes are doing. Thanks in part to their efforts, the Netherlands is among the most innovative countries in Europe – by working on groundbreaking ideas and concrete innovations day in, day out.

As a country, we continue to invest in research and innovation, by the government as well as by the business community. We want to further utilise and apply our knowledge in various fields including healthcare, energy and agriculture. This is good for the Netherlands, and also for our planet. By doing so, we are also working on the jobs of the future, and the TO2 institutes play a crucial role in this. Thus, together we are building a future in which the Netherlands will continue to shine as a leader in innovation.

I hope you enjoy reading this edition,

Micky Adriaansens,
Minister of Economic Affairs
and Climate

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

The T02 federation consists of:

Deltares

Deltares

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

MARIN
BETTER SHIPS, BLUE OCEANS

MARIN

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

nlr Dedicated to innovation in aerospace

NLR

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

Follow-up

The T02 federation consists of:

TNO

The Netherlands Organisation for Applied Scientific Research (TNO) has a mission to connect people and knowledge to create innovations that boost the competitive strength of industry and the well-being of society in a sustainable way. TNO believes in the joint creation of value in economic as well as social terms and, together with partners, focuses on innovations in six domains: Mobility & Built Environment; Energy & Materials Transition; Defence, safety and security; Healthy living & Work; High Tech Industry; ICT, Strategy & 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, material and chemical technology. Key technologies are characterised by a wide field of applications or scope in innovations and sectors. They will radically change the way we live, learn, innovate, work and produce. Key technologies are essential in resolving social challenges, such as safety, energy and care. Key technologies also enable groundbreaking innovations of processes, products and services, and provide a major contribution to the economy, to the emergence of new businesses and new markets, to an increased competitiveness and to bolstering job creation.

WUR

Wageningen University & Research is the joint venture between Wageningen University and Stichting Wageningen Research (a foundation). We have more than 7,600 employees and 13,100 students from over 100 countries working in the fields of healthy nutrition and the living environment across the globe, both for government authorities and for the business community. The mission of Wageningen University & Research is "To explore the potential of nature to improve the quality of life".

Wageningen University & Research's strength not only lies in combining specialised research institutes and the university, but also in collaborations among various natural, technological and social science disciplines. As a result, scientific breakthroughs can quickly be translated into practice and into education. Wageningen Research is part of the T02 federation and consists of several research institutes who are active with the topics Food & Biobased Research, Bioveterinary Research, Livestock Research, Marine Research, Economic Research, Environmental Research, Plant Research and Food Safety Research. ■

Nitrogen solutions thanks to more precise measuring

In the eye of the nitrogen storm, scientists, environmental managers, farmers and residents in the vicinity are jointly investigating the vulnerable Liefstinghsbroek nature reserve. Such intensive measuring into the source of nitrogen is unprecedented in the Netherlands: where it comes from, how it spreads and where it is deposited. A learning project in technology and trustworthiness. ▶

Peter Laloli at TNO.

TNO, WUR

Problem: farmers who have to adapt or cease their business, nature that is deteriorating rapidly. Nitrogen is keeping the Netherlands in its grip. To arrive at sound solutions, we need to know exactly where nitrogen comes from and where it is deposited and in what quantities.

T02 Solution: a pilot study combines methods of measurement, meteorological data and information on agricultural activity. As a consequence, a far more comprehensive picture comes about of nitrogen in an environment than by using existing models. Researchers, farmers and environmental managers provide data, which can only be used for the agreed purposes. TNO developed the Data Spaces system for this.

Impact: this pilot study '*Maatwerk met meetwerk*' ['Measuring for customization'] in the Liefstinghsbroek nature reserve, should provide measuring results, on the basis of which a committee advises the province of Groningen on solutions for better nature conservation in combination with agricultural activity. This could become a standard measurement network for nitrogen hotspots in the Netherlands and is an example of sound cooperation between knowledge organizations and public authorities.

The Liefstinghsbroek is an ancient, marshy nature reserve with deciduous trees and grasslands, partly located along the small Ruiten Aa river. This Natura-2000 area of twenty-hectares in Groningen, is susceptible to nitrogen. However, the nitrogen problem also affects companies in the surrounding area. There is a great deal of uncertainty about the future, because the granting of permits is at a standstill. If the natural environment recovers, the granting of permits can get underway. That is why the province of Groningen has set up the Liefstinghsbroek Advisory Committee on an Area-focused approach to nitrogen (*Adviescommissie Gebiedsgerichte Aanpak, GGA*). This committee is having additional nitrogen research carried out and having talks with local partners, farmers and residents in the vicinity, to make recommendations to the province on local solutions. Part of this is the pilot study '*Maatwerk met meetwerk*' ['Measuring for customization'] in which research institutes, such as Wageningen University & Research (WUR), environmental managers, companies and residents in the vicinity work together under TNO's leadership.

Learning project

No other place in the Netherlands is currently being measured so meticulously, both in time and in surface area, where the source of nitrogen is (emission), how it spreads (concentration), where it is deposited (deposition) and in what quantities. The project also measures other aspects that affect nitrogen data, such as agricultural activities, weather and the type of vegetation. Various measuring methods are used in twenty measuring systems scattered around the area: e.g. in and around stables and in many places in and around the nature reserve. In addition to validated methods, new techniques such as ammonia sensors are also used for measuring.

"The more precisely this is recorded, the more effectively solutions can be found."

Emotions

Peter Laloli of TNO is the project manager of this pilot study. He is the link between the partners in the project and the advisory committee. Every month he presents measuring results in the measuring workgroup. "I like to work on projects that have a social impact and on the fringes of what is technically and financially feasible." However, he also likes to work sheltered, and that's rather different in this nitrogen project. "There is tension everywhere. It also concerns people, who may perhaps not be able to carry on with their home or business." There were emotions in this project, too. Laloli understands that. Yet everyone works well together, which makes this project extra special. "This area has a long-standing tradition of collaboration." ▶

TNO, WUR

Trustworthiness

Laloli chooses his words carefully. He does so consciously, because this pilot study is all about trustworthiness, rather than technology and science. "Measuring equipment is available at farm yards. Farmers also keep records of their activities. That enables us to correlate information." Take the point in time, for example, when farmers spread their manure on the land. This affects the dissemination and deposition of nitrogen. Sometimes the data reveals something about agricultural activity. Laloli is then able to request additional information from a project participant. "This can only be done if they can rely on me not to use that information for other purposes." Laloli invests a lot of time in the bond of trust between the partners. Together with a colleague, he visited each participant at home, and every two months they talk to everyone about what the researchers are gaining from the measurements. "Everyone can ask all kinds of questions. But, I'm not going to reveal what the neighbour's values are and what he is doing." The strength of this pilot project also lies in the value of the data itself. Laloli: "Farmers want to know the situation for themselves, because the measuring data provides an insight into how they can improve their own business operations."

Independent position

The data management system developed by TNO called Data Spaces, also relies on trustworthiness among the partners in the project. Thanks to a dashboard developed by TNO they can use the data, but only for the agreed purposes. Data Spaces is based on the International Data Spaces (IDS) standards in combination with open source components. This system of agreements also ensures that the data is accurate and securely shared. Laloli emphasizes the researchers' independent position in this project. It is all about developing a good method of measurement and a reliable data management system. "Yet, we do not make recommendations about the measures needed in Liefstinghsbroek. This is done by the Advisory Committee who advises the province of Groningen based on the knowledge gained in the project." The project has been operational for a year now. Laloli cannot disclose much about the initial insights into the measurements. He is able to reveal that one can already see how nitrogen spreads during specific agricultural activities, e.g. when a fertilizer silo is opened, the mixing of manure, and working on the land. "The more precisely this is recorded, the more effectively solutions can be found." ■

Peter Laloli explains the measuring project in and around the Liefstinghsbroek nature reserve in the '*Vroege Vogels*' radio programme of 4 June 2023.

Who: TNO and OnePlanet Research Center, the University of Amsterdam, Wageningen University & Research and RIVM in collaboration with agricultural companies, LTO, Prolander, environmental managers (Society for the Preservation of Nature), residents in the vicinity, the municipalities of Westerwolde and Stadskanaal, the Hunze and AA water board and the province of Groningen.

Duration: 2022 until the end of 2024.

Budget: EUR 1.2 million, financed by the Ministry of Agriculture, Nature and Food Quality (LNV) and the province of Groningen.

Follow-up: TNO is also working on a pilot measuring study in the province of Gelderland regarding the nitrogen hotspot Food Valley. It ultimately wants to transfer the plan of action to market parties to set up new measuring networks. TNO and its partners are developing the technology further.

More details about this project:

Fewer nitrogen emissions through emission-free construction

A complete ready-made home, straight from the factory. It is one of the ways in which the construction sector can cope with the nitrogen crisis, thanks to the Clean and Emission-free Construction roadmap. TNO is an expert partner in a number of projects and ensures there is a coordinator who, together with all parties, shapes the various ways of innovating. ▶

TNO

Problem: in the Netherlands there is a major shortage of housing. This shortage will rise to 317,000 homes in 2024. How can we achieve many additional homes as quickly as possible, without exceeding CO_2 and nitrogen standards? That is the huge challenge currently facing the construction sector in the Netherlands.

T02 solution: accelerated and emission-free construction led by a programme by the Ministry of the Interior and Kingdom Relations (BZK), driven by TNO. Within this programme, the emission site is relocated due to building more prefabricated elements. This will enable homes to be erected quicker and more efficiently at their final location (formerly the construction site).

Impact: In 2022, the Clean and Emission-free Building consortium expanded considerably from around fifty to more than one hundred companies in the construction sector and knowledge institutes. This yielded the initial detailed results in 2022, such as the modular building of the Natural Pavilion that attracted a lot of attention at the Floriade. This project also won the Cobouw trade journal's 2022 Innovation Award.

In the Netherlands, too much nitrogen is released into water and soil, with all the harmful consequences that this entails. Although the construction sector accounts for a small share of nitrogen emissions – less than 0.6% nationally – for each of the tens of thousands of projects it undertakes annually, it has to prove that its activities do not have a deteriorating effect on the natural environment. Until the end of 2023, the government will therefore provide EUR 50 million for the Clean and Emission-Free Construction roadmap. This is a knowledge and innovation programme that focuses on building without harmful emissions.


Mario de Rooij of TNO.

Prefab construction

Of the total budget, EUR 20 million has been made available for prefab construction. For this part, TNO is the 'manager', i.e. responsible for the programme management. This has been designated to Mario de Rooij, Principal Project Manager at TNO. Together with the partners, he is working on knowledge and innovation projects for smart construction logistics and industrial prefab construction to meet the emission targets of the programme in achieving a 60% nitrogen reduction (2018 – 2030) and 0.4 Mton CO_2 reduction (1990 – 2030). "We are working on all kinds of initiatives and most of them are about how we can build smarter", says De Rooij. "Practical examples of this are: concrete houses and modular construction, reusage of scrap wood, such as pallets. For a modern prefab concrete house, the floor slabs, façades and walls are manufactured in the factory in such a way that the builders can erect it directly at the construction site. For modular construction, the entire module is built in the factory and relocated to the construction site in its entirety." TNO coordinates the parties, monitors financial progress and provides its own knowledge and experience. For example, about new mix-designs or new applications. An example of a new mix-design is an innovative concrete mixture, in which the concrete is no longer cast on site, but is produced in advance as a sustainable prefab shell and core. An example of a new application is pallet wood used as the basis for cross-laminated timber (CLT). There is a great deal of innovation in optimising the process, which means less transport to and from the construction site and in product innovation, such as ready-to-use homes.

"This approach means there are significantly fewer carbon emissions than when using the conventional method of construction."

Fewer emissions

In the meantime, an emission-free house of 50 m^2 in the construction sector is already in production at Startblock. "This is being built in its entire at the factory", says De Rooij. "Then it is merely a question of connecting the piping and this house will be ready for occupancy by one or two people. The fact that they make this house in the factory and hardly any building work is done on site, means there are significantly fewer carbon emissions than when using the conventional method of construction." Architects still need to get used to working with series-based products, but they are increasingly envisaging more possibilities. 'Especially when they see that beautiful designs are still possible.' A next step is the creation of family homes, which the consortium is currently working on. ■

View the video here

Who: Who: TNO, Universities, ROCs (regional training centres) and Universities of Applied Science, construction companies.

Duration: 2021-2023, with a possible follow-up.
Budget: EUR 25 million of which EUR 17 million subsidy.

Follow-up: work is currently underway on a follow-up in which TNO hopes to obtain permission to continue the programme for another term.

In search of climate-optimal flight

In a European research project into non-CO_2 climate impacts, NLR has investigated how operational improvements in aviation can be made to reduce the climate impact of aviation. Twenty recommendations should bring about an improvement in this situation. ▶

NLR

Problem: with the current approach and pace, it will be a challenge to achieve climate-neutral aviation by 2050. New techniques and innovations are urgently needed to achieve this climate target.

T02 Solution: Within the European ClimOP project and together with other parties, NLR has conducted research into operational improvements in non-CO_2 climate impacts in the aviation industry, a lot of which still remains unclear. Research has produced twenty recommendations that will enable universities, knowledge institutes and market parties to set to work.

Impact: calculations show that non-CO_2 climate impacts account for two thirds of the total aviation contribution to global warming. The study is an important step towards achieving the ambition of climate-neutral aviation by 2050.

In addition to CO_2 the combustion of aviation fuel in an aircraft engine generates other gases and particles, such as nitrogen oxides, soot particles and water vapour. At a cruising altitude, these emissions have both chemical and physical influences on the atmosphere which contribute to climate change. Because these emissions are not greenhouse gases themselves, they are referred to as the 'non-CO_2 climate impact of aviation'.

ClimOP

For many years already, advanced research has been conducted into the non-CO_2 climate impact of aviation. Nevertheless, there are still many uncertainties in the predictions of climate impact of individual flights. In recent years, there has also been a greater interest in the effective implementation of measures addressing the overall climate impact of aviation. This gave reason for launching the European project ClimOP (climate assessment of innovative mitigation strategies towards operational improvements in aviation), in which NLR, together with other parties, sought operational improvements to reduce the climate impact of aviation. “The most tangible of the non-CO_2 climate impact in aviation are aircraft contrails, which are created when water vapour freezes into ice crystals”, says researcher and project manager Elisabeth van der Sman of NLR. “These stripes can cause heating or cooling, depending on the time of day, but, on average, they have a highly warming effect. Aircraft contrails provide the largest contribution by aviation to all climate impacts, followed by CO_2 and NOx being ranked as third.” Nitrogen oxide emissions contribute in the short term to the formation of ozone, leading to warming. In the longer term, it causes the degradation of methane that has a cooling effect. There are still many uncertainties about the climate impact of these effects. This makes it a unique challenge, specifically for aviation, Van der Sman explains: “Aircraft contrails often remain in the air for several hours, while CO_2 remains in the atmosphere for at least a hundred years. So you're talking about a very different time scale, and the effects depend on the location, altitude, and atmospheric conditions. If we analyse this better, it will allow us to take very targeted measures.” ▶

Elisabeth van der Sman of NLR.

“Aircraft contrails often remain in the air for several hours, while CO_2 remains in the atmosphere for at least a hundred years.”

NLR

Mitigation strategies

Operational improvements can be aimed at individual flights, the airline network, and operations at the airport. These in-flight operational improvements include, for example, lower and slower flying or making a slight detour during a flight. Operational improvements on the ground, for example, seek alternatives for more sustainable aircraft taxiing, such as electric towing of aircraft to and from the runway. The ClimOP results show that by flying lower and slower, the overall climate impact of individual flights can be mitigated by an average of 6% to 13% if the temperature change on earth over a twenty-year period is taken into account.

"Aircraft contrails are created in specific air layers depending on the local temperature and humidity. By detouring the flight somewhat or flying lower, those aircraft contrails can be avoided and there is less climate impact. That costs more fuel and therefore additional CO_2 emissions, but because these contrails do not occur, on balance it is better for the climate." In its research project, NLR focused on three mitigation strategies to implement the operational improvements. "In our analysis we looked at the impact on various parties, such as airline companies. To avoid an area where there is an increased risk of aircraft contrails, airlines must detour during flight or they must fly lower. This entails additional costs. We have investigated how to increase the likelihood that airlines travel in flight paths with a reduced impact on the climate. This can be done by way of pricing, for example, and aircraft would then have to pay to fly over such an area."

Climate-optimal flights

The recommendations have been published and made available to the market, but according to Van der Sman, it will take time for the operational improvements to become common practice in the aviation world. "From a scientific point of view, further research is needed to predict the climate impact of individual flights more accurately. Market parties could contribute to this, for example by developing sensors and applying them to aircraft. This will then allow more accurate identification of the location of climate-sensitive areas. This information will allow airline companies to integrate these climate-optimal flights into their schedules and decision-making processes. It is important for policy makers to further assess the costs and benefits of various mitigation strategies and to analyse the legal feasibility." ■

Recommendations by ClimOP

Who: NLR.

Duration: 2019 to summer 2023.

Budget: EUR 1 million.

Follow-up: NLR intends to submit new research proposals to the European Commission. This includes the question of how the use of renewable fuels, with fewer soot particles and sulphur emissions, has a positive effect on non-CO_2 climate impacts.

Safe travel by road, water and rail

Roads, ports, railways and, for example, energy and communication networks are essential for our daily functioning. Due to ageing and increased usage, but also due to climate change, these infrastructures need a great deal of attention to maintain their resilience. Deltares is working on applications for climate-resistant infrastructures. ▶

DELTARES

Problem: climate change is increasingly affecting the functioning of roads, ports and energy networks. Extreme weather conditions, such as floods, drought and extreme precipitation, can jeopardize the safety and reliability of these large-scale infrastructures.

T02 Solution: Deltares offers research and applications to improve the resilience of infrastructure systems. One such application is the RA2CE framework, which focuses on identifying the vulnerability of the most critical infrastructure components and providing action prospects to increase the resilience of infrastructure when needed.

Impact: a secure and reliable infrastructure is essential for our daily lives, a strong economy and the functioning of society.

Thomas Bles, Resilient Infrastructure specialist at Deltares, was stranded in a valley during a holiday in Austria. A landslide had cut off the valley from the world and he was compelled to stay in the apartment for a few more days. It was the first time that Thomas, an expert on climate-resilient networks, realised that reliable infrastructure is not a matter of course. In the Netherlands, too, things sometimes go wrong. In 1995, the A1 motorway was closed for three days due to a huge wildfire. And recently – in 2021 – floods in Limburg caused power failures in several villages and no trains could travel due to flooding.

Resilience

Heat waves, extreme precipitation and drought can jeopardize the functioning of our infrastructure. Deltares offers research and applications for some of these issues. For example, the knowledge institute uses data, measurements and scale models to fathom the mechanisms and to provide effective solutions. In addition, a model toolbox is used to identify which stretches of roadway are vulnerable in the existing and future climate. This is done at various levels, from individual properties and connections to the level of network. "A network approach is important", says Thomas. "A roads network consists of all kinds of links: a tunnel, a viaduct or a road embankment. They are often the individual links that are affected by climate change, such as extreme weather. If one of these links fails – a tunnel that floods with water or a road embankment that subsides – the entire infrastructure will no longer function. That is why it is good to consider the roads network as a whole. The proper functioning of networks is also of importance to be able to respond immediately during and after a disaster by quickly getting aide into the area or getting people out of it."

Climate-resilient networks

If these infrastructure networks fail, even national security could be jeopardized. "Emergency services can no longer function and vital functions such as ports and hospitals can no longer be reached. By investing in climate-resilient networks, we can improve the accessibility and safety of our infrastructure and thus society." One of the methods used by Deltares is the RA2CE framework (Resilience Assessment and Action perspective for Critical infrastructurE), which public authorities and road authorities use to understand the climate resilience of their roads network. "We have applied this method for Rijkswaterstaat, in which the impact of floods, wildfires and other climate events has been assessed for the roads network of the Netherlands. It helps Rijkswaterstaat to address the vulnerabilities when replacing and renovating roads."

"If one of these links fails – a tunnel that floods with water or a road embankment that subsides – the entire infrastructure will no longer function."

Complex systems

The Netherlands must invest heavily in infrastructure over the coming decades and make strategic choices to be well prepared for the future. "We now have the models to analyse the climate resilience of our infrastructures on a network scale. Now it is time to understand the complex interaction between these networks and to learn how climate change affects the liveability and security of society through these complex systems. The next step is actually getting all stakeholders together and overseeing the complexity of these infrastructures", Thomas concludes. ■

Who: Deltares.

Duration: 2019 - ongoing.

Budget: funded by several research and market projects (> 1 million).

Follow-up: in collaboration with Rijkswaterstaat and national and international market parties, we are committed to further developing the RA2CE framework towards operational applications.

What is permitted where in the design of the Netherlands?

New housing, renewable energy, food production, nature, water storage and recreation all make a claim to Dutch space. At the same time, there are boundaries to shaping the Netherlands, as shown by the nitrogen crisis, climate change, declining biodiversity and poor water quality. It is therefore necessary to manage our soil and water better, according to researchers at WUR. ▶

Bas Breman, Project Manager at WUR.

WUR

Problem: the boundaries to the 'makeability' of the Netherlands lead to disturbance of the natural environment and biodiversity. Climate change calls for a different approach.

T02 Solution: WUR is investigating ways to focus on 'water and soil control' in all spatial developments. By using the most fertile soils for food production, building new housing on higher grounds in connection with the sea level rise, as well as switching to other crops, other business systems, and other building methods in certain areas.

Impact: an attractive spatial design of the Netherlands. Exploiting and strengthening the natural system is not only beneficial for the natural environment and biodiversity, but also for people. By planting more greenery in your own garden or on balconies, cities become cooler, more people start exercising and stay healthier.

"God created the earth, except the Netherlands, because the Dutch did so themselves", is a well-known saying. Land reclamation by draining the Zuyder Sea, keeping the water level in ditches at a certain level, tilling the soil for agriculture. "In the Netherlands, certainly in the last 60 to 70 years, we have become very used to manipulating the system to our liking", says Bas Breman, Project Manager at WUR. "That has brought us a great deal, but now we are increasingly becoming aware that we are reaching the limits."

Vulnerability

The flip side of this shaping is a certain vulnerability, Breman explains. "Natural systems have lost much of their resilience. Heavy tilling of agricultural soils happens at the expense of the soil quality and the ability to store water. All interventions to drain the water quickly have caused us to now have a shortage in dry spells." Because of climate change and weather extremes, we desperately need this resilience, he emphasizes, and for this reason it is good to focus on soil and water systems again in all spatial developments. Focusing on water and soil control means that we take the natural system as the starting point for all space claims and spatial developments, such as housing and energy. This includes relief in the landscape, the substrate, the soil, the water system, ecology and land usage. "That is the basis and determines what you can or cannot do somewhere."

Smart environmental management

To do this, we literally have to start thinking and dealing smarter with nature, says Breman: "By using the most fertile soils for food production and building new housing on higher grounds in connection with the sea level rise. Retain fresh potable water wherever possible and switch to other crops, other business systems, and other building methods in certain areas." Using and strengthening the natural system has many advantages, he explains. The planting of different vegetation on dykes not only ensures that these deeper roots strengthen and reinforce the dyke, but also benefit biodiversity. Prolonged water retention in the sandy soils in the stream valleys further increase availability of freshwater, which can ultimately have added value for agriculture as well as for the natural environment. Breman: "People can also strengthen the natural system in their immediate living environment and benefit directly from it. By planting more greenery in your own garden or on balconies, cities become cooler, more people start exercising and stay healthier."

"Now we are increasingly becoming aware that we are reaching the limits."

What is permitted where?

The researcher refers to the report '*Niet alles kan overal*' ['Not everything is possible everywhere'] on the approach to the nitrogen problem in 2020. "The next question is: but what is suitable and where? What is the natural capital in a particular place and how can you link that as best as possible to the current challenges that we as a society are facing? We need food, energy and housing, and we must also combat climate change." His research group has been working for many years on studies surrounding the topics of water and soil control. ▶

WUR

An example is '*De Natuurverkenning*' ['The Nature Survey'], a publication every four years by the Netherlands Environmental Assessment Agency. The latest edition looked at how the Netherlands can become more nature-inclusive by 2050. "Instead of dividing the Netherlands into areas for housing, businesses and agriculture, as we have done over the past decades, we are making nature more emphatically part of our environment", he explains, "and with that, we are also using its resilience for challenges such as climate change." Breman's colleagues also developed the map 'The Netherlands in 2120'. This is a vision of what our country can look like in a hundred years' time if nature is taken as the basis of spatial planning and what choices we have to make now.

Increasing interest

Using a water and soil basis to design the land is already happening on a small scale, but it is a challenge to scale it up, Breman has noticed. Interest has been growing since the topic was mentioned in last year's Letter to Parliament from the Ministry of Infrastructure and Water Management as being 'a very important starting point', and it is also a key principle within the new National Programme for Rural Areas. "Many government agencies are inspired by our research and want to do something with it", he says. "Companies have also realised that they should do something about this. For example, banks, project developers or construction companies. In consequence to the map 'Netherlands in 2120', we received hundreds of requests to give presentations."

Sticking their necks out

For this redesign, he also says that new things must also be tried out, experiments for which people stick their necks out. For example, rice cultivation in peat meadow areas with high water levels. "It is not yet certain whether there is a business model for this and there will undoubtedly be counteractions from the social environment. How can you deal with that?" Here, the WUR's slogan 'Finding Answers Together' is appropriate, he says, because: "We have a great deal of knowledge, but we don't know everything either. We are able to provide guidance in these kinds of social quests and help in seeking solutions based on different perspectives to start a dialogue, about what does or does not work."

Far-reaching but necessary

To do things differently when it comes to aspects like eating, living, building or running a farm, is of course quite drastic and Breman therefore stresses the importance of engaging with the people involved in the process. Jointly understanding how the natural system works, exploring new land usage, new business models, but also looking at how certain ingrained patterns of behaviour can change and to accept that some things simply cannot go on like this any longer. This societal side of things is sometimes forgotten and is perhaps the greatest challenge." This redesign of the Netherlands is far-reaching, but has many advantages, Breman summarizes. Besides, if we don't do it, we'll be even worse off. "By protecting and strengthening our soil and water systems, we will keep nature and agriculture healthy and we can literally and figuratively reap the benefits." ■

Who: WUR

Duration: the research group conducts various studies on this topic.

Follow-up: ongoing research, including through a National Growth Fund application NL2120.

Good seeds produce a better harvest

No less than one in ten people worldwide do not have enough to eat. Access to quality seeds of crops and varieties that have been adapted to local conditions is important to increase crop yields and food production in Africa. How is the WUR making improvements in the seed production sector? ▶

Marja Thijssen, Senior Seed Consultant at WUR.

WUR

Problem: rapid population growth, climate change and low crop yields in Africa threaten food and nutrition security in the world.

T02 Solution: WUR is working to improve a well-functioning seed production sector as a contribution to sustainable and higher agriculture and food production. This is done through a sector-based approach: researchers are working in partnerships on the study and implementation of technical innovations, but also on better coordination and seed policy.

Impact: on a worldwide scale, this leads to higher food production and greater food security. In Ethiopia, for example, new varieties have been introduced into the agricultural system, which has increased local food production.

In recent decades, much has been invested in the development of new varieties of important agricultural and horticultural crops, but it is often not yet possible to get these varieties to the farmer. From the start of the development of a new variety to the use of that variety's seed by the farmer other parties are involved, each of them having their own expertise and interests. In addition, each crop needs its own approach. WUR researchers work together with public authorities, research institutes, companies, NGOs and farming organisations to ensure that farmers in Africa get better seeds. This is done through a sector-based approach: they work in partnerships on the study and implementation of technical innovations, but also on better coordination and seed policy.


Marja Thijssen

Strategy development

"It all starts with the development of a common vision and strategy for the seed production sector", says Marja Thijssen, Senior Seed Consultant at WUR. She and her colleagues created a 'National Seed Roadmap', a document to support policy makers and companies in a coordinated and structured way in strengthening the sector. On this basis, she collaborated with Dutch public authorities and the business community on a programme to improve the quality of the seeds in Nigeria. "We then, together with Dutch organisations, established which priorities we are able to contribute based on Dutch knowledge and expertise," she says. This resulted in a Dutch-funded seed programme that is coordinated by WUR. Based on these and similar experiences in Ethiopia, Uganda, Mali and Niger, Wageningen scientists decided to create a guide for the development of national seed roadmaps.

Pivotal role

In national seed programmes like in Nigeria and Ethiopia, WUR plays a pivotal role as a knowledge partner, also to match up science and practice, to introduce innovative approaches, to support action research and to link local African and Dutch seed experts, organisations and companies to each other. Thijssen: "In Nigeria, we work in conjunction with researchers, companies and farmers to find out what is preventing the use of improved seeds, varieties and cultivation methods of vegetable crops. We test new approaches to accelerate the registration and acceptance of new varieties into the market and to strengthen the capacity of local companies to promote new varieties." Thijssen and her colleagues collaborate a lot with international research teams. For example, they conduct research into the effectiveness of seed policy, farmer access to genetic diversity in relation to climate change, and access to seeds in emergency situations such as conflicts and war. For example, last year they organised a major conference in Rwanda on the future of the seed production sector in Africa. There, 170 people in the sector gathered to endorse new insights and approaches, and to discuss priorities and ambitions. "We can achieve the goal of increasing farmers' access to quality seeds in various ways", says Thijssen.

Higher production

What have all these efforts achieved so far, for example in Ethiopia, where the research group has been working already for thirteen years? "We have introduced more than 170 varieties to the men and women in farming households. Over a period of four years, more than four million farmers in Ethiopia were given access to quality seeds," says Thijssen. "This increased local food production." ■

View the videos here

Who: WUR

Duration: ongoing.

Follow-up: with local partners and financiers, there are ongoing projects to increase food security by way of better seeds.

Idse Hoving of WUR.

Farmers cause less peat degradation with high water levels

Peat soils in the Netherlands subside by about half a centimetre to one centimetre per year. This not only results in skewed houses and frequent ditch level reductions, but also to additional CO_2 emissions due to peat degradation. WUR is researching how higher water levels reduce CO_2 emissions and how dairy farms can adapt to such change. ▶

WUR, Deltares

Problem: the subsidence of peat areas in western and northern Netherlands frequently requires ditch level reductions and CO_2 emissions due to peat decomposition.

T02 Solution: saturation, thus wetting the soil, helps to counter soil subsidence and CO_2 emissions. WUR is conducting research into how peat bogs can continue to function properly with the help of water infiltration at high groundwater levels.

Impact: the aim of the research is to lower the groundwater level to twenty centimeters below ground level in the summer and to see what the impact is for farmers. It is estimated that this could reduce peat decomposition by three quarters, which would also significantly reduce CO_2 emissions.

Parts of Western and Northern Netherlands consist of peat grassland areas, a type of soil formed by decayed plants in marshes. "For many of these areas, their drainage in the 1960s and 1970s was increased by reducing the level of water level in ditches. This resulted in degradation of the peat, causing the soil to settle and subside," says Idse Hoving, researcher of livestock and water management at WUR. Once every few years, the water boards review the water level, but this is increasingly becoming more expensive due to soil subsidence, he explains. Costs for dewatering and draining the water are increasing.

"Saturation, thus wetting the soil, helps to counter soil subsidence and CO_2 emissions."

Additional soil subsidence

Peat degrades because oxygen gets to the decayed plants. "As a consequence, the soil subsides", Hoving continues. "Saturation in particular protect peat soils against oxygen penetration. Degradation accelerates due to low water levels in ditches, but also due to drier spells as a result of climate change. CO_2 is released in this process, which is precisely what we want to prevent, to combat climate change." Saturation, thus wetting the soil, helps to counter soil subsidence and CO_2 emissions. Many dairy farms are established in peat grassland areas and the question is to what extent can saturation be stretched. Grasslands must not be allowed to get so marshy that farmers can no longer render it usable for cows and machines.

Farmers dealing with high water levels

"Severe saturation calls for a change in the farmer's business operations", says Hoving. Together with various partners, he is conducting research at the high groundwater farm in Zegveld in the province of Utrecht into how dairy farms can operate with very high groundwater levels. "Farmers are likely to be able to produce less grass per hectare than they do nowadays, which increases costs", says Hoving. It is important to quantify the impact on business operations so that the economic disadvantage can be calculated. It is up to managers to decide how to proceed with this.

Water infiltration

At the high groundwater farm in Zegveld, the water in ditches is kept at twenty centimetres below the surface level and water infiltration also takes place. Perforated horizontal pipes spaced four metres apart allow water to flow out of the ditches into the soil to additionally raise the groundwater level. Water infiltration is Hoving's speciality: he looks at how you can do this as best possible and what the effects are on the groundwater level during the summer. The aim is to bring the groundwater level in peat grasslands to twenty centimetres below ground level – it is currently at an average of around sixty centimetres in summer and can drop to more than a metre during long dry spells. "We expect that with a groundwater level of twenty centimetres below ground level, the peat degradation will be a three quarters less than it is today." The high groundwater farm is also one of the locations of the National Research Programme for GHG Peat Grasslands of the WUR, Deltares and other research partners. The partners of this project measure the impact of groundwater levels on CO_2 emissions for plots with and without water infiltration. ■

Who: WUR, Deltares.

Duration: ongoing.

Follow-up: this project is part of the Veenweiden Innovatie Programma Nederland (VIPNL). The greenhouse gas measurements take place from the National Research Programme GHG Peat Grasslands and 'Region Deal – Soil Subsidence Green Heart'.

DELTARES / TNO

Jointly accelerate disconnection from natural gas supplies with *Nieuwe Warmte Nu* [New Heat Now]

How can we heat up houses and buildings without natural gas? And how do we take that step towards becoming free of natural gas as soon as possible? The *Nieuwe Warmte Nu* programme, with subsidy from the National Growth Fund, brings together twelve flywheel projects and six innovations to implement sustainable, collective heat systems and to gather and share knowledge about them with future projects. The impact is huge: subsidised with EUR 200 million from the National Growth Fund, *Nieuwe Warmte Nu* can disconnect 26,000 houses and buildings and 800 hectares of greenhouse horticulture from natural gas supplies.
Deltares is part of the consortium and is the driving force of the learning and development programme, which shares knowledge and experiences with future projects. In addition, Deltares is involved in two innovations: improvement of the Heating Grids Design Toolkit and improvement of well designs for large-scale seasonal storage of heat – High Temperature Storage.
The heating systems are achieved using renewable heat sources such as geothermal energy, waste heat and aquathermal energy. The projects include various forms of ownership and management of the heat systems. Sometimes heating companies or grid operators are the initiators and in other projects it could be a municipality or a local district cooperative.

nieuwe warmte nu

More information?
www.nwn.nu

One of the small electrolysers.

TNO

200x less iridium in electrolysers

Green hydrogen, produced by means of electrolysis using solar and turbine-powered electricity, will play an important role in the transition from fossil fuels to renewable energy. The propagation of green hydrogen from 300 megawatts of worldwide electrolyser power set in 2020 to dozens or even hundreds more gigawatts in 2030, has a downside. It means a proportionally growing need for scarce iridium for the electrolysers to be built. Previous research by TNO shows that the scaling-up of electrolysers, particularly the PEM type (Proton Exchange Membrane), is in jeopardy due to the modest availability of scarce materials. “In ten years' time, the demand for iridium will far exceed the quantities available. Moreover, we depend on only a handful of countries for the supply, with all the risks that this entails”, says Lennart van der Burg, Cluster Leader for Green Hydrogen at TNO. Researchers at TNO have succeeded in developing a method that requires 200 times less iridium, which already enables a performance of 25% to 46% of the current generation of electrolysers being achieved. Researchers at TNO who specialise in electrolysis, are working in the Faraday Lab in Petten, together with colleagues from TNO Holst Centre in Eindhoven, on the further development of this technology.

MARIN

Database for alternative fuels

Together with the European Sustainable Shipping Forum (ESSF), MARIN has developed the Sustainable Power portal, an online database which aims to provide an as complete and comprehensive overview as possible of alternative, sustainable fuels (such as ammonia, methanol) and power systems for ships. The portal allows users to view various graphs and representations of data. It provides an overview of existing knowledge on the performance and possibilities of various alternative technologies for renewable energy and energy conversion for shipping. MARIN wants to use this portal to help the marine industry make efficient and feasible choices to quickly reduce their carbon emission levels. The project was created by the ESSF and its Sustainable Alternative Power for Ships (SAPS) task force, who consults and exchanges knowledge with the European Commission. The task force comprises experts from all over Europe, from energy suppliers, ship owners, shipyards and port authorities, to classification societies, engine manufacturers, producers of energy carriers and NGOs.

More details:

WUR

Better understanding of the role of the landscape in the event of bird flu

Landscape elements, type of business, and geographical location play an important role in contamination with bird flu at poultry farms. These factors may make it attractive for contaminated wild birds to seek or specifically to avoid the immediate surroundings of poultry houses. This is apparent from an analysis carried out by WUR. The institute studied the data of outbreaks in the period 2014-2022. Of the various poultry farm types, duck and turkey farms have the highest risk of bird flu, and broiler farms have the lowest risk. In addition, there is a greater risk of bird flu as the surface of water near the poultry farms increases and the distance from the poultry farm to the water decreases. The greater the surface area of grassland surrounding the poultry houses, the greater the risk of contamination.
The geographical location of poultry farms in the Netherlands is also important. The risk increases from east to west and from south to north. This probably relates to the frequent presence of bodies of water in the Western and Northern Netherlands. This knowledge can help in the choices to be made in the agricultural transition.

TNO

New method for measuring young children's development

A good development in early childhood has a positive effect on the rest of life. Global Scales for Early Development (GSED) is a new method of assessing the development of children aged up to 36 months using measurements that are culturally neutral, easy to apply, freely accessible and understandable for carers and children. TNO forms part of the team who developed the GSED package. By means of the 'Developmental score' (D-score), TNO provided the backbone for the GSED. The D-score is a universal measure that reflects a child's development as a unit of measure, such as metres for height and grams for weight. When calculating with the use of the GSED package, different development areas such as cognition, language, motor skills and socio-emotional skills are shown in a single number. The D-score allows comparisons between countries and groups of children, even if the data collection uses different measuring instruments. In addition, the score can show the effect of measurements to improve the development of children. The good results led the World Health Organisation (WHO) to launch the GSED in February.

TNO

StreetWise to validate safety of autonomous transport

Safety is crucial in the development of self-propelled vehicles. But testing and validating autonomous vehicles is time consuming and costly. TNO has developed a methodology called StreetWise, to test and validate complicated automation and driver assistance systems. A high volume of traffic scenarios and test cases has been distilled from real-world vehicle data which are suitable as scenario simulation data. Assisted by StreetWise, Automated Driving Functions are extensively tested against a wide range of realistic traffic situations. An innovation that has brought the safe introduction of self-driving cars a step closer.
Torc Robotics, a subsidiary of Daimler Trucks and a trendsetter in automatic driving applications, uses StreetWise to prepare self-propelled trucks for all possible traffic situations that may occur. The driving data of trucks is analysed and categorised in scenarios using StreetWise. For example, Torc can collect scenarios to conduct extensive virtual testing of autonomous technology according to the latest international safety guidelines and protocols.

TNO

Ultrasonic patch replaces hospital visit

An ultrasound is usually performed by an expert sonographer in a hospital to visualise the condition of the heart or circulatory system. In view of the rising costs of healthcare and the increasing staff shortages, there is a need for solutions that the patient can perform at home.

TNO has developed a technology in which a flexible patch on the skin creates images with ultrasound of the organ to be examined over a longer period of time. This eliminates having to go to the hospital for extensive examinations because the patient can be followed at home. The technology called PillarWaveT™, has been patented and TNO is negotiating with manufacturers of medical equipment to launch it in the market. There are innumerable applications. Where measuring blood pressure or a heart rate is often a snapshot, wearing a patch offers an image over a longer period of time. This results in a much better diagnosis and can even prevent unnecessary operations. As a consequence, this examination is not only more pleasant, but also better and cheaper.

NLR

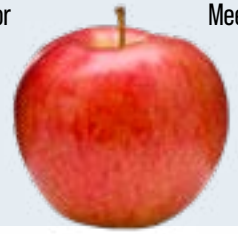
Fewer delays and nuisance at and near airports

Congestion at airports have been quite newsworthy of late. However, it's not only the number of passengers that causes congestion, the sky overhead is congested too. To make aviation cleaner and quieter, in the European SESAR2020 ITARO project, NLR has combined several individually studied solutions in an operational concept that improves the operational planning of the Air Traffic Management (ATM) system.
This integrated concept has been tested in NLR's ATM simulator and has, among other things, allowed air traffic control to place aircraft on fixed arrival routes with a continuous descent approach as efficiently as possible, while maintaining a safe minimum distance between the aircraft.
In addition to carrying out simulations, and together with the German Aerospace Center (DLR), NLR tested a system at Groningen Airport Eelde to maintain an agreed distance (time interval) more accurately between two aircraft during their approach to the airport. Various scenarios were tested. This technology will lead to improved capacity solutions because aircraft will be less likely to deviate from their preferred flight path. This not only reduces fuel consumption and noise nuisance, but also maintains the number of aircraft that can be handled at peak times.
The ITARO (integrated TMA, airport and runway operations) project has been finalised in the meanwhile. The SESAR (Single European Sky Air traffic management Research) programme now determines how to proceed further.

WUR

Healthier food in care and hospitality industry

Healthier and more sustainable supply of food in the care service and hospitality industry lead to more satisfied clients and guests as well as more motivated employees. This is one of the most important conclusions of the 'Healthy food in the care service and hospitality industry' research report. Many people want to eat healthier and more sustainable food. But, in practice that is not so easy, especially if people live in a care facility or depend on the hospitality industry to cater for meals. Together with other parties, Wageningen University & Research conducted research into this. The researchers went to care institutions, catering establishments and daycare centres, to discuss various aspects, share ideas and organise workshops. In conjunction with those involved, they implemented measures to offer healthier and more sustainable food. In doing so, they looked into the effects of food choice behaviour of guests, clients or children/pupils, as well as the possibilities for caterers to implement an intervention. "To achieve a different consumption pattern, it is important that there is more appreciation for the alternative. Greater customer satisfaction is also important because both care staff and catering staff working in the hospitality industry get a great deal of satisfaction from making the people they serve happy," says Project Manager Marieke Meeusen of WUR.



More details:

TNO

70% more energy with new battery technology

Batteries are becoming increasingly important in our society. They can be found in mobile telephones and electric cars and, in the long term, in storage systems for renewable energy. With the increasing use of batteries, requirements such as faster charging, more energy storage and a lower carbon footprint are also becoming important. For ordinary lithium-ion batteries, the anode or negative pole is made of graphite or carbon. A new technique developed by TNO uses copper foil to which silicon, extracted from pure sand, is applied. This new technique allows a battery to store 70% more energy. An entrepreneurial duo took on the innovation, worked out the plan, sought financiers, and within a year the company LeydenJar was a fact. The company now boasts having major suppliers of consumer electronics and car manufacturers as customers.

More details:

DELTARES

Greater need for bathing locations due to climate change

Climate change has an impact on official locations for bathing and open-water swimming. It will lead to a deterioration of the swimming water quality in lakes, canals or ditches. It is expected that in future more pathogens will be present locally in the water, such as bacteria and viruses. After a heavy rainstorm, sewage or dog poop can end up in a ditch or canal, which creates a health risk for swimmers. Higher water temperatures can also lead to an increase in organisms that cause health problems, like the larvae of the *Trichobilharzia* parasite, which lead to swimmers' itch, and like the *Vibrio* bacteria in coastal water. Propagation of *Cyanobacteria*, commonly called blue-green algae, particularly increases in spring and autumn. Suzanne van der Meulen of Deltares conducted research into the quality of open-waters for swimming at 32 popular spots. Climate change is increasing the need of locations for open-water swimming, partly bolstered by population growth and urban densification. According to participants of *Zwemwaterdag* 2023 [Bathing Water Day], the solution lies in expanding the number of bathing locations, preferably in waters that are less susceptible to adverse effects of climate change. Some suggest that a directive should be drawn up to deal with, for example, the distance between housing and bathing spots or the proper spread of bathing water locations; not only on the outskirts of the city but also in the city itself. According to Van der Meulen, it is important to weigh up the various functions of water. Her doctoral research shows that for other uses of urban waters, such as transportation by water and aquathermal energy, demand will increase in forthcoming decades. “If the various functions collide, such as swimmers and pleasure boating, then it must be taken into consideration whether to separate these functions in time or space.”

Refined drug research thanks to heart-lung machine and pig organs

With a heart-lung machine, originally intended for organ transplants, the liver and kidneys of pigs can be kept alive outside the body. This will allow pharmaceutical researchers to determine exactly what is happening with drug candidates in the body. ▶

Lianne Stevens is a researcher at TNO and studies various applications of organ perfusion for drug development.

TNO

Problem: how medicines behave in the human body is difficult to predict, but important for the development of new drugs.

T02 Solution: TNO tests drugs for organs that are kept alive outside the body. For this purpose, TNO uses livers and kidneys from pigs. This enables drugs to be monitored: how are they metabolised in the liver and excreted by the kidneys?

Impact: drug developers can use the results in the preclinical and early clinical phase of drug research. Data on metabolism and excretion, interactions with other medicinal products and determining the correct dosage, accelerate development. The results are easier to translate in respect of humans rather than results from cultured cells or computer simulations and are more detailed than animal studies. Ultimately, this technology also reduces the need for laboratory animals.

Those who swallow pills, activate an entire body mechanism, which metabolises, breaks down, and then excretes the ingested substance. How this works, particularly depends on the active substance: the liver and kidneys process certain substances quickly and others slowly, and some substances are metabolised into other substances with their own effects. Sometimes different drugs interact with each other: they affect each other's effect. "We can study this process very well thanks to organ perfusion", says Evita van de Steeg, Senior Scientist in Preclinical Pharmacokinetics at TNO in Leiden. With the help of a heart-lung machine, normally used for organs intended for organ transplants, researchers keep a pig's liver and kidney alive and functioning for a day. This is long enough to examine how a specific drug behaves.


Evita van de Steeg

Pig organs

"We work with pig organs, because they are very similar in structure and function to those of humans", says Van de Steeg. It provides valuable data for pharmaceutical companies. "You want to establish how long a drug remains in the body, how quickly the amount of medication decreases in the blood, and how it is excreted via urine or faeces", says Van de Steeg. It also allows you to identify potentially harmful interactions to other drugs at an early stage. Pharmaceutical companies are interested in applying this technology in preparation for the first clinical trials in humans. "We started out by purchasing a heart-lung machine in 2018."

Fewer laboratory animals

Offal is used for organ perfusion, which means it is not animal testing. An important advantage of organ perfusion compared to animal testing is the highly detailed data that is obtained in a short space of time. "Concentration levels can be determined at any time and biopsies can be taken from the organ, something that is far more difficult with a living animal." Ultimately, this highly detailed data results in fewer laboratory animals being required.

Another commonly used alternative are laboratory-cultured cells of organs, in other words *organ-on-a-chip*. Van de Steeg: "They are very promising and developing rapidly. TNO is also very active in this field together with research partners, but this has not yet enabled us to mimic a fully functioning organ as we are able to do with organ perfusion. This could be, for example, the network of blood vessels and the many different cell types that are in an organ."

Just like for people

As is the case in the human body, the heart-lung machine pumps oxygenated blood through the organs. The organs are kept alive for about ten to twelve hours for research, but the researchers are working to stretch that time by enhancing the imitation of the biological process. Another perspective for the future is to combine more organs. "We are currently doing the first studies with a piece of the intestine, the liver, the spleen, the pancreas and both kidneys together", says Van de Steeg. This makes the data even more realistic: "It is then possible to follow how the drug is absorbed via the intestine. Actually, exactly as it happens in humans." Together with LUMC Leiden, which has extensive experience with organ transplants, it is also being examined how this can be applied to diseased human organs. This involves for example, a diseased liver that is removed during transplantation. It is being examined what the effect is of a disease process in the organ to the behaviour of the drugs. "In this way, we can get a very realistic picture of the effect and clearance (the rate at which a certain substance is removed from the blood by the body) of drugs in the patient", says Van de Steeg. ■

Who: TNO, LUMC, Takeda Pharmaceuticals, other pharmaceutical industry.

Duration: ongoing project within multiple grants, internal research projects and client assignments.

Budget: the research is covered by several ongoing projects, but as an indication, the budget of the collaboration with Takeda Pharmaceuticals was EUR 250,000.

Follow-up: perfusion of more comprehensive systems of organs and methods to keep organs alive longer.

Combating IEDs with Augmented Reality

Improvised Explosive Devices (IEDs) are cheap and easy-to-manufacture explosives that cause many victims in conflict zones among both military personnel and civilians. Because of the major impacts that opponents can achieve with this, they are widely used and evolve rapidly. This not only makes combating them challenging, but all the more significant. NLR developed technology to bolster this combating. ▶

NLR

Problem: Improvised Explosive Devices (IEDs), improvised explosives, are major hazards in conflict zones. They cause severe injuries to personnel and damage to materiel, and restrict the freedom of movement and mobility of military units.

T02 Solution: NLR is collaborating with Defence on Spatial Computing technology, including Augmented Reality, to improve the collection, analysis and sharing of information during military operations.

Impact: the technology not only increases the safety of military personnel in conflict zones, but also has applications in urban environments where criminals can carry out attacks using IEDs.

In order to identify the terrorist networks responsible for these IEDs, military units collect and analyse as much information as possible. This process is also called Technical Exploitation (TE). Technical exploitation is somewhat similar to forensic investigation with specific military characteristics. As with forensic investigation, forensics are collected in the field, which are then analysed further in a laboratory. "In military situations, there are major time constraints and work is done close to the front line, for example in deployed laboratories. The closer you are to the front line, the sooner you will have relevant information. This makes it possible to correlate new links quickly. In addition, these can be distributed sooner, to better support decision-making processes," says Roy Arents, Engineer Simulation & AR/VR Expert at NLR.

Spatial Computing

In practice, the collection and sharing of information is not always easy. This can be improved, by simplifying communications between TE experts and making knowledge and resources available closer to the front line. The ARTEX (Augmented Reality for Technical Exploitation in Counter IED-operations) project explores whether and how Augmented Reality (AR) and other so-called Spatial Computing technology can improve and accelerate the TE process as a whole. AR adds a layer of virtual information to the 'real world'. Because AR devices, such as smartphones but also in the form of spectacles, are 'aware' of their position and orientation in the environment – with high precision both outdoors and inside – the virtual information can be integrated with the real world. This category of smart devices that know precisely where they are in the environment, is also known as Spatial Computing Technology. This includes satellite navigation, which we put into practice on a daily basis. With interchangeable hardware and software components, such as sensors and smart algorithms, many new applications are possible, so too within the realm of TE.

Demonstrators

NLR has combined and developed these components in collaboration with the Ministry of Defence in what is known as 'demonstrators'. ▶

Roy Arents, Engineer Simulation & AR/VR Expert at NLR.

"In military situations, there are major time constraints and work is done close to the front line, for example in deployed laboratories."

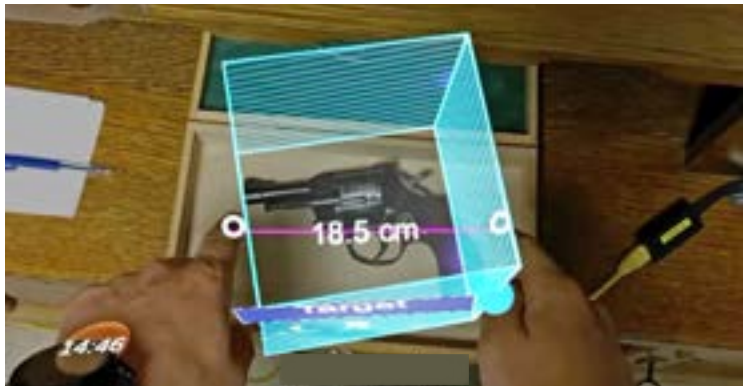
NLR

"After further development, the technology can be deployed in a war, but also in a city where attacks with IEDs take place."

These contain various functionalities that can be evaluated by the operational experts at Defence. One of the functionalities focuses on the TE specialists in search teams who are responsible for the identification and collection of objects, by enabling them to jointly construct a 3D floor plan of a building in real time. "In this way, we improve their spatial awareness and communications within the team. The team coordinator can see the building's floor plan being constructed on a laptop, making it immediately clear where team members are located and any concealed spaces can be seen where IED components, clues or evidence may be lodged. By storing all this information, the context regarding found relevant objects is safeguarded. This will allow laboratory specialists to further analyse the information previously collected by their colleagues, and possibly go back virtually to the relevant moment including all the context. A picture is worth a thousand words, video is often worth even more: we offer a shared interactive AR environment. Arents: "We have noticed that communications can always be better, within TE too. In practice, investigators in a laboratory must draw conclusions about the information that military personnel have found on site and then pass it on to other military personnel who use it for decision-making and risk assessment purposes, for example. They don't always talk on the same level, and we want to improve that situation with this AR and Spatial Computing technology. This will help them understand each other better."

Military personnel and civilians

In 2023, routine testing will take place and in early 2024, ARTEX will be part of a US military exercise. "We will then test the technology further." Ultimately, this must lead to a safer environment for both military personnel and civilians. "After further development, the technology can possibly be deployed in the war in Ukraine, but also in a random city where attacks with IEDs take place." ■



View the video here

Who: NLR, Ministry of Defence, Defence Science & Technology, Defence Expertise Centre Counter-IED,

Duration: 2.5 years with extension in 2024.

Budget: EUR 1 million.

Follow-up: in 2023, routine testing will take place, in early 2024 ARTEX will be part of a US military exercise to test the technology and to achieve an actual implementation of this technology.

Tackling loss of containers at sea

Transport vessels lose hundreds of containers every year. This is hazardous and harmful, which is why MARIN, together with the shipping industry, wants to identify and tackle the main causes of container loss. Two culprits are resonant and parametric rolling, hazardous motion conditions in which ships can lose many containers in one fell swoop. ▶

Jos Koning of MARIN.

MARIN

Problem: on an annual basis, transport vessels lose hundreds of containers. If containers break loose, it is hazardous for the crew and passing ships. They also pose a threat to the environment. The containers are difficult to recover and their contents – which can also be hazardous – spreads across a vast area.

T02 Solution: MARIN has identified various causes of container loss, such as the loading plan and the condition of the containers themselves, checks carried out on them and the offshore conditions. In particular, two specific conditions of motion can have a major impact on vessels and container vessels: resonant and parametric rolling.

Impact: the number of incidents can be reduced through improved limiting conditions regarding planning, loading and inspection prior to departure. Moreover, adding mandatory and certified warning devices on the ship's bridge. This enables MARIN, together with the shipping industry, to identify and tackle the main causes of container loss.

Annually, transport vessels carry around 250 million containers from A to B across the world's seas. Of that astronomical volume, 661 containers were reported as being 'lost' last year, which is less than 0.00048%. "From a financial and economic perspective, this is almost negligible. And so, hardly a problem," says Project Manager Jos Koning of MARIN. "But if you look at the actual number of containers, a completely different picture emerges. A modern container measures forty feet, or twelve metres in length. That would be like a container train of eight kilometres, travelling into the ocean annually."

MSC Zoe

Containers that become dislodged, eventually cause containers being tossed overboard and posing all kinds of risks. "First of all, there is the danger to the ship's crew", says King. "They can be hit by a falling container. Besides, the contents could sometimes be chemical or a fire hazard. Once the containers hit the water, there is a danger of passing ships colliding with them. And finally, there are the detrimental effects to the environment. The containers are often difficult to recover, and their contents can also be spread across a vast area. In some cases, you can rightly speak of an environmental disaster."

But how are containers tossed overboard? That is exactly what MARIN wants to find out in the TopTier Joint Industry Project (JIP). To answer this question, researchers carried out a comprehensive analysis of incidents in which ships lost containers. "This shows that the lion's share of container loss is caused by major incidents involving hundreds of containers being tossed overboard in one fell swoop", says Jos. Take for example, the MSC Zoe accident, which lost no less than 342 containers north of Ameland in the night of 1 to 2 January 2019. A year later, the mega-container ship ONE Apus lost about 1800 containers in the Pacific. And in 2021, Maersk Essen lost about 750 containers in the same area. ▶

A test set-up at MARIN.

"A container train of eight kilometres, travelling into the ocean annually."

MARIN

Bouncing

"Assuming that we can identify the causes of these major incidents and prevent them from now on, then we've taken a giant step in reducing container losses", says Jos. And, as it turns out, the majority of these accidents are caused by two specific roll motions of the ship that can occur all of a sudden under exceptional conditions, namely: parametric and resonant roll.

"Resonant roll occurs when a ship is continuously struck by waves at a frequency to which it is super sensitive. It's like sitting in a car that drives over a ridgeline pattern that makes it bounce increasingly faster," explains Jos. "Parametric roll is a motion pattern in which the waves usually come straight towards the bow or stern and where you do not expect any yaw angles. But, through a link between the length of the waves and a roll period several times longer, the ship becomes unstable and sensitive to such roll. Extremely treacherous, because roll motions up to thirty degrees can occur out of the blue."

Ship's bridge

The problem with both motion conditions is that they seldom occur, which means that ship crews have little practical experience with them. "That is also part of the solution", says Jos. "More attention must be paid to this in the training. In addition, information must be available on the ship's bridge to help identify these motions in a timely manner. There are instruments for this, but they are not mandatory." Fortunately, the recommendations of the project group – which largely includes the shipping industry – are well accepted by the International Maritime Organisation (IMO), so Jos certainly foresees improvements in this area. "Nowadays, the sense of safety on ships is mainly 'rule based': it is safe if you comply with the rules. We hope that our project will contribute to more active safety management", says Jos. "Not only complying with the rules, but also actively monitoring that you are still safe." ■

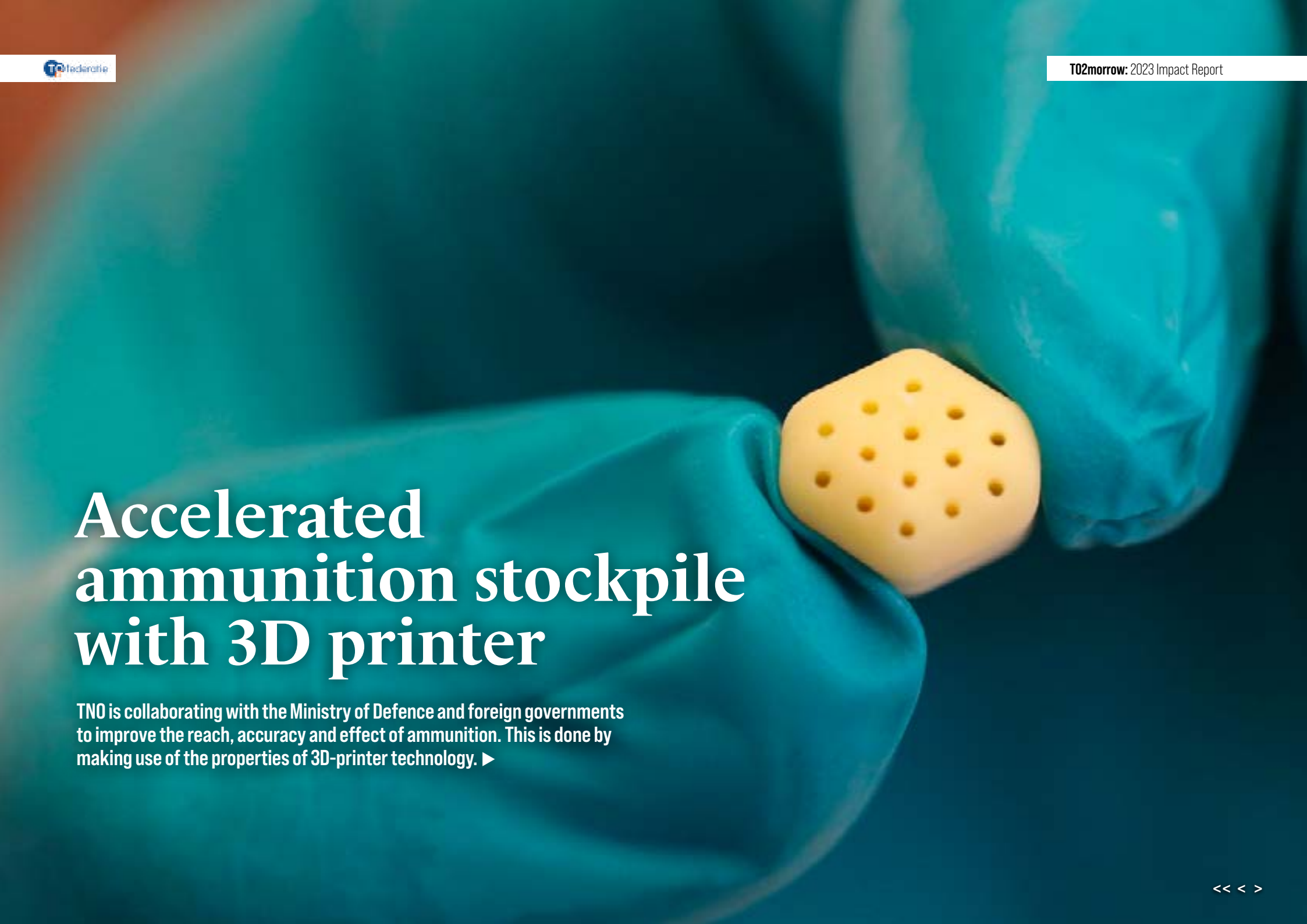
"It's like sitting in a car that drives over a ridgeline pattern that makes it bounce increasingly faster."

View the video here

Who: forty participants were involved in the project, including governments and industry. These include three national governments, ten shipping companies, seven classification societies, five suppliers of lashing materials to secure containers, insurance companies and providers of systems and services to support the crew on board.

Duration: the project started in 2021 and will run to the end of 2024.

Budget: EUR 3.9 million, contributed by private and public parties.



Accelerated ammunition stockpile with 3D printer

TNO is collaborating with the Ministry of Defence and foreign governments to improve the reach, accuracy and effect of ammunition. This is done by making use of the properties of 3D-printer technology. ▶

TNO

Problem: there is a major worldwide shortage of ammunition capable of increasing performance. Existing ammunition production methods are obsolete and raw materials are scarce or not available due to geopolitical or environmental reasons or simply because suppliers no longer produce them. It forces countries to ensure that their armed forces are optimally equipped to defend themselves, both now and in the future.

T02 Solution: TNO is developing 3D-printing technologies that make energetic materials (propellant, explosive and pyrotechnic substances for ammunition) into energetic products that perform better than conventional ammunition.

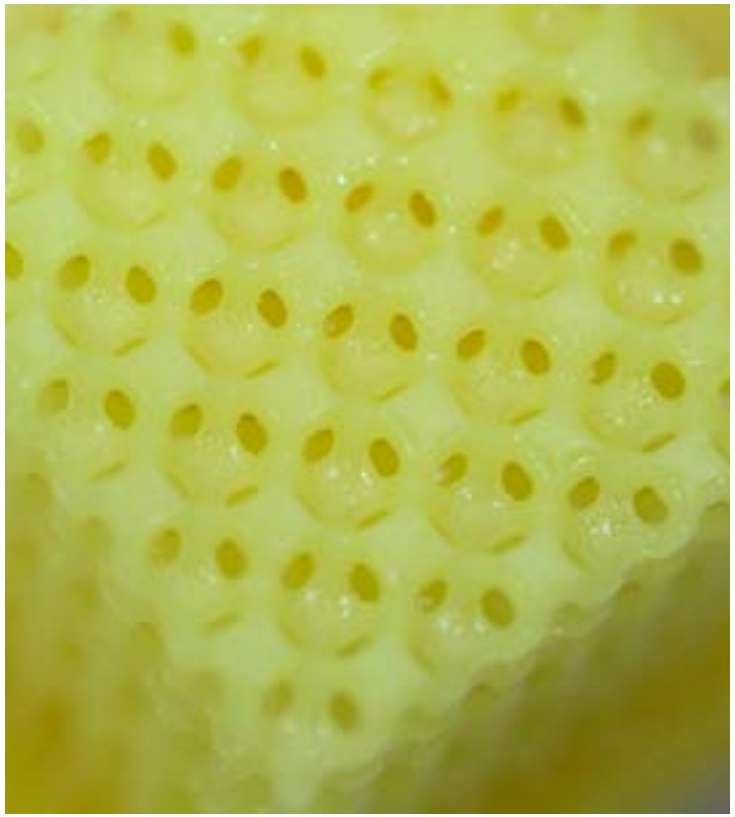
Impact: the developed production method is safer than conventional methods. More will be possible with the weapons systems and this will help (Western) countries to better arm themselves for global tensions.

The war in Ukraine has already confirmed that there is a massive ammunition shortage in the world. Ingredients for ammunition are scarce, such as materials like the widely known TNT. The reasons for this are geopolitical developments, environmental regulations and industrial consolidation. Many years of austerity have led the defence industry to move from a large number of companies to a small number of monopolies. "The latter only want to do the things they can safely earn a big margin on. It is for this reason that a lot of chemicals that we need are not being produced at this point in time", says Senior Business Developer Joost van Lingen of TNO. "Conventional production of ammunition is at the end of its development cycle. Existing production methods date from the Second World War and leave little room for further development."

Burn rates

In 2013, TNO started conducting research into 3D-printing technology as a new production method for energetic materials, such as weapons propellants, missiles and explosives. At the same time, research has been conducted into energetic materials with the aim of making them suitable for processing with 3D-printing technology.

The great advantage of 3D-printer technology is that it can print complicated shapes of gradients. Those gradients consist of several layers of different energetic materials, each having their own burn rate. "With conventional artillery weapons, the gunpowder burns, leading to pressure build-up behind the projectile and shooting the projectile out of the barrel. The barrel's strength determines the maximum pressure that must not be exceeded. When using classic gunpowder grain geometry, the maximum of this pressure will only be achieved for a fraction of the time. If the burn behaviour of the gunpowder grains can be adjusted, the pressure can be maximised over a longer period of time and thus shoot the projectile with more force, or you can choose to reduce the pressure so that the barrel will wear less quickly. Rocket engines can also be set up in the same way. In many cases, missiles have a fixed speed. By using various burn rates in the material, the missile can be accelerated or vastly deceler- ▶



"The combination of two printing techniques ensures even better performance of the ammunition."

TNO

ated in a final attack phase. Because of the unpredictability, these missiles are more difficult for conventional air defence systems to intercept."

Medium and large calibre

The technology not only focuses on the medium and large calibre weapons systems from 20 mm to 155 mm, but also on mortars and missiles. TNO is a worldwide leader with this technology. "We have been working on energetic materials for seventy years and printer technology for the last twenty-five years. Our strength lies in the pooling of this knowledge." In 2022, the knowledge institute started to work with students on combining two printing techniques, allowing for high resolution printing with high energetic materials. "That ensures even better performance of the ammunition."

Performance

This is what TNO is focusing on: optimising the performance of the gradients in energetic materials. TNO is already being engaged by the ministry of Defence and companies in the defence industry to further develop pyrotechnic substances. "In the last twenty years, worldwide focus has been on making ammunition safer. Hence, the performance came under pressure. Making use of 3D-printing technology is a step towards higher performance." In countries like the United States, public authorities are already experimenting with 3D-printing technology, but industry is still lagging behind. "Companies must set up a qualification process to ensure the safety of ammunition. NATO has defined this for every weapons system and that process costs millions." ■

"Because of the unpredictability, these missiles are more difficult for conventional air defence systems to intercept."

The 3D printer.

View the video here

Who: TNO, European partnership AMTEM (Additive Manufacturing Techniques for Energetic Materials).

Lead time: AMTEM's follow-up is from 2023 – 2027.

Budget: the project consists of individual projects, totalling EUR 1.5 million.

Follow-up: In the coming years, TNO will focus on optimising the performance of the gradients in gunpowder.

Norwegian-Dutch nano satellites enhances safety to a higher level

In January 2023, the Ministries of Defence of the Netherlands and Norway launched two nanosatellites that can very precisely detect and locate radar sources on Earth. The countries cooperate with TNO, NLR and the Norwegian FFI within the MilSpace2 programme for military use of space. TNO developed the satellite duo's sensors and this was a first for the institute. ▶

TNO, NLR

Problem: Defence Vision 2035 states that outer space above our Earth has become a necessary link for information-driven action by armed forces. Defence is increasingly making use of satellites, for example for navigation and communications systems.

T02 Solution: Defence develops and launches its own satellites in collaboration with Norway to give effect to Defence Vision 2035. TNO, NLR and the Norwegian knowledge institute FFI designed two nanosatellites that fly in tandem formation. This allows them to accurately detect, classify, and locate radar sources.

Impact: at a European level, countries are seeking ways to pool satellite capacity and to exchange and share information. The Huygens and Birkeland project puts the Netherlands on the map for this type of collaboration. With this knowledge, TNO can advise Defence even better to ensure that outer space remains safe.

There was much enthusiasm at the launch of the satellite at Cape Canaveral, Florida.

The BRIK II satellite that has been orbiting Earth since 2022.

They are called Huygens and Birkeland, the two small instruments that are slightly bigger than a shoebox, which have been orbiting Earth in tandem formation since January 2023. The satellites are named after the Dutch astronomer Christiaan Huygens and the Norwegian physicist Kristian Olaf Birkeland. Their special antennas capture radar signals at a certain angle. The satellites have a small rocket engine that can adjust to keep them spaced apart at a distance of fifteen to twenty-five kilometres. As a consequence, they receive the radar signal with a minor time difference. This allows them to accurately determine the location of a radar source on Earth. Satellites continuously cover a large area from outer space. This offers significant advantages compared to radar detection from an aircraft or a ship, which is random and covers a much smaller area. These two nanosatellites make it possible to map navigation patterns of vehicles onshore and vessels offshore. "This is a step up in complexity in comparison to the first step taken by Defence", says Wouter van der Wiel, Programme Manager Military Operations at TNO. That first step was the BRIK II satellite that has been orbiting Earth since 2022.

TNO's first satellites

This is the first time that TNO has developed satellites from concept to completion. "By tradition, we develop instruments on board other ▶

TNO, NLR

people's satellites, the payload", says Van der Wiel. They focused on the sensor payload this time too, but now they worked closely with both NLR, who designed the satellite platform, and the Norwegian FFI, who was responsible for the ground station and control. "To develop something right from its initial idea to something that really floats in outer space, that is very cool. As an aerospace engineer, you hope that such an opportunity will ever happen." In January 2023, SpaceX launched the satellites from Cape Canaveral in Florida. "It was very impressive to see and especially to hear and feel the sound waves and the power that come from such a rocket."

left to right: Gerhard Reeling Brouwer, Wouter van der Wiel and Michiel Ringers (MilSpace Business Developer).

Collaboration in outer space

Defence Vision 2035 focuses on the development of capacity in outer space. Satellite systems are increasingly becoming essential for navigation and communications, but also for gathering information on potentially harmful activities of countries worldwide. Collaboration with the Norwegian Ministry of Defence takes place under the umbrella of the Strategic Mutual Agreement on Research and Technology (SMART), in which both countries collaborate more closely both technologically and operationally. Gerhard Reeling Brouwer, Technical Project Manager at TNO: "We are involved in the entire mission. All partners jointly monitor the process. So we now know a lot more about producing a satellite and using it. We can make good use of all this extra knowledge for our main task: to advise Defence's Space Security Centre on the use of satellites. This includes how they can combine data with that of other sensor systems and how they can evaluate what other systems are capable of that might pose a threat to the Netherlands."

"Satellites are becoming more affordable and come within reach of countries that have a smaller budget."

Europe

Van der Wiel hopes that there is even more to come: "We continuously take measurements to calibrate the sensors and to improve the algorithms and data processing. We want to learn as much as possible from this to apply in the next satellite, because we hope that the constellation of satellites will be expanded with new ones. Satellites are becoming more affordable and come within reach of countries that have a smaller budget. Other countries are already interested in joining. They see this project as being a success." Reeling Brouwer adds: "Europe is looking for opportunities to combine satellite capacity. This project well and truly puts the Netherlands on the map in this type of collaboration. What started on a whiteboard in 2018, is now something that the Netherlands can use in a European context." Van der Wiel closes by saying: "This seed has been planted and will grow in all directions." ■

View the video here

Who: the Dutch Ministry of Defence, the Norwegian Ministry of Defence, the Norwegian FFI, and Dutch knowledge institutes NLR and TNO.

Lead time: 5 years.

Follow-up: within Defence's aerospace agenda, satellite systems are increasingly becoming essential. TNO continuously take measurements to improve the performance of Birkeland and Huygens. The constellation may be expanded with new satellites. This type of outer space capacity is increasingly becoming accessible to small countries with a small budget.

TO2 Digilab: pooling collective thinking

The Netherlands has evolved through innovations and technological breakthroughs. To ensure this in the future, synergy among knowledge institutes is a prerequisite. TO2 Digilab aims to facilitate the collective brainpower of TO2 institutes, in order to make a substantial contribution to the challenges we face. ►

left to right: Han van Veldhuizen, Marijn Kuijper (Unitmanager Deltares Software Centre) and Hanneke van der Klis make up het digital transformation team at Deltares.

Deltares

Problem: the world is changing rapidly and unpredictability is increasing. Solutions to problems such as climate change or the nitrogen problem are complex and require an integrated approach. How can knowledge institutes collaborate even better on social issues?

T02 Solution: Deltares, together with the other T02 knowledge institutes, want to accelerate digital transformation. To set up a digital facility, a T02 Digilab, is a significant step in this direction. A T02 Digilab focuses on digital innovation, technologies and solutions. It is a virtual collaborative environment in which knowledge institutes – and later public authorities and market parties – have flexible, efficient and secure access to each other's data, algorithms, models and computing capacity.

Impact: a comparable virtual collaboration environment is not yet available. An innovative 'ecosystem' such as the T02 Digilab, enables the knowledge institutes to find even better and more profound solutions to the most complex research issues, such as dyke breaches, promoting cleaner aviation, or guaranteeing food security.

One of the technologies shaking up the world in a big way, is the development of Artificial Intelligence (AI). "Take AI technologies like ChatGPT. A year ago, we couldn't have imagined that this form of AI would play an important role in our lives so soon", says Han van Veldhuizen, ICT Manager at Deltares. With AI, and big data too, cloud computing, robotic technology and 3D printing, technological breakthroughs are rapidly gaining pace. "To maintain our high ranking as a knowledge institute, it is essential that we work data-driven", says Hanneke van der Klis, Digital Transformation Manager at Deltares. "We have been working on this for a long time, and we want to gain pace. Data management needs to meet today's demands, and our software needs to match the new technologies." "It is not just a question of technology", adds Van Veldhuizen, "it is also important to make employees enthusiastic about these new technologies and their application, because it involves a different way of working."

Significance of a strong foundation

In order to shape the digital transformation, it is necessary to get your own act together. Van Veldhuizen: "At Deltares we worked hard to get the basics right. For example, we improved our data management. For each project, we consciously think in advance about which data to use, how to process the data, and which data we will and will not retain. This also applies to the approach to our software development. Instead of moving a member of staff from project to project, we will use a team of staff to develop a software product line over a longer period of time. By focusing on that, we can improve our products. For example, the Ecology and Water Quality software product line team – together with Rijkswaterstaat, provinces and waterboards – formulates detailed goals about where we want to go with the new software over the next five years, and how we will achieve that. These are very definite agreements that we make with each other." ▶

"We want to mobilise the collective brainpower of all the great minds."

Han van Veldhuizen, Hanneke van der Klis and Marijn Kuijper, digital transformation team at Deltares.

Deltares

Agile organisation

Deltares has changed the way it works using the digital transformation; teams are organised differently in terms of composition and with a focus on agility. This enables the teams to respond quickly and effectively to change. Van der Klis: "We have organised the process of digital transformation in an agile manner. Small teams work closely together, achieve results step by step, and set new goals every quarter. The goals are not just about technology. We set up training programmes for our people, in which we also seek cooperation with colleagues from other TO2 institutes and market parties. They face the same challenge to increase the level of knowledge and skills of staff in the field of digital development."

Synergy

To ultimately force the technological breakthroughs that are needed, synergy among various disciplines and expertise is a prerequisite. The digital infrastructure to support this interaction is not yet fully in place. In early 2022, all the TO2 institutes met to discuss what they would be able to do together. This resulted in the proposal to establish a shared digital facility: the TO2 Digilab, a virtual collaborative environment in which different compositions of researchers can work together. Van Veldhuizen: "The TO2 Digilab is a digital facility where we share data, models and computing capacity to mobilise the collective thinking of all the great minds."

Control of own data

Aside from the knowledge institutes, public authorities and semi-government organisations, educational institutions and the business community can eventually be affiliated to the TO2 Digilab. Van der Klis: "A worthwhile aspect is that we can build this digital facility using the expertise of all TO2 partners. For example, TNO has a department that specialises in developing these kinds of platforms. The technology is available, the real challenge however, is to agree about sharing information." Van Veldhuizen: "Every party involved, including market parties who play a crucial role in applied research, prefers to keep control of their own data. We see a great willingness to work together in projects involving several market parties. However, because of trade secrets, not everyone can simply share all the data with others. The TO2 Digilab can provide a solution by making data and models available only under certain conditions and to specific groups. In this way, each party retains control over their own data." ■

"Each party retains control over their own data."

Who: Deltares, MARIN, TNO, NLR and WUR.

Lead time: January 2024 to December 2025.

Budget: EUR 10 million over the next two years, EUR 2 million per TO2 institute.

Follow-up: the knowledge institutes want to launch the TO2 Digilab and data sharing in early 2024. The second phase is to add computing capacity, expected in 2025, so that knowledge institutes can use each other's analysis and modelling techniques.

F-series marine propellers are all about efficiency

An oil tanker has difficulty decelerating, which is an almost proverbial fact. Once such a huge ship is up to speed, the aim is to reach the destination using the least amount of fuel and emitting a minimum of carbon dioxide. A tailor-made marine propeller plays a crucial part in this. MARIN has worked with partners to develop a series of marine propellers, the F-Series, which offer high efficiency and meet the requirements for noise, vibration and erosion resistance. ▶

Jie Dang, F-Series Project Manager at MARIN: "Our testing methods have been significantly improved since the introduction of the B-series."

MARIN

Problem: due to the energy transition and to meet the climate targets, marine propellers must operate as efficiently as possible to minimise fuel consumption. At the same time, they must meet more stringent requirements in terms of noise nuisance and comfort levels. How can you find the right balance?

TO2 Solution: MARIN has developed one hundred and fifty unique variants of 'fixed pitch propellers', and tested them thoroughly. All performance data is accessible in a database where a shipbuilder can search for the optimal propeller design for the type of vessel. In doing so, the designer can take into account various requirements, including efficiency, noise reduction and vibration control.

Impact: early in the design stage, shipbuilders and propeller manufacturers can save time and costs by weighing up design risks more thoroughly. MARIN is currently testing an FC series, where C stands for comfort: these propellers produce less noise, which is a strain on both the crew as well as on marine life.

For large cargo ships, but for ferries and cruise ships too, the main goal is to reach the next port as efficiently as possible. A fixed pitch propeller (propeller with blades fixed to the hub) is the best way to do this. MARIN has recently developed and tested an entirely new range of this type of propeller: the F-Series.

Extensive testing

"The F-Series replaces the previous B-Series, which was the worldwide standard for the shipping industry for more than 50 years", says Jie Dang, F-Series Project Manager at MARIN. In the meantime, the requirements have been tightened, so that the ship's crew should not be unduly affected by vibrations and noise nuisance on board. In addition, technology has evolved further, allowing e.g. for the risk of erosion due to cavitation being better controlled.

The team has designed a total of one hundred and fifty different scale-size model propellers, which vary in blade numbers, blade surface and pitch (the angle at which the blade is seated on the hub). After that, these scale-size models were subjected to rigorous testing in the advanced MARIN basin, in 'open water' conditions. "Our testing methods have been significantly improved since the introduction of the B-series. We now work with higher rpms which reduce scale effects and we measure with greater precision. Besides, we are now able to reverse as well as experiment with different variables such as rotation, speed and direction – so-called 'four quadrant' operation, in order to accommodate the electrification of ships."

Bronze propellers

The F-Series is primarily a comprehensive data set that includes both propeller design data and performance characteristics. Easy-to-use software with a graphical interface is provided to shipbuilders and propeller manufacturers to access all performance data of the testing. Enter characteristics such as vessel resistance and engine rpms, and the software generates a set of propeller designs that match optimally. "It often also provides an estimate of the weight and moment of inertia (giving the degree of resistance to change in angular velocity of a body with a certain mass). Propellers are made of bronze and

"The F-Series offers high efficiency and meets the requirements for noise, vibration and erosion resistance."

that is the most important cost factor in a quotation." For example, this provides a shipbuilder or propeller manufacturer with fast and accurate data to prepare a tailored quote. "The F-Series propeller accurately reflects the current requirements in the market", Dang concludes.

Less noise

For large cargo and passenger ships, efficiency is paramount, but that does lead to a higher noise level, according to John Huisman, the team's propeller specialist. "A propeller with a high tip load distributes the propeller force optimally and thus increases efficiency. However, that tip vortex does make a noise." Noise can be burdensome for both the crew and for marine life. That is why MARIN is testing an FC series, where C stands for comfort: these propellers produce significantly less noise. ■

Who: MARIN, the Dutch Navy and 35 industry participants, including shipyards, classification societies and almost all propeller manufacturers of the world.

Duration: December 2018 – June 2023.

Budget: EUR 2.5 million.

Follow-up: the FC series with lower noise propellers is now being tested.

Completion probably by end 2023. In addition, MARIN will start testing in late 2023 to develop a data set that is representative of the true size of a propeller.

DNS Analysis scans for global cyberattacks

It started with a network security assignment. “One of our clients is Rabobank”, says Dimitri Hehanussa, Business Development Manager Cybersecurity at TNO. The bank wanted to protect itself from cyberattacks and asked TNO to elaborate an idea. The assignment led to the company Sceptr, and DNS Analysis security software . ▶

This image is an AI-generated photo, the very first in TO2 magazine. It was designed using Midjourney software.

TNO

Problem: cyberattacks on valuable targets such as banks can sometimes be undetectable, as the attack takes place from computers that do not yet appear on blacklists.

TO2 Solution: DNS Analysis security software, developed by TNO, scans for unconventional patterns in network traffic in the DNS system. This is the system used to obtain IP addresses of computers on a network.

Impact: By hosting DNS Analysis at the company Sceptr, other parties and financial parties will also have access to this security software, which will lead to a safer internet for everyone. DNS Analysis is easy to integrate into existing IT systems and infrastructures.

"The problem with banks is that they are bothered by targeted attacks", says Hehanussa. This means that the standard 'signature detection' method, which scans for internet traffic via blacklisted addresses, does not work, because banks are confronted with the first attack from new addresses. "These are gangs of criminals who also have an innovation department", Hehanussa outlines the danger of this development.

Unconventional behaviour

TNO's idea was to track down deviant behaviour by analysing the Domain Name Server (DNS) system, 'the internet phone directory'. When a computer wants to visit a website, it asks a DNS server – a computer on the network – for its IP address. If that DNS server does not know that, it will redirect to another DNS server until the IP address has been found.

"Rabobank said: we would like to buy this as a product"

"DNS is used by all kinds of applications, hence it provides an insight into what is happening in a network", says Tim Ruhl, Chief Technology Officer at Sceptr. "The question was: can you spot behavioural aspects that indicate malicious behaviour?" This could, for example, include a machine that requests domains in an unusual area, e.g. a domain in Russia. Another possibility is that the antagonistic software exposes information. This can be done by making multiple DNS requests, which eventually end up at an antagonistic server. Data can be encoded from the requested URL names, Ruhl explains. "Although not much data fits in a single URL name, many DNS requests can be made, and thus expose a great deal of data."
So, deviating DNS behaviour can betray an attack, but how do you detect suspicious behaviour without triggering false alarms all the time? "For this purpose, we developed an AI that detects behavioural changes in the DNS field", says Hehanussa.

Socially responsible

That software, which was called DNS Ninja at the time, turned out to work well. "The bank said: we would like to buy this as a product. This was also from a socially responsible point of view, so that other parties could also protect themselves. But TNO is not a product organisation: we research and develop. But maintenance, upgrades, marketing, and setting up a service organisation, we don't do that. I spotted this as an opportunity, and signed up for TNO's spin-off programme." So, Hehanussa established the company SightLabs, which was acquired in 2020 by NetDialog, which specialises in network monitoring: which monitors the network to ensure it continues to perform well. This cyber security and IT management perspective complement each other well, says Ruhl, and now the company has been renamed Sceptr. To emphasize its broader application, the name DNS Ninja – with its strong emphasis on cybersecurity – has also been changed to DNS Analysis. Ruhl: "But we kept the ninja in the logo." ■

Who: TNO, SightLabs, NetDialog, Sceptr, Rabobank.

Duration: initial thoughts on DNS Ninja were formulated in 2015. SightLabs was established in 2018 and acquired in May 2020 by Nexus International, Sceptr's parent company.

Budget: as an indication: Sceptr's first round of funding involved an investment of EUR 800,000.

Follow-up: to further develop the DNS Analysis product and to integrate it into a *software security operation centre,* so that the right information reaches the right people within the company.

From polluting to sustainable electronics

Consumer electronics have brought many technological revolutions to the world, but smartphones, PCs and laptops also create a lot of waste. TNO developed a technique in which circuits on the PCBs of these electronics are no longer etched but printed on ultra-thin foil with special ink. The ink can be recovered and the foil can be recycled. ▶

Ashok Sridhar (left) of TracXon and Ton van Mol of TNO Holst Centre.

TNO

Problem: printed circuit boards (PCBs) in electronics cause large amounts of waste, which is difficult to recycle.

T02 Solution: TNO has developed technologies to print electronics on plastic foils in the form of functionally conductive or specifically isolating inks. The metals in the ink can be recovered again and the foil can be recycled.

Impact: this new technology still has niche applications that rely on light, transparent and flexible, stretchable and even pliable foil. In the long run, almost all types of electronics can be lighter, more durable and recycled easier.

According to a report by the United Nations in 2019, we produce more than 50 million tons of e-waste, or electronic waste every year, of which we recycle twenty percent at most. A large part of it consists of hard-to-reuse PCBs; the circuit boards onto which electronic connections are soldered with copper, soldering material and chemicals on top of that.

Conductive ink

The startup TracXon, which has emerged from TNO's Holst Centre, is working on an alternative. "We print the circuits directly onto flexible plastic foil, in the form of inks that conduct electricity or are specifically isolating, or have other electronic properties", says Ton van Mol, Director of the Holst Centre. Then the electronic components – from tiny LEDs to chips with dozens of connectors – are placed and glued. "In the long run, this will make it possible to switch to fully recyclable electronics", says Van Mol, "but we do not yet have the economies of scale of conventional production of PCBs. We want to work towards this step-by-step."

Niche products

"We apply this to an industrial technology", says Ashok Sridhar, formerly TNO Holst Centre, but now CEO of TracXon, the spin-off that TNO established in 2022. Printable electronics is a technology that Holst Centre has been researching for many years. But to cross the notorious valley of death, the difficult no man's land between promising research results and scalable market application, TNO decided to take the step of its own accord. Sridhar: "If you want to scale this up, you first have to start with niche products that utilise the unique characteristics of printed electronics, e.g. that it is flexible and thin." TracXon is currently running eight paid pilot projects for clients, he says, two of which are going into medium-scale production at the end of this year: tens of thousands of units. An example is an advanced Internet of Things (IoT) tag for use in medicine logistics, says Sridhar. "They can monitor temperature and movement and pass them on via an antenna." Another pilot project is a stick-on sensor that can be worn by people in developing countries who have high risk of TB or malaria. Sridhar: "Sensors on the chip can detect pathogens in the breath, and transmit via the electronics that someone is infected." Large-scale production is a key to its success. "The electronics are currently still being printed page by page, like in the printer located at home", says Sridhar. Together with TNO, TracXon is working on the development of roll-to-roll production. "Just like newspapers are printed." Then it involves many square metres and hundreds of circuits per minute.

"Ultimately, a hundred percent reusability is possible."

Less polluting

Applications include transparent screens with LEDs to provide information on windows or sunroofs in cars, but in due course, also electronics that do not explicitly use the flexibility, transparency and ductility of electronics on foil. The technology is already more sustainable than today's electronics. "According to a study by VU Amsterdam, we already use four to twelve times fewer chemicals, almost no water, and printed electronics score much better in carbon footprint", says Van Mol. This will improve further when full re-usability becomes apparent in the long run, whereby the conductive ink dissolves again, the electronic components are disassembled and the foil is recycled. Van Mol: "Ultimately, a hundred percent reusability is possible." ■

View the video here

Who: TNO Holst Centre, spin-off of TracXon, with several partners including Copprint, AGP, Tag-N-Trac.

Duration: TNO Holst has been conducting research on printable electronics for 18 years. TracXon was established in 2022.

Budget: The funding round for TracXon was EUR 1.1 million. A second round late in 2023 will be between EUR 3 million and EUR 4 million.

Follow-up: the development and upscaling of roll-to-roll production facilities in collaboration with Holst Centre. Development of cheaper, copper-based ink instead of silver-based ink. Full recyclability. Use of bio-based foils.

Lighter aircraft with a thermoplastic 'fuselage'

NLR is collaborating with other parties on a new fuselage with thermoplastic components. This material offers the same strength and service life as aluminium, but reduces the total weight of the aircraft's fuselage by more than ten percent, reducing the aircraft's carbon footprint. ▶

NLR

Problem: aviation accounts for about three percent of global CO_2 emissions. Global demand for energy efficient air transportation may possibly increase.
The aviation industry has therefore taken up the challenge of developing technical solutions to reduce the environmental impact of its products.

TO2 Solution: a consortium of parties – including NLR – is working on a thermoplastic fuselage section of 4 × 8 metres for big short to medium-range aircraft, including the cabin and cargo floor structure and with main interior and system elements, which can be made efficiently in large production volumes.

Impact: the fuselage is expected to be more than 10% lighter and will lead to corresponding reductions in CO_2 and nitrogen emissions, with which the Netherlands contributes to a climate-neutral aviation target in 2050.

In 2023, the Indian airline IndiGo placed an order for five hundred Airbus aircraft, which the aircraft manufacturer Airbus will deliver between 2030 and 2035. To ensure global mobility, the growth of air traffic is likely to increase significantly over the coming decades. At the same time, the European aviation industry and public parties are taking initiatives towards a climate-neutral aviation in 2050. The Netherlands can contribute to this with industrial technologies to bring about the necessary major changes in respect of the current generation of aircraft.

"Thermoplastic means a weight saving of ten percent."

Carbon fibre

A consortium of predominantly Dutch parties (STUNNING), under the direction of GKN Fokker, worked within the Airbus-led Multi-Functional Fuselage Demonstrator (MFFD), to build the undercarriage part of an aircraft structure in composite, the world's largest thermoplastic aircraft structure. Another consortium concurrently worked on the upper part. The two parts are now, after completion, being joined together in Germany. "In 2021, NLR in Marknesse, produced the skin of the undercarriage in a single segment of 8 metres long and 4 metres in diameter, the world's largest single thermoplastic part for aircraft construction. In tandem, GKN Fokker in Hoogeveen, among others, started manufacturing the other parts of the fuselage. European partners also supplied innovative components. 2022 was dominated by the integration of parts of the fuselage interior work by GKN Fokker and TU Delft at SAM|XL in Delft, such as the cabin and cargo floor structure with main system elements", says Johan Kos, principal R&D Engineer at NLR. Research is being conducted into a large-scale application using a composite, carbon fibre reinforced thermoplastic Low-Melt PolyArylEtherKetone (LMPAEK™) resin, in big aircraft for the short and medium-range like the A320 Airbus, which is currently still manufactured in metal. For even bigger aircraft, such as the Airbus A350 and Boeing 787, the fuselages are often already equipped with composite materials, but this is thermoset resin and has the disadvantage that it is poorly recyclable. Thermoplastic can be melted several times and this promotes reusage. In addition, thermoplastics make it possible to weld the parts of the fuselage. "Joints are now often implemented with mechanical fasteners. That takes a lot of time and adds weight. Thermoplastic ensures a weight saving of more than ten percent in the fuselage compared to the current generation."

The fuselage of the aircraft.

Watch the video here

A hundred aircraft

Production volumes have also been taken into consideration. Kos: "For an A320, production in 2019 was at more than sixty new planes a month. Research in the MFFD using thermoplastic is aimed at reaching a production of a hundred aircraft." This can only be done with a fully automated production process. "We investigate how this should be done and use our own Automated Fibre Placement machine to fully automate the placement of narrow strips of carbon fibre reinforced thermoplastic with a robot in forming a skin. This technique is not new, ▶

NLR

but has not been used before for such large thermoplastic surfaces. Hence, we can guarantee faster turnaround times, which contribute to cost savings in building new aircraft."
In the MFFD project, the assembly is more modular in parts that can be built separately from each other. In addition, NLR is collaborating with other partners to find solutions to structure the cabling and systems as efficiently as possible. "We are exploring which new techniques are now the most successful for thermoplastic application and are still investigating where local improvements and even faster induction welding technology are possible." The wings could also be made of thermoplastic, but that research is not covered by this project.

"The challenge is to simultaneously bring all these technologies together in a new aircraft to be designed. In Europe we're aiming for 2035."

Large surfaces

In this project, NLR makes use of infrared thermography, an inspection technique that quickly and effectively provides a clear picture of the surface temperatures of the checked components. This technique is being researched to find defects during production. Kos: "Inspections with thermography are faster, because you can inspect large surfaces at once, whereas in the conventional ultrasound technique scans are made in small narrow strips. If errors are found during production, thermography can sooner help to stop them from occurring, which can help us save costs and prevent waste of materials. This also minimises interruptions of the further production process."

The development of the fuselage for the new generation of aircraft is just a small cog in the machine. Research institutes and market players worldwide are working on more economical, cleaner and quieter aircraft. From new propulsion technologies to innovative wing structures. "The challenge is to simultaneously bring all these technologies together in a new aircraft to be designed. In Europe we're aiming for 2035, when we expect the first aircraft with all the technology to be ready. This objective is also clearly stated by all the teams working on this." ■

Who: Consortium STUNNING (GKN Fokker Technologies, GKN Fokker Aerostructures, GKN Fokker Elmo, Diehl, NLR, TU Delft, SAM|XL), Airbus, and other European MFFD partners.

Duration: The MFFD project runs from 2015 – 2023. Consortium STUNNING and NLR joined the project in 2017.

Budget: Funding from the European Union through the Clean Sky 2 Joint Undertaking and by private parties participating in it. Private funding for NLR by TKI High Tech Systems and Materials and from the NLR programme Aircraft and Spacecraft Development.

Follow-up: The FASTER H2 project in the Clean Aviation programme further develops certain fuselage techniques for hydrogen-powered aircraft that do not emit any CO_2. It is now up to the market parties to take further initiatives to apply this thermoplastic technique.

Using more information to encourage biobased construction

Construction with normal materials such as cement and steel produces major CO_2 emissions, while biobased building materials like wood retain CO_2. Ignorance breeds contempt still applies to these materials and WUR wants to change that. ▶

WUR

Problem: building with cement and steel causes a lot of CO_2 emissions and too little is known about wider applications of biobased construction.

T02 Solution: building with biobased construction materials that retain CO_2. WUR wants to increase the use of biobased building materials by actively sharing information about environmental performance, certification and availability through the Biobased Building Materials catalogue and the National Environmental Database (*Nationale Milieudatabase, NMD*).

Impact: architects and contractors are going to make more use of biobased materials because they are more aware of the environmental impact, and consequently fewer CO_2 emissions.

The majority of buildings worldwide are built of mainly concrete and steel. However, their production generates a lot of CO_2 and this leads to climate change. Instead, we can build with renewable biobased building materials: wood, thatch, cork, straw, loamy clay, clay, flax, cotton and coconut, for example. In addition to the advantage that biobased materials are renewable, these materials capture CO_2 in the building for longer periods, Arjen van Kampen explains. He is a Project Manager of biobased products at WUR.

Not used often until now

At present, biobased construction is not applied often in the Netherlands: about two percent of the buildings are made of wood and only 0.1 percent are made of other biobased materials. "Very little is still known within the building industry about the environmental performance of these materials", says Van Kampen. The amount of biobased insulation materials, such as flax or hemp fibre instead of glass wool, has already increased somewhat in recent years. More requirements in the tender procedure of construction projects can accelerate their usage.

More knowledge

In order to raise awareness of these building materials, the research group created a Biobased Building Materials Catalogue, commissioned by the Ministry of Economic Affairs and Climate. It contains all the biobased building materials currently on the market, with practical applications. The catalogue was first published in 2012 and updated in 2019. The 2019 version has subsequently been downloaded 7,500 times from the website. So, it meets a need.

Calculate environmental performance

Architects and project developers can calculate the environmental performance of materials in a building using the National Environmental Database (NMD). "The database contains plenty of materials, especially many types of concrete, steel and glass wool, but only a few biobased materials", says Van Kampen. So, he and his colleagues are working on the Biobased-in-NMD project, which aims to introduce 13 biobased building materials in the NMD, including a number of types of wood, lime hemp, mycelium, bamboo and wool. Another aim of the project is to develop a method to calculate the impact of CO_2 storage in the life cycle analysis of the NMD – that is the environmental impact of building materials throughout their service life. If these materials are incorporated in official databases and the CO_2 effect becomes clear, more architects will work with these materials, Van Kampen expects. "They are the ones who largely determine the materials of a building. So the possibilities to build with biobased materials need to become more widely known."

"Architects largely determine the materials of a building."

Developing biobased materials

Nowadays, biobased building materials are often even more expensive than fossil and mineral variants, because they are only available on a small scale. He expects this to change in forthcoming years. He also coordinates WUR's activities in the field of biobased material development. "Our aim is to ensure that they are applied on a wider scale and more effectively." Attention is also being paid to development of the production chain and certification. WUR is also working on new building products, such as biobased asphalt, cement recycling and biobased construction panels. ■

Biobased building materials catalogue:

Who: Wageningen Food & Biobased Research.

Duration: Mid 2021 – end 2023.

Budget: EUR 250,000.

Follow-up: WUR invests in further knowledge accumulation.

Floating cities to keep the Netherlands more liveable

How can the Netherlands meet the challenges of water, like flood risk and sea level rise? Open-water and surplus water areas in the Netherlands offer opportunities for large-scale floating building. Floating Future is investigating how this can be made possible. ▶

MARIN, Deltares

Problem: the need for places to live, industrial areas, space for energy transition and food production is increasing, while sixty percent of our country is vulnerable to flooding. Climate change exacerbates this through sea level rise and nonrecurrent increased river water drainage.

T02 Solution: aside from risks, water offers opportunities for large-scale floating construction. MARIN's Floating Future research programme investigates from various angles what is needed to enable floating construction on a large scale and what the social acceptance of this would be.

Impact: the Floating Future partners are developing floating climate-resilient solutions for inland (IJmeer), port cities and the North Sea.

How can we keep our densely populated country liveable? The demand for space for housing, industrial sites, the energy transition and food production is increasing. At the same time, some sixty percent of our country is already vulnerable to flooding, and climate change poses an increasing threat to sea level rise and the drainage of surplus river water. Aside from the risks, water also offers opportunities for new forms of safe usage of space: large-scale floating construction. For example, ports or residential areas or places where food can be grown or coastal protection with floating elements. Houses have already been built on the water, as in Amsterdam, but these are not fully-fledged residential areas including public amenities.

On a large scale

The Floating Future research programme is specifically looking into these possibilities. It explores from technological, ecological, legal, economic and social perspectives how floating construction is possible on a large scale. What will it take to move this idea forward so that people embrace the concept of living and working on the water? What technology is required? What does the business case of a floating port look like, without causing damage to the natural environment or even with added value for the natural environment? "Together with companies, research institutes and government organisations, we are going to gather a huge amount of knowledge in the field of floating construction", says Olaf Waals, Offshore Manager at MARIN and Project Manager of Floating Future.

Both technical and social breakthroughs are needed to scale up floating infrastructure. "Technically, because we must investigate what is needed to be able to actually construct afloat, so that the construction can withstand environmental conditions, such as waves and tides and without affecting the natural environment (e.g. water quality). Here, for example, we can tap into MARIN's know-how of simulation technology. The social breakthrough concerns administrative solutions (such as legislation and regulations for floating construction) for floating islands in inland waterways and coastal areas, and for social acceptance of living and working on water. There are also opportunities to combine this with existing coastal water methods such as the construction of dykes and sea defences."

Pilot set-up in the MARIN basin

Watch the video here

Climate cafés

Floating Future's partners will meet in so-called Climate Cafés with stakeholders like municipalities (Rotterdam and Amsterdam), offshore companies, district water boards, floating construction companies and NGOs. Waals: "These are on-site sessions where we discuss what is needed and what can already be done. These sessions lead to knowledge questions that PhDs from the universities involved can work on for interdisciplinary research into a variety of fields." ■

Who: MARIN, Universities (Delft, Groningen, Rotterdam and Utrecht), Deltares.

Duration: 2024 – 2029.

Budget: EUR 5 million grant from NWO and EUR 1 million through the partners involved.

Follow-up: this consortium includes the municipalities of Rotterdam and Amsterdam, as well as several developers, designers, architects and NGOs. The first collaborations for actual 'floating' developments can be established on the basis of this knowledge project.

Getting a grip on dredged sludge

Strengthening a dyke, deepening a fairway or creating new nature: lots of dredging work is done to improve the natural environment and ecological water quality, and to keep the waterways of the Netherlands navigable. When dredging sludge, greenhouse gases often escape from the soil. How much and how severe, is virtually unknown. ▶

Deltares

Problem: in 2030, the Ministry of Infrastructure and Water Management (IenW) and the Ministry of Agriculture, Nature and Food Quality (LNV) wanted to operate in a climate-neutral and circular manner. In the long term, we will also have to reduce emissions from the soil and water, whereas little is known about the amount of greenhouse gases that are released from them.

T02 Solution: the *Duurzaam Nat Grondverzet* (*DuNaG*) [sustainable wet earthmoving] project is identifying the emissions caused by dredging in both large and small waterways when undertaking coastal projects, such as construction of the Marker Wadden, or for maintenance of fairways or navigation channels.

Impact: by having a better understanding of the parameters that determine emissions, practical tools can be provided to reduce them. This includes flaring emissions or capturing gas and using it as new energy. By opting for 'green' rather than 'grey' solutions, in the long term additional carbon can be captured, which will have a positive impact on climate.

The coastal projects, such as land and port development as well as coastal protection, mainly focus on fossil fuel emissions by dredging equipment. Martine Kox, researcher/consultant at Deltares: "It is logical, because that is the aim of the government's policy. But we forget the carbon that is stored in the material we extract from the soil." Kox is referring to sediments that are rich in organic material such as those in coastal systems like seagrass meadows, saltmarshes and mangroves, and those in freshwater systems like peat systems, ditches and lakes. In a healthy carbon cycle, carbon emissions and uptake are balanced, or carbon is withdrawn from the air. When soil is moved then gases stored in certain soils are unintentionally released. The impact can be significant; mangroves, for example, contain five times as much carbon as a comparable stretch of rainforest. "There are reasons and goals for disturbing the natural environment, but it takes a long time for such a soil system to become stable again and to start absorbing greenhouse gases", explains Wouter van de Star, Project Manager of DuNaG and Biogeochemistry researcher at Deltares. "This absorption can compensate for emissions over time."


Martine Kox.


Wouter van der Star.

Marker Wadden

In order to get a grip on the carbon cycle during wet earthmoving, the *Duurzaam Nat Grondverzet* (*DuNaG*) [sustainable wet earthmoving] project was set up, which is a collaboration that includes Sweco, RHDHV and Arcadis. The first measurements took place at the formation of the Marker Wadden in the Markermeer. Van der Star: "The air above the earthworks blows through what is known as an eddy covariance tower, which measures greenhouse gas concentrations such as CO_2 and methane over a large area ten times a second. Taking air variables into account, we can calculate the concentration of greenhouse gases per unit of surface area per hour. In addition, we monitor on site, by placing enclosed chambers over stretches of soil and water."

Carbon-inclusive solutions

It seems that the vast majority of emissions are released at the time of excavation. Kox: "This is not so much due to the active microbial activity at that time, but due to stored gas that escapes from the soil during work." That knowledge enables you to seek solutions to tackle these emissions. Perhaps it is possible to flare methane, or you can capture and reuse gas as biogas. Another option is to work during winter, when the microbial activity in soil and thus the impact of the work, is much lower. An alternative is to work slowly, so that the natural environment can continuously restore itself in the meanwhile. Kox: "Mangroves in some places across the world are being restored, so that in the long term they will capture carbon again. An example in the Netherlands is peat recovery or the planting of a willow forest on a foreshore. Instead of pouring concrete to keep the water at bay, we would be much smarter to cooperate with the natural environment in the form of a Nature Based Solution to find green, carbon-inclusive solutions." ■

Who: Deltares, Witteveen+Bos, Radboud University, EcoShape, Society for the Preservation of Nature and Boskalis, arising from a collaboration in which Sweco, RHDHV and Arcadis are also involved

Duration: 2022 – 2025

Budget: EUR 500,000

Follow-up: reporting on the monitoring at Marker Wadden began in September 2023. In addition, measurements take place at several common dredging projects spread across the Netherlands.

Credits

T02morrow is a publication by the collaborating applied research organisations, united in the T02 federation. They create the link between knowledge and innovation for the benefit of the government, business community and society. © 2022.

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