TO2MORROW

Magazine on results in the Open Innovation Network

2021

Deltares

TNO innovation for life

MARIN
BETTER SHIPS, BLUE OCEANS

WAGENINGEN
UNIVERSITY & RESEARCH

TO2 federatie
De samenwerkende organisaties in toegepast onderzoek

nlr Dedicated to innovation in aerospace

>

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Foreword

How does care remain affordable and accessible? How do we continue to cope with the consequences of the corona pandemic or climate change? How can companies continue to grow and innovate so that we can remain a prosperous country? These are not small and neither are they simple issues for which Deltares, MARIN, TNO, Wageningen University & Research and the Royal Netherlands Aerospace Centre (NLR) – one could say the 'big five' applied research institutes – are seeking solutions. Yet, these are the topical issues of today. Issues for which very good applied research can be conducted, and for which there is a dire need in society.

All five institutes develop knowledge in their own professional disciplines, so that their specialist expertise increasingly becomes more profound. This expertise is also developed interdisciplinary, i.e. through special joint research programmes. This will allow research to be more broadly developed and the solutions to be more comprehensive. For example, the experiences and insights that the institutes are now gaining with research into floating islands in the North Sea, contribute to what is agreed in the Climate Agreement. MARIN supplies floating structures for this, TNO investigates the strength of the materials, Wageningen Marine Research looks at effects on the environment and Deltares uses the Delta Basin for testing. I think it is a solid hybrid research structure, which allows researchers to use both a microlens and a wide-angle lens.

The institutes have also shown this year how socially relevant their work is, despite the fact that it was a rather strenuous year. The corona pandemic demanded extra time and attention. Moreover, the institutes were reviewed. I'm really proud that the review committee came with good news: the quality of research is very high, and the knowledge and insights are socially and economically viable. The committee detected that the people who work there add a great deal, which is a good reason for viewing the research work in this third TO2 Impact Report through the eyes of the researcher too.

Institutes for applied research also responded quickly to social issues that we are suddenly facing. In a very short space of time, Royal NLR was able to investigate jointly with the National Institute for Public Health and the Environment (RIVM), how likely it is to contract a corona infection on board an aircraft. This is essential knowledge for governments and aviation companies to be able to take measures against the virus.

This means that the institutes seem to succeed in their mission. It certainly makes me curious about the implementation of the new strategic plans for the coming years. But I first would like to invite you to enjoy the many, inspiring examples of applied research in this report.

Focco Vijselaar

Director-General for Enterprise and Innovation
Ministry of Economic Affairs and Climate

In the overview below, each of the institutes, 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 perspective of water and subsoil, 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 in the Netherlands and internationally. This knowledge organisation conducts applied scientific research in the market segments: industry, civil aviation, aerospace and defence. NLR's work covers the full spectrum of 'Research, Development, Test & Evaluation' (RDT&E). Within the mission-driven innovation policy, NLR's research focuses on the 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 for nine domains: Buildings, Infrastructure & Maritime; Circular Economy and the Environment; Defence, Safety and Security; Energy Transition; Healthy Living; Industry; Information & Communication Technology; Strategic Analysis & Policy; Traffic & Transport.

Developing 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 application or scope in innovations and sectors. They will radically change the way we live, learn, innovate, work and produce. Key technologies are essential in resolving social challenges, such as safety, energy and care. Key technologies also enable groundbreaking innovations of processes, products and services, and provide a major contribution to the economy, to the emergence of new businesses and new markets, to an increased competitiveness and to bolstering job creation.

WUR

Wageningen University & Research is the joint venture between Wageningen University and Stichting Wageningen Research (a foundation). We have more than 6,800 employees and 12,900 students from over 100 countries working in the fields of healthy nutrition and the living environment across the globe, both for governments 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 in the themes Food & Biobased Research, Bioveterinary Research, Livestock Research, Marine Research, Economic Research, Environmental Research, Plant Research and Food Safety Research. ■

BlueCAN: clear water for the climate

Ponds with poor water quality emit as many greenhouse gases as 200,000 cars. This appears in research by Radboud University into greenhouse gas emissions from ditches and urban ponds. BlueCAN helps water authorities estimate carbon emissions from surface water. ▶

Deltares

Problem: pools and lakes in the Netherlands that have a poor water quality have far higher greenhouse gas emissions than those that have clean waters. Estimates indicate that five percent of national greenhouse gas emissions could derive from surface water.

T02 solution: together with Witteveen+Bos and STOWA, Deltares is gaining insight into the processes that contribute to the greenhouse gas emissions from fresh surface water within the BlueCAN project. This is used as the primary guideline to map the reduction of greenhouse gas emissions of fresh surface waters in the Netherlands for a strategy that combines monitoring and modelling.

Impact: the BlueCAN project not only contributes to improving water quality and biodiversity, but also leads to fewer greenhouse gases. In this way, water authorities can make a significant contribution to the government's climate objectives.

Deltares conducted research together with engineering firm Witteveen+Bos, on the water quality of pools and lakes in the Netherlands. 'We knew very little about this and decided to conduct joint research together into the relationship between poor water quality and carbon emissions', says Sacha de Rijk of Deltares.

Factor ten

The BlueCAN project examines these 'forgotten' greenhouse gas emissions. The results have revealed that in polluted waters that have many nutrients (such as algae formation), emissions can increase up to ten times higher than in clean and clear waters. 'The poorer the quality, the more greenhouse gases arise in the water', says De Rijk.

This triggered a follow-up project to develop a tool that allows water authorities to estimate the amount of emissions from their water systems and how they can reduce them. The tool allows you to eventually define the greenhouse gas emissions of pools and lakes by means of a number of parameters, such as the size, depth and composition. Water authorities can use the tool to quickly identify spots and calculate the savings on emissions. For example, you can simulate what the positive effects on carbon emissions are when using less phosphate. With the BlueCAN tool, you can slide a bar back and forth and then you can see that emissions decrease or increase. One of the measures that can then be taken is either not to dredge or to reduce the phosphate load in another way.

Water Boards

The initiators hope that the BlueCAN project will continue to develop into a research programme aimed at greenhouse gas emissions from waters, because the benefits are twofold. 'Measures to improve water quality not only contribute to the restoration of biodiversity, but water authorities can also work on the reduction of carbon emissions.' ■

Who: Deltares, Witteveen+Bos and STOWA. In addition, contacts have been established with Bware and Radboud University.

Duration: The project has been running since 2019.

Budget: €400,000, but the budget is still increasing with additional contributions from STOWA and the Water Boards.

Follow-up: The BlueCAN tool is still under development, an initial version will be presented in mid-2022.

View a YouTube video here

Floating, flexible offshore islands

Erik-Jan de Ridder of MARIN.

MARIN, TNO, Deltares, WUR

Problem: more and more wind farms are appearing off the coast of the Netherlands. And as they are placed further and further away from the shore, it becomes more complicated and costly to maintain these wind farms and to transmit electricity to the land.

T02 solution: a Dutch consortium comprising T02 institutes MARIN, TNO, Deltares and WUR, is investigating whether energy processing and storage as well as maintenance of wind farms, can take place offshore. The possible solution lies in a combination of permanent and floating islands situated close to the wind farms.

Impact: by improving the infrastructure of permanent and floating islands, the Netherlands will sooner be able to comply with the Climate Agreement. It states that the power capacity from offshore wind farms will grow to 11 gigawatts in 2030, which is 40% of the current electricity consumption. Further, floating islands can be used to grow crops, or as a base for the coastguard, or for recreation.

Floating offshore islands can provide for storage, energy processing and maintenance of wind farms situated far off the coast. But this is difficult in the North Sea where the sea is rough with a lot of swell. A consortium of four T02 institutes MARIN, TNO, Deltares and WUR are exploring the solution of a combination of a partially permanent and partially floating island.

In 2007, the first wind farm of the Netherlands with a power capacity of 108 megawatts, was opened off the coast. In 2021, there are now seven wind farms off the Dutch North Sea coast that jointly generate 2.5 gigawatt of electricity. Offshore wind energy already supplies the Netherlands with a significant proportion of electricity, which will grow considerably in the years ahead.

Rough sea

Future wind farms, however, will increasingly be placed farther off the coast, making it more difficult and more expensive to maintain them, and to transmit the electricity to the land. This prompted Maritime Research Institute Netherlands (MARIN) to conduct research – in the HybridEnerSeaHub project – into islands with floating and permanent parts. 'The latter is important because the northern North Sea is quite rough. That makes it difficult to have a completely floating island', says project manager Erik-Jan de Ridder of MARIN. The permanent part ensures protection against the rough sea; the floating part offers the possibility to add certain functions to the island. 'A floating island is also future-proof. You can construct an island with functions that are needed at that point in time. However, in ten years' time, the circumstances may have changed and these functions may change. Floating parts are easier to expand and replace.'

Transformer

One of those functions is that the floating island can act as a transformer station. The generated current deriving from the wind turbines, is then converted offshore to a practical low voltage. TenneT already uses offshore transformers, but these are positioned on what is known as jackets. These are iron structures at sea that form the foundation for the transformer station. These jackets are quite compact and pricey to build. 'When you construct an island, it admittedly costs more, but you have far more space and that could be more advantageous for larger wind farms.'

An island can extend to one square kilometre. And that space provides options for other applications, such as storing spare parts and materials, servicing wind turbines or energy storage and power conversion. ▶

'A floating island is future-proof. You can construct an island with functions that are needed at that point in time.'

MARIN, TNO, Deltares, WUR

▶ 'Other applications are the cultivation and drying of seaweed, but also a place for the Coast Guard to park their fleet.

The HybridEnerSeaHub is a joint project of a Dutch consortium, with each having its own speciality: MARIN (floating structures), Deltares (permanent infrastructure and environmental conditions) and TNO (costs, risks, strength of materials), Wageningen Marine Research (environmental impact), RoyalHaskoning DHV and Offshore Service Facilities (design and construction). In October 2021, a model trial was started in the Delta Basin at Deltares. It is a concept island with fifteen floating modules. Two-thirds of the island floats, one-third of the island has a solid substrate with hydraulic sand fill.

Rising sea level

In 2022, the project will lead to a completed concept and calculation models. 'I expect that islands will increasingly be more relevant and floating or partially floating would then be a worthwhile option. Similarly, with the threat of a rising sea level and extreme weather conditions, it may be worthwhile to consider floating constructions. If the sea level rises, a floating island rises too. If you construct something permanently, there is a higher chance of flooding. Floating islands are being considered in other countries too, such as Singapore and Denmark. By already developing this knowledge and these models, we will be able to apply them all over the world.' ■

Who: MARIN, Deltares, TNO, Wageningen Marine Research, RoyalHaskoning DHV and Offshore Service Facilities.

Duration: 2019 – summer 2022.

Budget: €1 million (Joint Industry Project) with Top Sector Energy Subsidy from the Ministry of Economic Affairs.

Follow-up: From 2022 onwards, commercial parties will be able to use the knowledge gained to develop hybrid islands. In the meanwhile, cooperation is also being sought with schools and universities to get floating construction higher on the agenda.

View a YouTube video here

Floating, flexible offshore islands

From blast furnace gas to marine fuel

The steel industry is facing a major challenge to drastically reduce carbon emissions. TNO has developed technology that substantially reduces its carbon footprint while simultaneously contributing to the energy transition. ▶

Soledad van Eijk of TNO.

TNO

Problem: about 15% of industrial carbon emissions are accounted for by the steel industry worldwide. In order to meet the climate objectives of Paris, the steel industry must accelerate the transition to more sustainable manufacturing.

T02 solution: TNO developed a carbon capturing technology that is 28% more efficient for blast furnaces than current state-of-the-art technologies. A demonstration project shows that this carbon can be reused efficiently, for example to manufacture methanol.

Impact: after adaptation with this technology, existing steelworks can capture up to 85% of their produced CO_2. This CO_2 can be stored, e.g. in empty gas fields, or reused. This could be manufacturing methanol, a relatively clean marine fuel. In this way the steel industry contributes to the gradual phasing out of fossil fuels, while the power supply remains safe, available and affordable.

Iron and steel form the foundation of our modern industrial society. In the meantime, iron and steel manufacturers are in the dock because of their huge carbon emissions and other pollution (e.g. Tata Steel in IJmuiden). As much as 15% of global industrial emissions are accounted for by iron and steelworks. In Europe, it concerns 200 million tons per year. The conclusion is clear: to meet the Paris climate objectives, this industry, too, must accelerate reduction of its carbon footprint dramatically.

One of the solutions is to build hydrogen-based steelworks. In this case, hydrogen replaces coking coal – one of the main causes of carbon emissions in conventional iron and steelworks – which transforms iron ore into iron. 'But that only makes sense if such hydrogen is ultimately produced with renewable energy', says Soledad van Eijk of TNO. 'That is a problem at many steelworks.' This means other solutions are needed that have a reduced impact on the production process, making them feasible in the short term.

'The University of Milan calculated that STEPWISE technology is 28% more efficient than existing capturing technologies.'

Type of clay

TNO developed such a solution: STEPWISE technology that enables CO_2 released in the production of iron and steel to be captured. Van Eijk: 'There are several technologies that capture CO_2. But we can do it more efficiently, by using less energy.' The University of Milan calculated that STEPWISE technology is 28% more efficient than existing capturing technologies.

Soledad van Eijk of TNO: 'Industry is so very eager that they are actively helping us.'

But that is not all, nowadays, a large proportion of the residual energy in a blast furnace is burnt in a power station to generate fossil fuel electricity. However, the technology developed by TNO makes it possible to use the energy in the blast furnace gas in a sustainable manner. 'Our technology transforms the energy content of the gases into CO_2 and hydrogen. The CO_2 for example can be stored in empty ▶

TNO

gas fields and the hydrogen can be used to generate electricity.' Yet the TNO technology allows even more smart applications, such as converting hydrogen with a portion of the CO_2 to obtain methanol, for example.

Stena Line

In the process, we have arrived at the FReSMe project, an abbreviation of: From Residual Steel Gases to Methanol. 'Why methanol, you might wonder', says Van Eijk. 'Well, shipping is currently one of the most polluting transportation options because of fuel oil. At the same time, electrification of cargo ships is very difficult; the batteries needed for this are so large that the ships can carry almost nothing else. A better solution would be to allow ships to sail on methanol. For this purpose, use a small portion of the CO_2 arising in steel manufacture, and store the rest. This will prevent shipping from having to burn extra fossil fuel – fuel oil – with all the environmental impacts that this entails.'

In order to prove that this is more than merely a fancy theory, TNO has collaborated with the Swedish research institute Swerim, among others, to build a test set-up on an industrial scale. Here, both STEPWISE and FReSMe were tested with blast furnace gas from the Swedish steelworks SSAB. The plant processed 800 m^3 of blast furnace gas per hour; about 14 tons of CO_2 was captured on a daily basis. In addition, the technology produced 1,000 litres of methanol per day. Van Eijk: 'In order to complete the experiment, one of the ships of the ferry company Stena Line sailed on this fuel.'

'85% of all CO_2 produced by steelworks can be captured in this way.'

Fertilizer

Blast furnace gas as a source of marine fuel: it is not the only conceivable application. In a follow-up project called INITIATE, we explore how residual gases from the steel industry can be used to produce urea, a raw material for fertilizer. Van Eijk: 'Here too it applies that: fertilizer is now produced in a completely fossil fuel-based process. We will soon be able to use recycled CO_2 for this. That is another good step in terms of the gradual phasing out of fossil fuel sources.'

Van Eijk expects that technology will be ready for a commercial roll-out in the next five years. 'Industry is so very eager that they are actively helping us. There is a necessity for change and, at the same time, our technology promises to be significant: 85% of all CO_2 produced by steelworks can be captured in this way. This will have a significant impact on the energy transition, and that is very pleasing.' ■

Who: TNO, Swerim and several other partners and industrial partners.

Duration: STEPWISE and FReSMe have now been completed; both had a duration of about 5 years.

Budget: STEPWISE received a grant of €13 million, of which €3.5 million was for TNO. FReSMe received a grant of €11 million, of which €1.4 million was for TNO.

Follow-up: The follow-up project INITIATE started recently and aims to further develop and test the technology on an industrial scale.

From blast furnace gas to marine fuel

Circularity in greenhouse horticulture is closing

Brussels and The Hague think that cultivation of fruit and vegetables in greenhouses must become circular in all areas, but how? Researchers in Wageningen mapped the material flows in greenhouse horticulture and identified opportunities to close this circularity further. In so doing, partnerships with other sectors were also considered, such as aquaculture and pig farming. ▶

Erik van Os of WUR.

WUR

Problem: greenhouse horticulture impacts both climate and the environment. Although greenhouse horticulture generally deals efficiently with raw materials, production chains are often linear rather than circular. An increased pressure, especially political pressure, is trying to change this. But the knowledge on how best to deal with this is inadequate.

T02 solution: a database of key material flows in greenhouses ensures greater fundamental knowledge for future scenarios for greenhouse horticulture.

Impact: government and the greenhouse horticulture sector know which specific steps are needed for circularity in greenhouse horticulture.

Greenhouse horticulture is an innovative sector that produces high-quality fruit, vegetables and plants, and handles raw materials very efficiently. Take, for example, the recirculation of water and fertilizers in the greenhouse. Yet the production chains are mostly linear, not circular. For raw materials, greenhouse horticulture depends on natural reserves that are spread all over the world, such as natural gas for energy and CO_2. Phosphate (P) and potash (K) are mined for the production of fertilizers. Basalt and peat are needed for substrates and crude oil for plastic. Both from Europe and The Hague, there is a growing desire to do something about this. Consumers also want more reusage and less waste. Yet, until now, there has been a lack of knowledge on what this circular operational management in greenhouses and at suppliers should entail.

Support

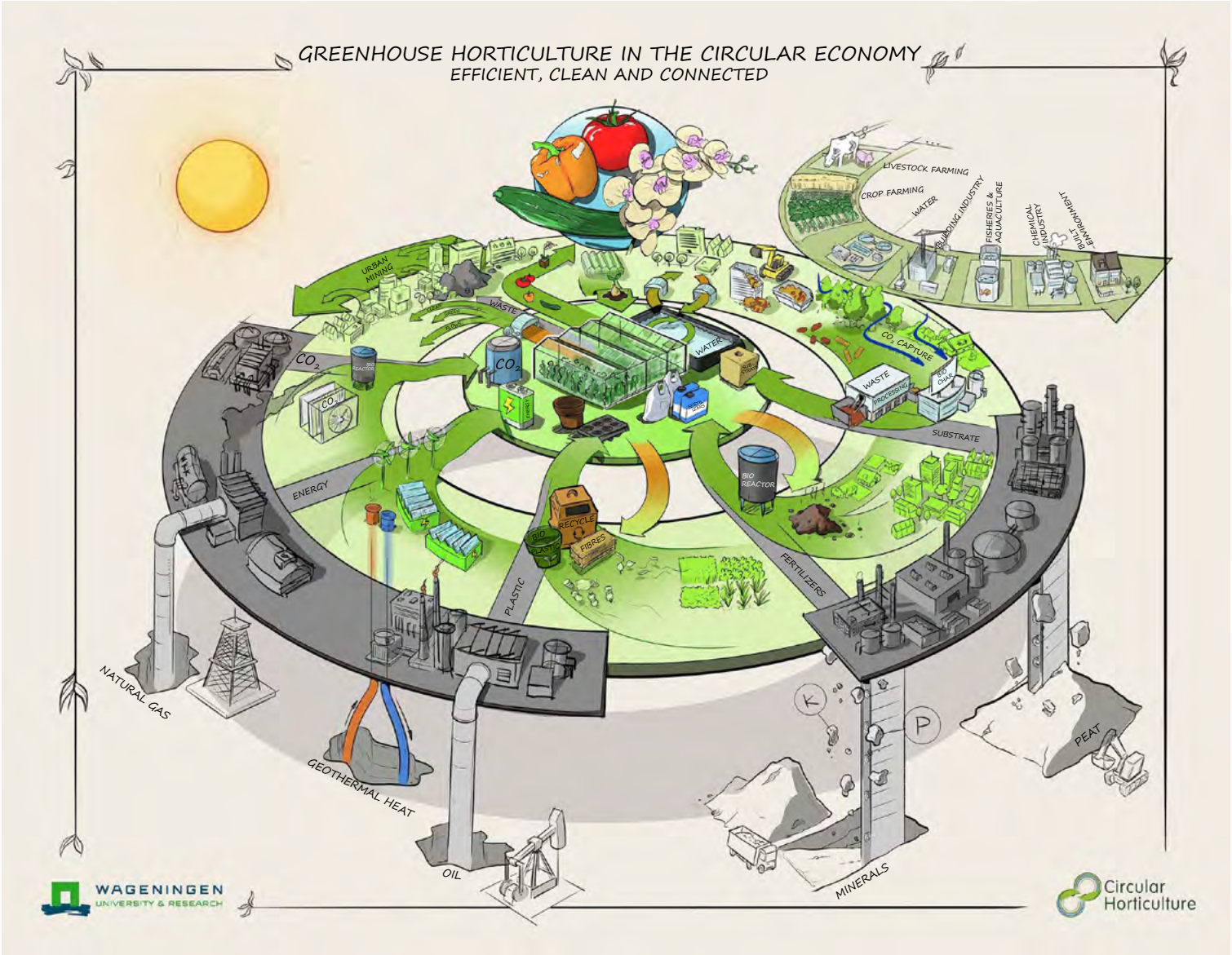
A multidisciplinary team of 14 researchers at Wageningen University & Research will map six major material flows: how much of this goes into greenhouses and how much goes out again? The data helps to transition to a circular operational management, project manager Alexander Boedijn thinks. Data visualisations clearly show growers and policy makers where the greatest opportunities and bottlenecks are. 'With this fundamental knowledge, we are able to close the gap, as it were, between daily practice and future government policy.'

In the sector itself, there is still a great deal of uncertainty about the size and costs of ▶

Erik van Os:
'The data helps to transition to a circular operational management.'

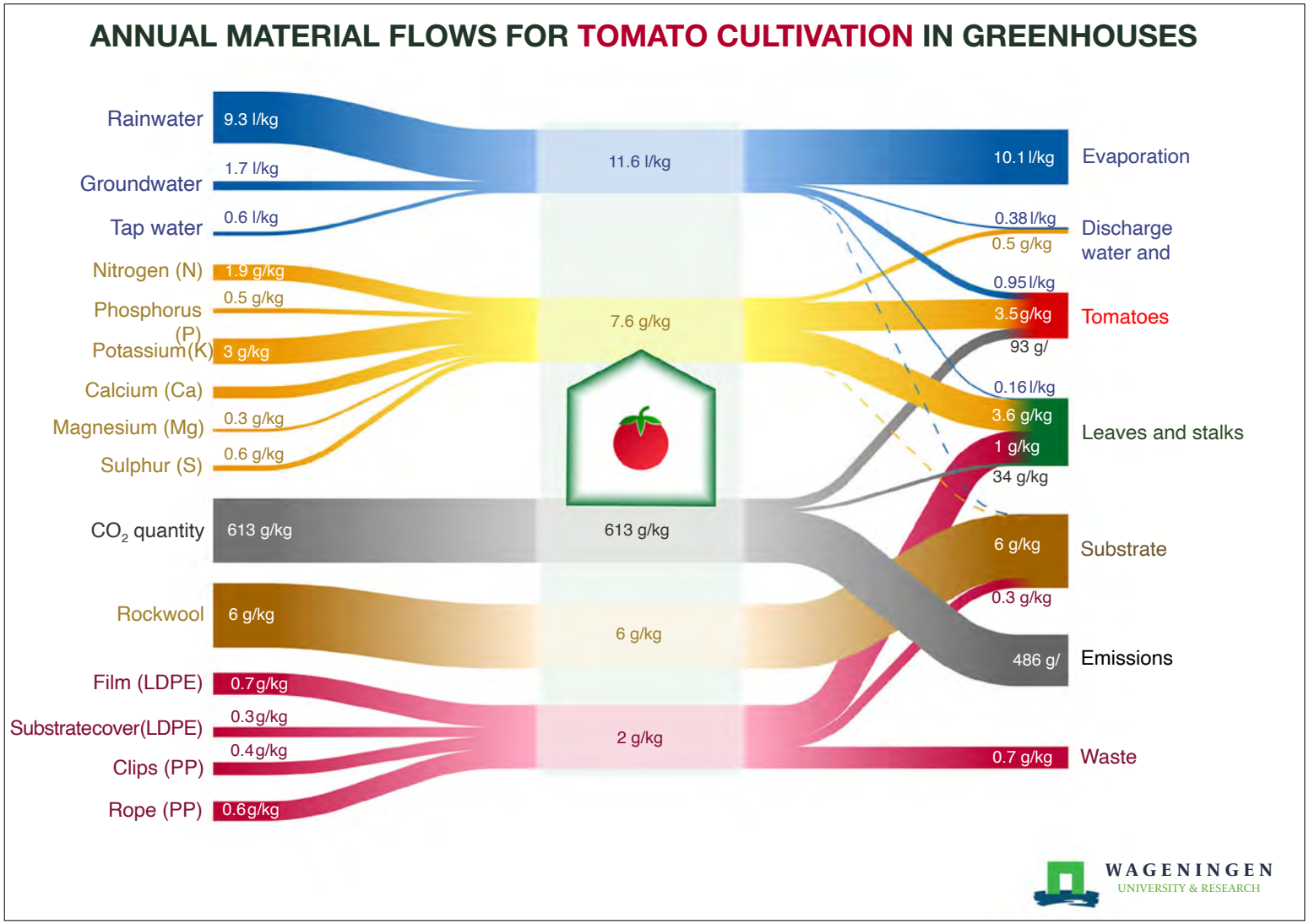
WUR

Circularity in greenhouse horticulture is closing



The future view of circular greenhouse horticulture.

WUR



Circularity in greenhouse horticulture is closing

WUR

this transition. The data sets and a substantiated outlook need to create more awareness and support. The perception of researcher Erik van Os is that growers are not negative about circular operating practices, but that they lack practical suggestions. During the period 1995-2015, Wageningen successfully started recirculating water and fertilizer, and as a result its usage was reduced by more than half.

Transition scenarios

Wageningen researchers use transition scenarios to describe which adaptations are needed for circular cultivation in future. In doing so, they also consider the potential of what is known as 'cross-overs'. The cross-over between greenhouse horticulture and aquaculture also explored the extent to which mineral fertilizers can be replaced by fertilizers produced by fish. Water flows can also be exchanged between aquaculture and the greenhouse in order to work together more efficiently. Another project explores the exchange of material flows between greenhouse horticulture and pig farming. These include surplus manure from pig farming and the use of green waste from greenhouses as animal feed.

In the penultimate year of this project, fundamental research already provides a list of follow-up studies, for example, to replace mineral fertilizers with organic, circular fertilizers. Sometimes small, simple solutions prove to be effective, says researcher Erik van Os. 'Biodegradable clips have been introduced in the cultivation of tomatoes and bell peppers, and now biodegradable rope should also be used. Then the crop can be chopped and composted more easily. A solution that really contributes to reducing the volumes of plastic.'

Who: Wageningen Plant Research (main performing party).

Duration: 2019-2022.

Budget: €120,000 per year.

Follow-up: Several follow-up projects are underway.

Circularity in greenhouse horticulture is closing

Harmony between water, energy and food

The ever-increasing population growth and climate change are leading to a growing demand for water, energy and food worldwide. These three sectors do not always work in harmony with each other, which threatens to cause shortages. The Water-Energy-Food Nexus approach seeks coherence and synergy. ▶

Reinaldo Peñailillo Burgos of Deltares.

Deltares

Problem: the Santa Eulalia River sub basin in Peru is not used efficiently by the Lima water company, nor by local sanitary facilities services, energy companies or farmers. This has caused shortages of water, energy and food.

T02 Solution: deltares partnered with WUR and TNO to develop an approach in an integrated manner, to assess and identify connections among these three sectors, to enable stakeholders to manage these resources more efficiently.

Impact: the project in Peru is not an isolated one. There are many more areas that can create better living conditions for the population by using this approach. That prompted the Bonn 2011 Conference to launch the Water-Energy-Food Nexus, which provides endangered areas with an integrated approach to water, energy and food. Knowledge institutes in the Netherlands contribute to this.

The Santa Eulalia River sub basin in Peru provides the 10.5 million inhabitants of Lima with water. In addition, the area is important for energy production. Five hydroelectric power plants were built in the river, accounting for 70% of Lima's total electricity consumption. There are also ten farming communities who depend on food supplies, mainly in agriculture and livestock farming. A sectoral approach and limited coordination, mean that the management and use of water, energy and food is not in balance and there is a constant demand for these resources. The Water-Energy-Food Nexus approach seeks to improve this. It is an integrated approach to find connections among three sectors, to manage the supply and demand of these resources more efficiently, and to make them available for the long term.

Connections

Deltares, TNO and WUR conducted research in this area in 2020. A nice combination: Deltares has a great deal of knowledge in the field of water, Wageningen University & Research knows everything about food, and TNO knows all about energy issues. 'In the next few years, Lima's population will grow further and it needs more energy, water and food', says Reinaldo Peñailillo Burgos of the Water Resources and Delta Management department at Deltares. Due to a lack of cooperation between the water company, utilities companies and farmers' associations, less water is available for the inhabitants and for agriculture in the valley. 'Coordination was weak and they did not know enough about each other's systems, and how those are connected to each other. Aside from that, the ecosystems have deteriorated, and as a consequence, the water availability (or rather lack thereof), water quality and sediment control.'

In the first phase, the researchers identified the key stakeholders in the sub basin and gathered details of the characteristics and problems in the light of population growth and climate change. In 2022, phase 2 will commence and Deltares offers support for decision-making on the area. 'We process the gathered information in tools and models to portray future scenarios. For example, you can calculate the extent of water shortages in forthcoming years and the impact

that this will have on water users and ecosystems.' At the request of the Dutch embassy in Peru, potential pilots have been identified. 'The water consumption by some farmers in the area is high. They can use our know-how to start a pilot, for example, to provide farmers with suggestions to deal with resources more efficiently.' Other prospects include technologies that raise the chance of water availability, such as the reuse of wastewater for irrigation or hydrological regulation with green infrastructure and ecosystem recovery. Another prospect is to optimise the reservoirs. ■

Who: Deltares, TNO, WUR, Futuro Sostenible (Peru).

Duration: The first phase was completed in 2020, phase 2 started in 2021 and lasts for one year.

Budget: €100.000 in phase 1.

Follow-up: The Dutch embassy in Peru will use the knowledge gained in pilot projects to improve the living conditions of inhabitants.

An alternative to testing on mice

In 2025, the Dutch government wants to be the world leader in the field of animal-free innovations. For research into food safety, Wageningen scientists are developing various alternatives to laboratory animal experiments. ▶

WUR

Problem: laboratory animal experiments can cause animals to suffer and, what's more, they are often not predictable enough where it concerns substance toxicity in food for humans.

TO2 solution: Wageningen University & Research develops animal-free test methods with cells cultivated in the laboratory. These are used for food safety research.

Impact: after national and European acceptance of these methods, fewer laboratory animals are needed and can sometimes even be fully substituted.

For many years, laboratory animal experiments were the only permitted method to determine whether shellfish such as mussels and oysters contain toxins. Researchers injected a shellfish extract into a mouse or rat and looked at whether the animal continued to live. If it died, the mussel or oyster was toxic. Researcher Ad Peijnenburg says that was such a rigorous method, which has now fortunately been substituted by a chemical analytical method that saves animals and which has largely been developed at WUR. On an annual basis, this 'mussel test' saves around three hundred thousand European rats and mice.

Cell cultures

Peijnenburg and his peers are mainly concerned with the development of biological methods to test substances that may be detrimental if present in food. In so doing, human cells are treated with a substance or combination of substances. Then, various techniques are used to assess whether effects emerge which indicate any toxicity. Computer models are also developed to 'translate' the results of the cell cultures into the situation in the human body. Making use of various case studies, Peijnenburg wants to explore and validate the viability of these methods.

Plant toxins

At the request of the European Food Safety Authority (EFSA), Wageningen toxicologists examined whether and to what extent a group of plant substances that is known to be toxic – pyrrolizidine alkaloids (PAs) – which occur in ragwort (Jacobaea vulgaris), for example, and as food contamination, is detrimental to humans. Research with laboratory animals previously showed that these substances can cause DNA damage and cancer. Wageningen research with human liver cells shows that these toxic effects also occur in humans. The researchers also discovered that there are major differences in the potency of the various PAs. 'Not all PAs appear to be equally hazardous.' Thanks to the research by Peijnenburg and his peers, EFSA is able to carry out a more realistic risk assessment. This is a result achieved without the use of laboratory animal experiments.'

Mineral oils

Researchers are already working on a new case study into the effect of aromatic hydrocarbons in mineral oils on cell cultures. These oils can also come into contact with food via ink on packaging materials and pose a potential risk to humans. Here too, the concern is that hydrocarbons could possibly cause DNA damage. The aim of these studies is to demonstrate the value and viability of alternative methods and thus to promote acceptance (by regulators and risk assessors) and the application of these animal-free alternatives. ■

Who: Wageningen Food Safety Research

Duration: 2008-2021.

Budget: €200,000 per year.

Follow-up: Expand research into other animal-free alternatives and other case studies in the field of food safety.

Catching COVID-19 on an aircraft? There's a small risk

The chance of catching COVID-19 in an aircraft is small. If there is a contagious person on board, the greatest risk is run by those in the three rows behind that passenger. This was shown in research by Royal NLR and RIVM using mist-spraying dummies during test flights. ▶

NLR

Problem: imagine a person that has COVID-19 boarding an aircraft. What is then the risk of another passenger also becoming ill?

T02 solution: royal Netherlands Aerospace Centre (NLR) in conjunction with the RIVM investigated the risk of COVID-19 in an aircraft cabin. Measurements were taken on board test flights using dummies as passengers, in which a 'contagious passenger' released artificial saliva. Simulations mapped different circumstances.

Impact: research offers governments and aviation companies a better insight into measures to reduce the spread of the coronavirus. It is essential to gain more knowledge on this subject matter as long as the virus is not under control.

Just imagine that, despite having health certificates and mandatory testing, there is a person on board that has COVID-19. Then the passengers in the three rows behind this passenger run the greatest risk of getting infected. For the people in front of or next to the passenger, that risk is smaller. 'We did not expect this outcome from the beginning', says NLR's aeronautical engineer Rui Roosien. He conducted an NLR study in conjunction with the RIVM on risks of corona infections in aircraft. 'Air from the ventilation system above the passengers flows downwards, but our investigation showed in the test set-up that particles were also drawn aft', Roosien explains.

Dummies as passengers

Measurements were taken on board test flights using dummies as passengers. One of the dummies released fake 'contagious' artificial saliva. Roosien: 'Sensors on the dummies were used to determine the quantities and volumes of particles in the cabin section. We also introduced simulations to map the spread of aerosols under various circumstances.'

The study shows that the chance to getting sick varies from around 1:1800 to 1:120 for a regular flight duration. This increases for longer flights, but the chance of contracting the illness is relatively small. It is comparable to those in well-ventilated areas on the ground. According to Roosien, this makes flying relatively safe. Wearing a face mask reduces the risk in any case. 'In the study we assumed that 90% of the time people wear their face masks, except when they're eating or drinking', says Roosien.

Virus particles

'This research combines literature studies, measurements and simulations, various test flights with a mist-spraying dummy in a test set-up with other dummies and sensors, as well as a risk analysis', Roosien explains. 'The US Defence and aircraft manufacturer Boeing, also investigated the risk of infections on board, but there has been no research into the combinations that we created. We also investigated the size of virus particles.' In addition to the type of aircraft, flight duration and seating of a passenger, this factor is important for the extent of spread of the virus particles. Other studies used particles of fixed and uniform sizes. ■

Who: Ministry of Infrastructure and Water Management (client), RIVM, Royal NLR, DLR (the German counterpart of NLR, supplied test dummies), MedSpray (supplied the nebuliser), airline companies (made aircraft available).
Duration: July 2020 – June 2021.

Follow-up: Further research in the context of the EU's Horizon Europe programme on the theme sustainable transportation and health.

Accelerated drug development

As the only one in Europe, TNO has a biomedical Accelerator Mass Spectrometer (AMS). Lead scientist Wouter Vaes developed an innovative method to enable faster, safer and cheaper drug development using this AMS. ▶

Wouter Vaes of TNO.

TNO

Problem: drug development is expensive, time consuming and risky. Development, from laboratory to patient, often takes longer than a decade and can run into billions of euros.

TO2 solution: TNO has developed an innovative method, using Accelerated Mass Spectrometry, aimed at process acceleration of clinical trials with candidate drugs. By automating the preprocessing of sample analyses of blood, plasma, urine or faeces, the process has been reduced from 6 days to 12 minutes.

Impact: the advantages are immense, because by using the AMS studies in humans can be carried out sooner, which will lead to drugs being introduced sooner. Research using the AMS can accelerate the development process of drugs by up to two years. Fewer laboratory animals are also needed.

It takes as long as thirteen years for a potential drug to progress from laboratory to patient. The costs of this could run into billions. Drug development is expensive, time consuming and risky. The probability that development fails during costly clinical trials and pretrials is high (around 90%). The reasons for this include a lack of efficacy (in 60% of cases) and safety reasons (40%), if the candidate drug has detrimental side effects for humans.

Innovative method

New collaborations and technological developments for process acceleration are of vital importance to reduce these costs (process acceleration leads to reduced development time and therefore a longer cost recovery period on patents), and to stimulate development of these drugs, so that they are available to patients faster and where possible, at lower prices. A TNO team led by Wouter Vaes devised this innovative method. This is unique process-acceleration technology: microtracing in combination with Accelerator Mass Spectrometry (AMS), including fully automated sample preparation and analysis. Wouter Vaes: 'The AMS was originally used in geology for dating materials. I saw the machine about twelve years ago at the University of Utrecht and was intrigued by its size (which was about 50 metres long) and its operation. An AMS consists of a linear accelerator, and by accelerating carbon-14 (14C) particles in a mammoth bone, for example, we can count individual atoms in a detector. Carbon-14 is radioactive and therefore decays. If the bone contains minimal carbon-14, then it is very old. At that time I thought it could probably be used in other fields, too. However, the plasmaprep – the essential sample preparation – took as long as six days.'

Aided by government subsidies, among other things, TNO acquired such an AMS. 'Subsequently, we developed another fully automated method to preprocess samples. Nowadays, we use the AMS to carry out fully automated sample analysis of blood, plasma, urine or faeces, based on automated combustion technology. This method allows us to optimise sample preparation and analyse many more samples per day to guarantee a shorter turnaround time. We have been able to reduce the preparation time from 6 days to 12 minutes. Moreover, the procedure is less labour intensive and therefore cheaper.' ▶

'We developed another fully automated method to preprocess samples.'

TNO

Microtracing

This innovative method is also practical in a pharmaceutical context and makes a major contribution to accelerated drug development. Strict guidelines apply when it comes to drug testing. 'Microtracing provides detailed information on how a particular substance is absorbed into the body and how it is excreted again. It is a technique in which tiny amounts of a drug are administered in humans to explore the feasibility of the drug at an early stage. We are then able to analyse this using the AMS.'

Due to the very low load of radioactivity – required for research into the effects of drugs – it is possible to test the drug on humans much sooner. This is already possible in the first phase of the clinical trial, rather than in the last and most expensive phase of the clinical trial. But not just that, 'the new method also allows us to conduct more and more trials with humans in the preclinical phase or even skipping aspects of the preclinical trial and directly conducting risk-free trials on humans. This allows us to accelerate trials and reduce the number of laboratory animals needed.'

Accelerated introduction

The advantages are immense, because acceleration of the process not only saves development costs, it also leads to drugs being introduced sooner. Research using the AMS can accelerate the development process of drugs by up to two years. It is not surprising that the pharmaceutical industry has already embraced this innovation. An intensive cooperation has been established with major pharmaceutical companies, such as Pfizer. 'We are now running more than 20 studies into the development of drugs annually. Requests keep on coming in from all over the world – Japan, Korea, the US and Europe', says Vaes. 'We're fully booked until halfway through 2022, so we will need to enlarge our team. This is a real game changer for the pharmaceutical industry. In the meantime, we are steadily working on the method itself. As far as I am concerned, sample preparation can be done even faster than in those 12 minutes.' ■

Who: TNO and pharmaceutical companies.

Follow-up: Currently, there are 20 studies into drugs annually, and this is expected to rise.

Accelerated drug development

New military uniform: both recognisable and well-camouflaged

In future, Dutch service personnel can be recognised by the Netherlands Fractal Pattern (NFP) printed on their uniforms. This pattern combines effective camouflage that is versatile in a variety of terrains. ▶

TNO

Problem: Dutch service personnel were in dire need of a contemporary and better camouflaged uniform with a distinctive Dutch flair.

T02 solution: in cooperation with Defence, TNO developed a multipurpose camouflage pattern based on 'fractals'; recurrent similar patterns that you also find in nature. This camouflage works very well both close by and from a distance.

Impact: the Netherlands Fractal Pattern (NFP), as the Dutch camouflage has been called, combines recognisability and wide versatility with more safety for the military. All clothing and equipment of the Dutch military are provided with this pattern which has been developed by TNO.

Woodland, desert, forest, jungle. These are the four different camouflage variants from which Dutch service personnel could choose until recently. But which uniform should you wear in an environment that is a mixture of dry and green areas, a dilemma that soldiers were faced with in the fertile river valleys of dusty Afghanistan? Or, when working in an urban environment? These were realistic dilemmas that prompted Defence re-examine the existing uniforms. Could a camouflage pattern be created that is effective in several environments? And could the Dutch military clearly distinguish themselves from service personnel from other countries? In 2009, this triggered the quest for a new, Dutch uniform that combines both requirements.

Field trials

The 'fractal' was chosen as the basis for the new camouflage. In other words, geometric figures that progressively accumulate out of smaller, more or less uniform figures. This creates infinitely detailed geometric figures that can be seen at multiple scales, both close by and from a distance. 'Fractal-like patterns often occur in nature, such as the structure of a tree or flower bud', says Maarten Hogervorst of TNO. 'Human perception tends to cluster similar patterns into a whole. So, a fractal-like pattern among foliage hardly stands out, hence, it is useful as camouflage.'

A single camouflage for every single environment, proved impossible. That is why there are four variants of the Netherlands Fractal Pattern (NFP): NFP-Green for wooded, rocky and urban areas; NFP-Tan for deserts, steppes, savannas and cities in these kinds of environments; NFP-White for snowy terrain; and NFP-Blue for fleet personnel.

Velcro

These colour schemes were created based on landscape photographs in combination with field trials. These trials also led to other discoveries, says Hogervorst: 'For instance that plain-coloured elements, like Velcro and fastening straps, impinge on the camouflage more than you would expect.' That is why these elements will now be fitted in camouflage or matching colours. All equipment – such as vests and backpacks – will also be provided with a matching camouflage pattern.

This does not mean the investigation into optimal camouflage colours and patterns has been completed. 'It seems to make quite a difference in how to spread netting when camouflaging vehicles', says Hogervorst. How to conceal yourself against thermal imaging and other sensors still remains quite a challenge. 'Of course, it all starts with a good uniform, which we fortunately have now.' ■

Who: TNO in cooperation with the Ministry of Defence.

Duration: the new patterns have been designed since 2009.

Follow-up: several follow-up studies are underway, including effective camouflaging of service personnel and military matériel for sensors such as thermal imaging scopes.

Test in the breakers

How do boats pass safely through the breakers so that crew members can land? Eelco Harmsen of MARIN had a model beach built to test that. 'We are now able to investigate whether a vessel is safe and know how to avoid capsizing.' ▶

MARIN

Problem: more and more countries are expanding their naval fleet with rigid-hulled inflatable boats (RHIBs). These rigid-hull boats are increasingly navigating faster. But how can you safely get through the breakers in landing operations?

TO2 solution: MARIN built a model beach and carried out tests with a boat modelled to scale, making it possible to make complex calculations.

Impact: safe landing instructions for Defence's amphibious operations.

'Many countries are expanding their naval fleet with landing vessels such as rigid-hulled inflatable boats (RHIBs). With their rigid-hull bottoms and air tubes all around, these boats increasingly navigate faster. They want to know how to get through the breakers safely', says Eelco Harmsen, Senior Project Manager at MARIN. The Maritime Research Institute in Wageningen conducts research into hydrodynamics and maritime technology by means of simulations, model tests and true-size measurements. How do you carry out landing operations safely? Operation Blue Beach had to find the answer to that question.

Safe amphibious operations

Harmsen outlines a D-Day-like scenario. 'You don't want boats capsizing and crew members toppling overboard when they're navigating through the breaker.' He notes that there is a need for research into safe amphibious operations. 'This had previously been surveyed with the best intentions, but the findings were not in line with reality.' There is no standard, readily available surveying method. 'We wanted to spend time on testing to see exactly how this works.'

Running the test along the coast – at a real beach with real boats – would be too dangerous for the crew. 'Besides, you want to exercise control on the circumstances so that you can create relevant and meaningful situations. You need quite a large beach to get a realistic depiction of waves.' MARIN built a model beach to scale in a basin, something that has not been done very often in the world. MARIN researchers were able to get started due to a grant of research funds from the Royal Netherlands Navy and its own research funds.

Analysing complex measurements

The boat was modelled to a scale of 1:8 and this appeared to make it difficult to follow the boat. A bridge was placed across the basin, onto which a measuring platform was stationed that followed the small boat with cameras. Sometimes the boat went so fast, that it disappeared from view and failed to record measurements. The research team learnt that they had to take a larger measurement

range and set the measuring trolley as aggressively as possible, to be able to keep following the model. The way in which the researchers analysed the data was also different to normal. Harmsen: 'In a normal swell of the sea you can assume similar conditions. But if you navigate to the beach hundreds of times, not once is it the same. The water depth, the breaking of the waves and the deceleration; the situation changes every five seconds.'

Yet, MARIN managed to analyse these complex measurements and to translate them into operational deployability, enabling the institute to be ready to tackle research questions. Those questions would arise from across the globe because many countries are buying new landing boats. Harmsen: 'We can assess whether a vessel is safe for the intended operations and give instructions on how to safely carry out a landing operation.' ■

Who: MARIN and the Royal Netherlands Navy.

Duration: 2020-2022.

Duration: six months.

Budget: €250,000.

Follow-up: MARIN is now able to answer research questions from across the globe.

View a YouTube video here

Rapid clarity on drug sample

Determine with a simple click whether a street sample contains cocaine. This can be done with an NIR scanner that scientists in Wageningen jointly developed with NFI, RIVM, the police, customs, UvA and CLHC. The next step is to develop a scanner that also detects other commonly used drugs. ▶

WUR

Problem: if the police or customs find drugs, it is not always clear whether the sample contains cocaine. There are scanners that can trace this, but they are very expensive.

T02 solution: wageningen Food Safety Research developed a simple handheld near-infrared (NIR) scanner that can quickly establish, on site, whether a sample contains cocaine.

Impact: the NIR scanner enables investigative services to establish faster whether it qualifies as a criminal offence (drug possession). The scanner is much cheaper than scanners currently being used by investigative services.

They have been using the same instrument for years, but had not collaborated before. All forensic scientists, the police, customs and food-safety laboratories use the NIR scanner if they quickly want to establish the contents of a certain sample's substance. In 2017, they decided to collaborate on a new application: tracing cocaine in street samples. Statistical researchers at Wageningen checked whether the measurements were correct.

Under normal circumstances, the NIR scanner at Wageningen Food Safety Research is mainly used to demonstrate protein levels in food or moisture content in meat. The police and the NFI examine mixtures of drugs and medicines quite often. Apart from WUR, almost all government labs appeared to be faced with cocaine, so the choice for this substance was obvious. Researcher Yannick Weesepoel and his peers programmed the scanner's signal as such that it can give a positive or negative diagnosis.

Prototype

In doing so, they faced different challenges as there were two types of cocaine; for sniffing and for smoking. In chemical terms, the scanner detects completely different substances, but in both cases it should give a positive diagnosis. Another complicating factor was that cocaine is almost never found in a pure form, but it is cut with fillers or other pharma-related substances such as paracetamol. To make it even more complicated, there are also substances in circulation that are permitted and give a similar signal.

The system was tested with 76 street samples from Amsterdam. The composition was already known and the scanner proved to be capable of 'robust cocaine detection', says Weespoel. With samples arriving every week at NFI, customs and the police, statistics were then improved and refined. The current prototype looks like a small remote control device with a single button that connects to a mobile phone. It costs €250, which is much cheaper than the RAMAN scanners currently being used by investigative services which cost €50,000 each.

There are several ways to establish whether a sample contains cocaine, for example, using a colour test, but this has the disadvantage that a different test is required for each type of drug. Whereas the NIR scanner can also be used for other types of drugs, such as XTC. In 2021, the research subject was to identify the 5 most common drugs in the Netherlands. Publication of these results is expected in 2022. ■

Who: WUR statisticians jointly with the police, customs, NFI and RIVM.

Duration: 2018-2021.

Budget: WUR budget €25,000 (and additionally, budget from other partners)

Follow-up: Research into other drugs that are commonly found (cocaine, amphetamines, XTC, methamphetamines and ketamines)

From unwanted sludge to valuable clay

The sea dyke from the Johannes Kerkhovenpolder up to the German border in the Eems-Dollard region must be strengthened in the coming years. Instead of more asphalted dykes, there will be a green dyke of locally-sourced clay. ▶

Deltares

Problem: there is too much sludge in the Eems-Dollard sub basin. As a result, the water quality is inadequate and biodiversity is declining. At the same time, there is a need for clay in the region to strengthen the current dykes, which no longer meet the requirements for 2050.

T02 solution: by extracting sludge from the Eems-Dollard region and converting it into clay, the water quality improves and clay becomes available for dyke reinforcement. Deltares measures and models clay ripening in the field. In the Delta Flume it tests a dyke of locally-sourced clay, carries out small-scale geotechnical experiments and model simulations, and is involved in the monitoring of a trial dyke in the field.

Impact: this project contributes to better protection against high water and floods in the low-lying Netherlands and offers prospects for future dyke construction. By constructing part of the dykes with locally-sourced clay produced from extracted sludge, this also reduces costs, the environmental impact, and nuisance. This will help to ensure good water quality, climate adaptation and the reuse of local raw materials.

The government's High Water Protection Programme works with 21 Water Boards to strengthen at least 1,500 kilometres of dykes to protect the Netherlands against 'rising waters'. Rijkswaterstaat wants to explore innovative solutions of dyke reinforcement, to undertake necessary improvements better, more sustainably, and cheaper.

Clay ripening facility

A fine example of this lies in the Eems-Dollard sub basin, near Delfzijl. Instead of reinforcing the sea dyke in a conventional way with asphalt, the Hunze and Aa Water Board wants to reinforce the current dyke between the Kerkhovenpolder and the German border with circular clay: a wide dyke that stretches for eleven kilometres, provided with a thick layer of clay, covered with grass.

Several parties including Deltares are involved in this project, which comprises several phases. Sludge has been extracted from the Eems-Dollard region near the port of Delfzijl since 2018. 'The sludge is transported by pipeline to a clay ripening facility to let it dry, and where it ripens for several years', says Luca Sittoni of Deltares. In 2022, the collaborating parties will construct a trial dyke measuring 600 to 1000 metres along the coast of North Groningen: the Wide Green Dyke demonstration project.'

Research

In the meantime Deltares has started on research project Suitability of Delta Clay, to test the processability and erosion resistance of locally-sourced ripened clay. Sittoni: 'To comply with the requirements of the technical guidelines for dykes, we need to reduce the amount of salt and organic substances during the drying process. This went slower than we had thought and, with that in mind, we started the research anyway into how to construct a safe dyke with this locally-sourced and ripened clay.' Aside from Deltares, private companies such as Van Oord and Boskalis also collaborate with regional authorities such as the Hunze and Aa Water Board and the Province of Groningen. The High Water Protection Programme is the most important financier and advises on the research. TKI Delta technology also provides a financial contribution.

The green dykes will help protect the Netherlands in future from flooding and high water, which may arise due to climate change. ▶

Deltares

From unwanted sludge to valuable clay

▶ In the Delta Flume at Deltares, researchers test a dyke of locally-sourced clay. They also carry out various related small-scale studies in the Deltares laboratory. In the flume, part of the dyke has been constructed at its true size and subjected to the conditions of a super storm, which occurs once every ten thousand years. 'The reference value is that the clay must withstand a super storm for 15 hours, but after 22 hours the dyke was still holding up', says Luca Sittoni. The results of the clay research are applied in designing the Wide Green Dyke.

One hundred thousand trucks

Safety is the primary goal, but this project is also an example of sustainability in which unwanted, locally-sourced sludge is converted into valuable clay. 'It makes the Dutch delta region safer, but in a sustainable way because of the use of local, natural materials', says Sittoni. Instead of transporting 100,000 trucks of clay from elsewhere, large volumes of sludge have been extracted from the salt marshes and the port of Delfzijl fifteen kilometres away. By extracting the sludge, the ecological quality of the Eems-Dollard region improves. Due to there being less sludge in the water, for example, there is more light, which improves the living conditions for fish and vegetation. The locally-sourced sludge can be used to raise agricultural land.

If the trials with the Wide Green Dyke are successful, then from 2024 onwards, the entire Dollard Dyke will be constructed using the same materials and design across a stretch of about eleven kilometres. 'If we can prove that this can be done, then in the long term this technique will also be able to strengthen or replace other dykes in the Netherlands and possibly abroad.' ■

Who: Hunze and Aa Water Board, Province of Groningen, Deltares, Van Oord and Boskalis. The High Water Protection Programme is the most important financier and advises on the research.

Duration: Until 2024.
Budget: €7 million, of which Deltares spends €2 million

Follow-up: The demonstration project Wide Green Dyke will be constructed in 2022. This dyke will be monitored from 2022 to 2024, with a significant contribution by Deltares.

Spot, the mechanical tracker

Introducing: Spot. A combined inspector and tracker. Spot is not of flesh and blood, but a robot on four legs. TNO is expanding possibilities aiming for: a robot that does not need help to inspect environments that are hazardous for humans. ▶

TNO

Problem: manufacturing sites in the chemical industry, a drug laboratory or a disaster area are hazardous for inspectors or rescue workers. For example, when searching for victims under debris or in the event of leaking tanks at chemical companies.

T02 solution: spot the robot, looks like a four-legged dog, can inspect a hazardous environment without endangering humans and animals. Equipped with a 360 degree view, Spot immediately 'sees' what's going on around him.

Impact: jobs in (for example) the chemical and petrochemical industry, at the Ministry of Defence or the police are safer if Spot can take over tasks. Spot also shows that robots are useful to people: Spot can change the way we look at robots.

When viewing video clips about Spot, you might laugh at the stiff and simultaneously authentic movements. But this robot is not only endearing, it can be invaluable to the police, Defence, and the chemical and petrochemical industry.

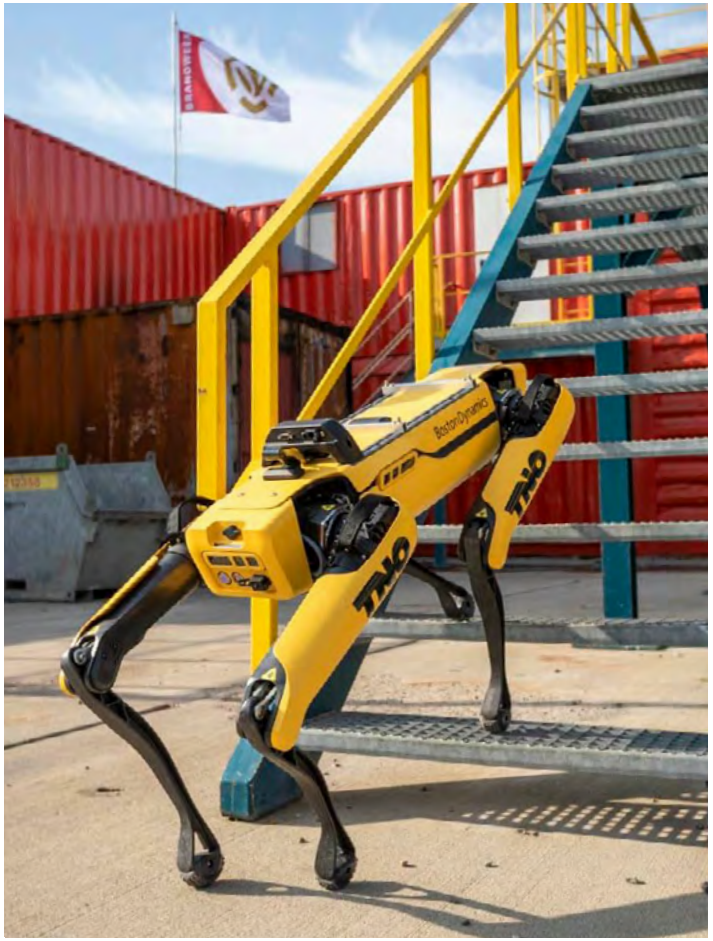
Hazardous work

Imagine the following setting: a gigantic manufacturing site with huge tanks. What is the contents of those tanks? Chemical substances that are not only toxic, but also highly flammable. A leak or excessive pressure can have catastrophic consequences. Ongoing and accurate inspections are essential. Nowadays, such inspections are carried out by people and that is hazardous work. There is always a risk of toxic gases being released or an explosion. ▶

TNO

We have good news for these inspectors: in future a robot can take over this work.

TNO is working hard on the continued development of this robot. Objective: an autonomous robot that inspects a potentially dangerous drug lab, inspects a disaster scene or patrols at the royal palace without any risk to humans and real animals. Equipped with a 360 degree camera view and a microphone, Spot can see and hear what's happening around him. As the robot will soon be equipped with the latest technology in the field of artificial intelligence, it will be able to work independently. An autonomous robot: no joystick or human operator is needed.



Spot, the mechanical tracker

Artificial intelligence

Spot was initially intended for use on construction sites, where it can transport equipment to places that are difficult to reach. It soon appeared that Spot could well serve as a tracking and reconnaissance tool. TNO is liaising with KMar (the military police) about using Spot for these purposes and is also working hard on other potentials. For example, research leader Joris Sijs and his team at TNO are developing algorithms based on artificial intelligence, to enable Spot to independently search a building for human victims after a disaster. Another wish: that Spot will also be able to survey an environment unknown to him. Spot will probably be ready in three years' time to inspect chemical or petrochemical plants. Maybe, in five years' time, you will not be addressed by a person in uniform, but by a robot dog who asks why you are walking on royal palace grounds without permission. ■

Who: TNO and Boston Dynamics.

Duration: the robot has been developed by Boston Dynamics in the US and, since September 2020, TNO has further developed the self-reliance and independence of this robot.

Budget: €1 million per year. Cost of 1 Spot: $75,000

Follow-up: in about three years' time there should be a version that makes Spot a useful tracker for 'real work' in the field, such as the inspection of chemical plants.

View a YouTube video here

Into space with military precision

No bigger than a shoebox, barely weighing 10 kg. The BRIK II flies into space within 90 minutes, to orbit Earth at an altitude of six hundred kilometres. The Royal Netherlands Aerospace Centre (NLR) supports the Royal Netherlands Air Force (RNLAF) in the development of this first Dutch military satellite in space. What an amazing feat! ▶

Bert-Johan Vollmuller of NLR.

NLR

Problem: satellites are indispensable for all kinds of applications, such as observation. The Dutch armed forces do not want to lag behind either in this advancement in outer space. At present, the armed forces are dependent on other NATO countries for data derived from satellites. They do not always provide the data you want.

T02 solution: with the BRIK II experimental project, the Ministry of Defence is launching its first satellite into space. Royal NLR designed one of the key instruments on board, called Phino. This hyper-efficient device allows the armed forces to monitor radio signals from outer space.

Impact: the fact that Defence is able to independently collect crucial data from outer space, makes the Netherlands safer. Thanks to enormous technical advances, small satellites have become affordable and they can carry matured instruments on board, including those from NLR. Dutch companies and knowledge institutes also benefit from this. They can extend their position as the world leader in small satellites.

There was some tension on the afternoon of 30 June. Contact was lost between the LauncherOne rocket and Virgin Orbit ground station in the Mojave desert of California. Nobody could see if the satellites were being ejected from the rocket or if they were stuck. 'Do we have to worry?', project leader Bert-Johan Vollmuller and NLR's space engineers wondered. In a hall along Antony Fokkerweg in Amsterdam, they were following the launch of 'their' BRIK II via a livestream. Tension was also running high during the livestream in the Royal Netherlands Air Force Command (CLSK) in Breda. Would LauncherOne manage to climb to an altitude of six hundred kilometres after launching from the wing of Cosmic Girl; a Boeing 747-400? Will delivery of this first Dutch military satellite succeed exactly in the right position?

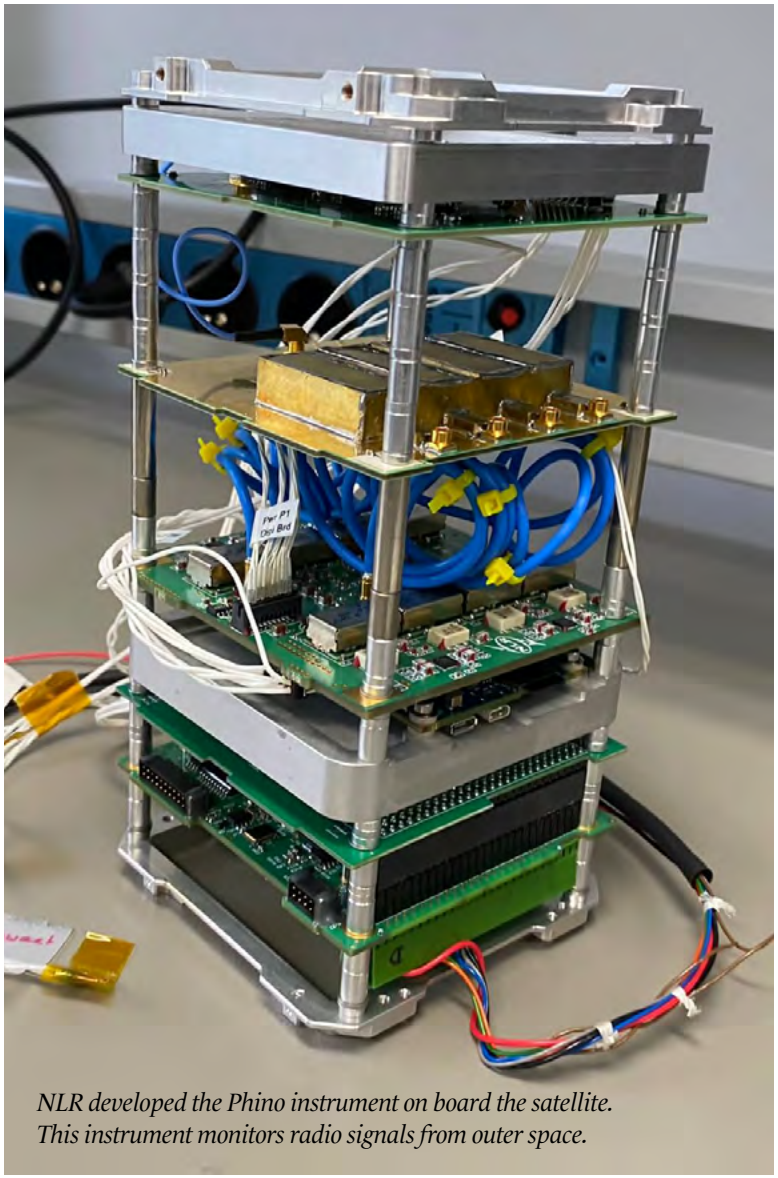
Nanosatellite

With its first satellite, the Ministry of Defence was testing the possibilities of nanosatellites for military and civilian use. The satellite was packed with ingenious instruments for navigation, observation and communication. This makes the armed forces less dependent on third party satellites. They are not always available, or the countries provide incomplete data. Defence does not exactly want to reveal to other NATO countries what it is searching for.

The satellite was named after the first Dutch military aircraft the Brik, which explored the skies in 1913. Since 2017, the NLR team has worked intensively with engineers from the CLSK, the Delft company Innovative Solutions in Space (ISISpace), the University of Technology Delft and University of Oslo.

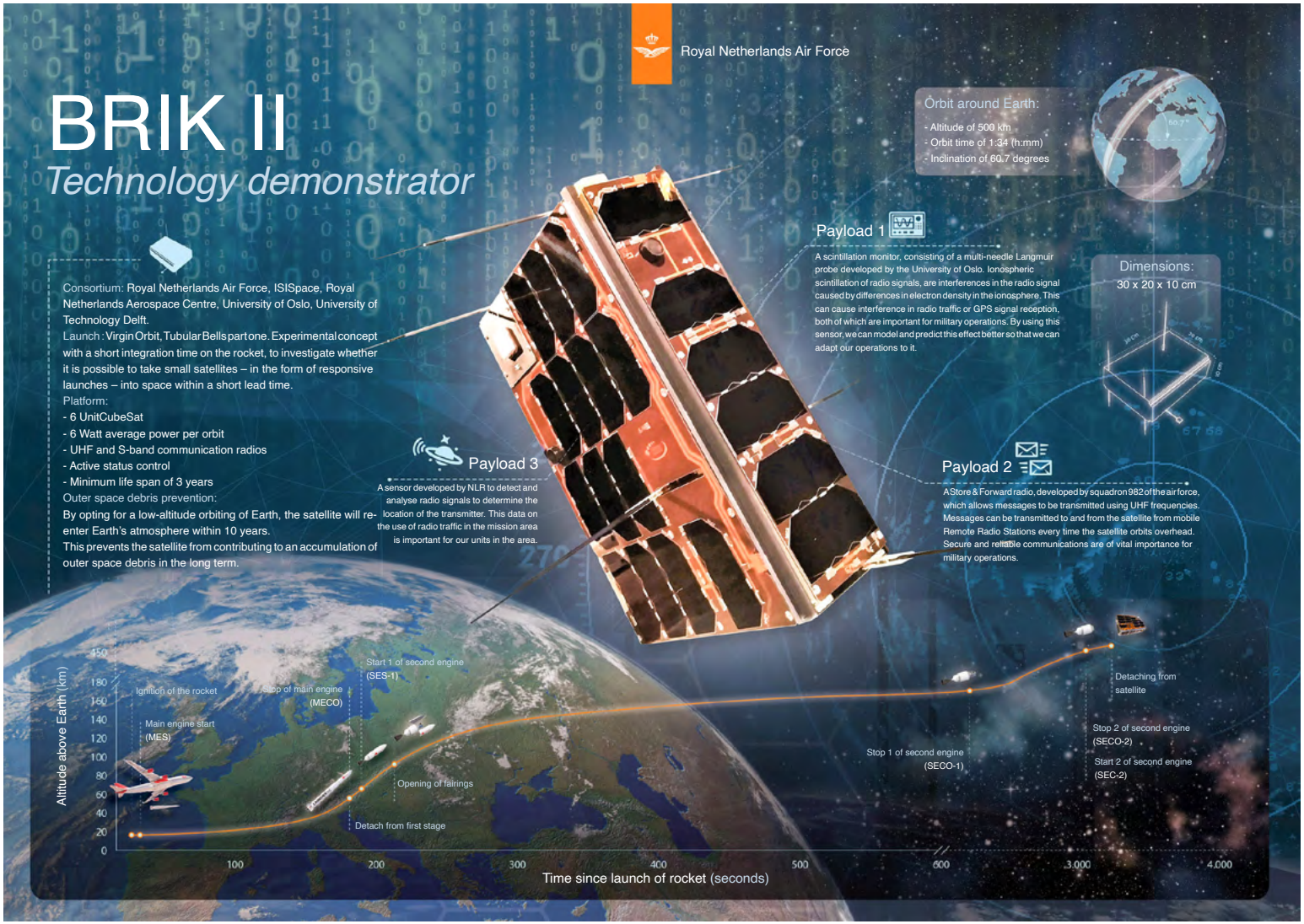
Radio signals

BRIK II is a CubeSat, in which many things have been standardised. Measuring 30 x 20 x 10 centimetres, it is not much bigger than a shoebox and weighs almost 10 kg. ISISpace designed and built the platform on which three instruments have been installed. University of Oslo designed an instrument that identifies interference in the atmosphere. This is crucial data for radio traffic. It indicates how well GPS signals are transmitted. CSLK produced ▶



NLR developed the Phino instrument on board the satellite. This instrument monitors radio signals from outer space.

NLR



Into space with military precision

NLR

Into space with military precision

the second device: a Store & Forward radio. This is a kind of letterbox that allows you to upload messages in the field and download them again at the CLSK head office in Breda, or vice versa.

NLR developed the third instrument on board, called Phino (Patches in Orbit). This instrument monitors radio signals from outer space. 'Such satellites already exist', says Bert-Johan Vollmuller, 'but not on such a small platform, with so little space and not much power on board.' What is particularly innovative, is the algorithm developed by NLR that effectively computes the enormous data flow. The instrument transmits the result to the ground station for further processing. This also happens in an innovative way and, as NLR hopes, even better than with big satellites.

Experimental mission

About seven NLR colleagues were involved full-time in the development of Phino and BRIK II. 'We have access to knowledge from the entire chain: from what Defence wants to achieve with the data, to operation of the instrument, such as antenna design, electrical design, software and mechanics.' Vollmuller thinks it is extraordinary that Defence dares to embark on such an experimental mission. 'The technical infrastructure of small satellites is becoming more mature and more affordable. A decade ago, this was only possible with a much larger satellite, often as part of major bureaucratic partnership projects, which cost between €20 million and €30 million rather than €3 million.'

If the launch is successful, the instruments can be tested. BRIK II has an estimated service life of three years. After that, it will burn up as it re-enters the atmosphere within ten years. In this way it does not leave any waste in outer space.

Sign of life

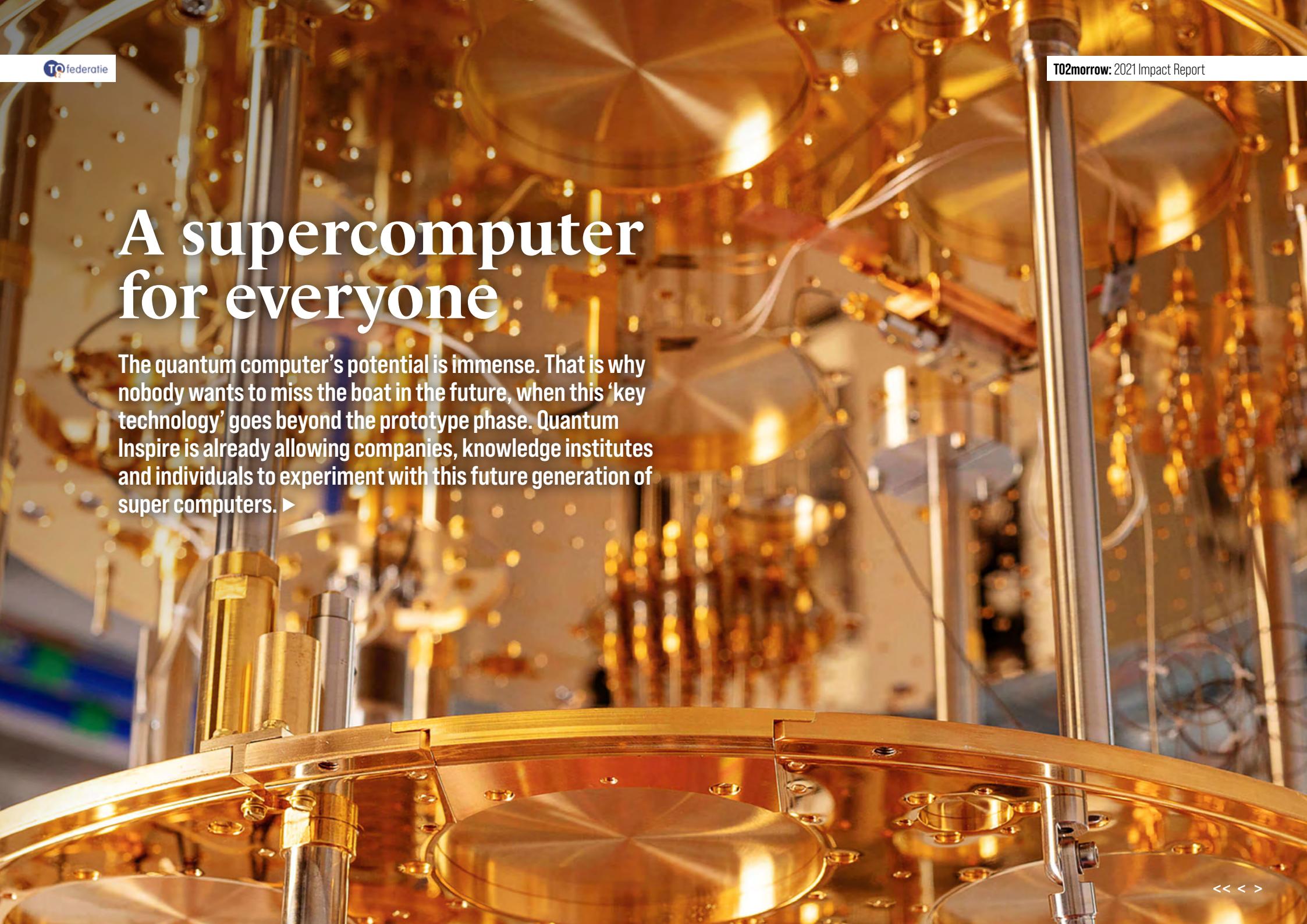
Contact had already been lost for 30 minutes between the LauncherOne rocket and Virgin Orbit ground station in the Mojave desert of California. Tension was running high among the NLR and CLSK engineers. But then came the liberating words from California: 'the rocket has ejected BRIK II correctly at an altitude of six hundred kilometres.' Ninety minutes later there was another message from the CSLK ground station in Dongen: there's a sign of life. Vollmuller still remembers exactly what he thought. 'A first for Defence, the first BRIK II in such a small format, is alive. A fantastic achievement.' ■

Who: Ministry of Defence, ISISpace, TU Delft, University of Oslo, Royal NLR.

Duration: 2017 – yet to be determined.

Budget: Approximately €3 million.

Follow-up: In a Dutch-Norwegian partnership called MilSpace and in collaboration with TNO and the Norwegian Defence Research Establishment (Forsvarets forskningsinstitutt, FFI), NLR is developing the successor to BRIK II. The platform will be acquired by the Lithuanian firm NanoAvionics. This mission comprises two identical CubeSats flying in tandem behind each other. They will be launched with a rocket by the aerospace company SpaceX, which is scheduled in Q3-2022.



A supercomputer for everyone

The quantum computer's potential is immense. That is why nobody wants to miss the boat in the future, when this 'key technology' goes beyond the prototype phase. Quantum Inspire is already allowing companies, knowledge institutes and individuals to experiment with this future generation of super computers. ▶

TNO, TU Delft

Problem: Quantum computing is a 'key technology' that ultimately enables radically new products and services, but this technical infrastructure is barely accessible.

T02 solution: Quantum Inspire is an open platform developed by TNO and TU Delft, which enables everyone – companies, educational institutes and individuals – to experiment with quantum calculations.

Impact: Quantum Inspire contributes to a faster introduction of the quantum computer as soon as the prototype phase is over. The platform also provides for the accumulation of academic and freely accessible knowledge on this key technology. The initiative also acts as a magnet for knowledge institutes, companies and start-ups. This will create an infrastructure that will enable the building of quantum computers and derivatives.

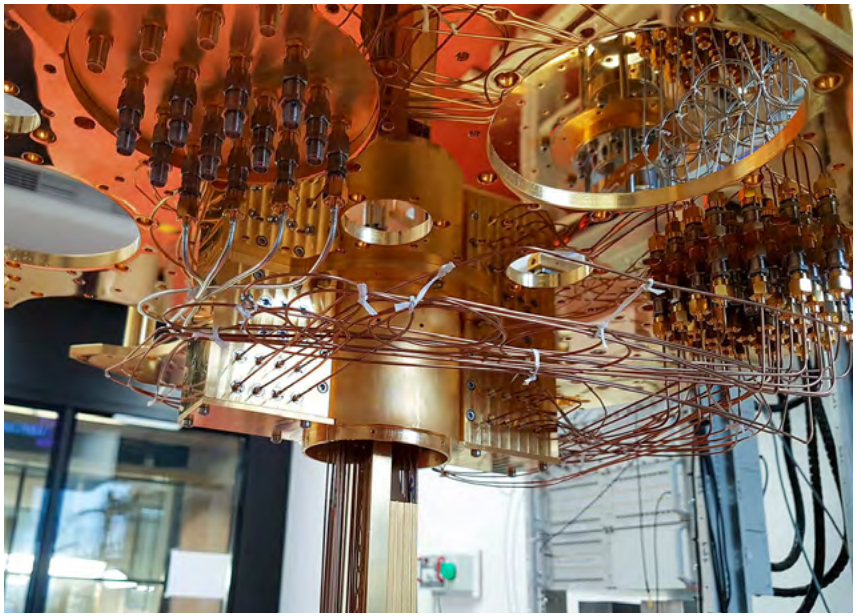
The development of new drugs, the optimisation of energy networks: with its immense computational power, the quantum computer can make a breakthrough in many fields. It is for good reason that major Chinese and American technological companies invest billions in the development of this technology, in the hope of forcing the first major breakthrough. The European Union and the Netherlands do not want to lag behind either. In 2016, the EU invested €1 billion in a large-scale European research programme, of which Quantum Inspire forms a part. Recently, the Dutch government approved the quantum technology growth fund. In that growth fund, Quantum Inspire is one of the key technologies that is further being developed.

Quantum Inspire is a cloud platform that allows users from around the world to experiment with a prototype quantum computer. 'The problem is that quantum technology is not easily accessible. Thanks to our platform, companies and students can already explore the possibilities', says Richard Versluis, an Engineer at QuTech, a partnership between TNO and TU Delft.

Complex device

Quantum Inspire not only serves a social and economic purpose. It also provides the know-how and academic knowledge needed to build such a system. 'This involves many different aspects that, thanks to this platform, we are able to see how our prototypes behave and which questions and applications users have. That provides us with the necessary input to refine our design and to take possible further steps.'

The quantum computer is therefore an extremely complex device, structured on the principles of quantum mechanics. But it is a complicated process going from theory to practice. For example, it is by no means certain which 'building blocks' are the best for the quantum computer. In this respect, too, Quantum Inspire is pushing the boundaries. Versluis: 'This is the only system in the world with two types of quantum chips on which you can perform calculations. This enables us to explore and find out the differences: what the most promising technology would be for the future.'



Overcoming obstacles

The steps that have been taken since the start of Quantum Inspire in 2017 are promising, but there are also many years of research ahead. Yet, this project is exactly what makes the work so wonderful for engineers and researchers, Versluis thinks. 'Jointly coming up with ingenious solutions to seemingly insurmountable problems. Quantum Inspire also makes a huge contribution to this.' ■

Who: QuTech, a partnership between TNO and TU Delft.

Duration: Since 2017.

Duration: No end date as yet.

Budget: Approx. €2 million per year

Follow-up: Quantum Inspire will be continued and expanded with new parties, including some universities and companies.

Personalised nutritional advice thanks to digital look-alike

Scientists in Wageningen are using a digital look-alike to predict how people react to meals. Not everyone reacts in the same way to fatty or sugar-rich foods. The ultimate aim: a digitally generated personalised nutritional advice that reduces the rise in blood fats and sugars and thus prevents long-term health risks. ▶

Diederik Esser of WUR.

WUR

Problem: General guidelines work insufficiently to predict individual health risks of fat rich and sugar rich diets.

T02 solution: Wageningen University & Research combines AI and nutritional knowledge in a digital twin that mimics an individual's biological system and can predict spikes in blood-sugar and fats after a meal. The aim is a personalised nutritional advice, for example via an app, that processes data such as BMI, age, fat distribution, blood pressure and fat response.

Impact: Personalised nutritional advice can make it easier to follow dietary guidelines.

Eat plenty of fruit and vegetables, avoid sugar and be cautious with fats – well-known advice for those who want to stay healthy. There is nothing wrong with these tips, say scientists in Wageningen, but they are actually too general. Each individual responds differently to nutrition. For example, when two people eat bananas, one may have a sugar spike, while the sugar level barely rises for the other. The degree to which this spike manifests itself, has an effect on the development of metabolism disorders such as diabetes. The use of AI makes personalised nutritional advice possible.

A digital twin mimics the reaction in the body and can make predictions about it.

Digital twin

The reaction to a meal is also different for each person on the intake of fats. Not everyone's fat content in the blood rises in the same way after eating a hamburger. This is important to know, because the rate of increase in blood fats is an important predictor of cardiovascular diseases. Unlike for glucose, there are no sensors for monitoring this. WUR does, however, have the data from previous studies of 500 middle-aged overweight people. They use that data to build a digital model that can be used in a digital twin, which mimics the reaction in the body and can make predictions about it.

What makes such a digital copy so convenient is that you can then adapt circumstances and predict effects, says researcher Diederik Esser. A team of researchers are working under the leadership of Lydia Afman on a biological digital look-alike project 'Me, my diet and I'. Aside from nutritionists such as Esser, the team consists of behavioural scientists, bioinformatics engineers, technical public administration experts and consumer surveyors.

Personal preferences

The ultimate aim is a personalised nutritional advice, which includes data such as BMI, age, fat distribution, blood pressure and nutrition, which aims to improve the spikes in blood-sugars and fats. By comparing the predictions of the digital twin to the actually measured blood values of fats and sugars, these predictions and the nutritional advice become increasingly more accurate. This information is used in a personalised advice that takes into account personal ▶

Diederik Esser of WUR: "What makes such a digital copy so convenient is that you can adapt circumstances and predict effects."

WUR

Personalised nutritional advice thanks to digital look-alike

The team wants to test a first prototype of the digital twin on real people.

preferences, such as taste and choice of organic products. Taking this into account increases the likelihood that users will actually follow the advice.

Anticipate

The team wants to test a first prototype of the model on real people. This will make it clear whether the predictions are correct and makes the predictive value transparent. In addition, data of the human guinea pigs provide new input to enhance the prototype even further, says technical public administration expert Marc-Jeroen Bogaardt. He focuses on the data governance and infrastructure in the project and the involvement of stakeholders throughout the digital twin's development. This means, among other things, that the target group – people with health problems – is involved in the project at an early stage. 'We want to take into account what potential end users consider to be important. Some people have doubts about the use of a digital twin if, in future, it is managed by a commercial party and not by the university. Others have less difficulty with this. We want to anticipate these as well as other concerns and needs of society and thereby enlarge the eventual use and impact.' ■

Who: Multidisciplinary team under the leadership of Human Nutrition and Health (WUR).

Duration: 2019-2021.

Budget: €1.2 million for the whole period.

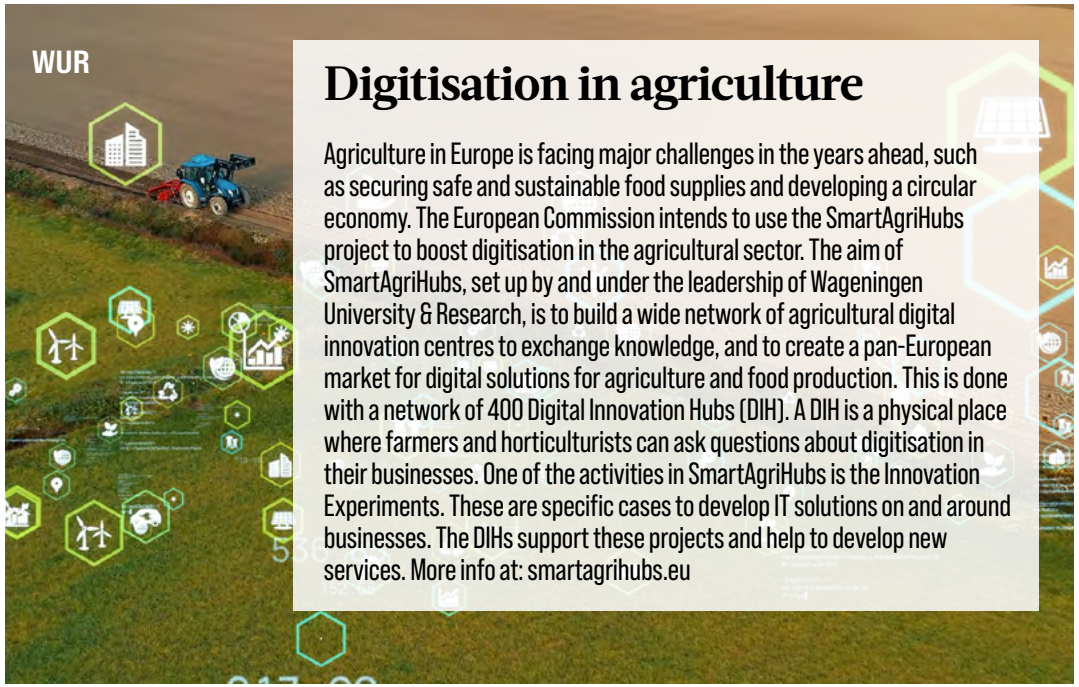
Follow-up: Personalised advice, e.g. in the form of an app.

MARIN

Floating food production and seaweed cultivation

Due to global population growth there is an increasing demand for offshore food production. MARIN is involved in various solutions, such as the Floating Food Farm by Floating Future and offshore seaweed cultivation. The Floating Food Farm is a concept to grow crops on open waters. Model tests have been carried out at MARIN's Shallow Water Basin on a scale of 1:5. The aim was to study the behaviour of the floating flexible structure in waves. The tests showed a promising result; the structure undulated with the waves and the salty seawater did not mix with the freshwater basins, not even for the biggest waves expected, which makes cultivation possible on water. Another project within the MARIN Blue Growth programme involves offshore seaweed cultivation. Cultivating seaweed is highly labour intensive, both sowing and harvesting is done manually from small vessels. The aim is to set up a farm that can produce throughout the year, far off the coast. The concept makes use of existing infrastructure and gas infrastructure to pump the seaweed to the shore using pipelines.

WUR



Digitisation in agriculture

Agriculture in Europe is facing major challenges in the years ahead, such as securing safe and sustainable food supplies and developing a circular economy. The European Commission intends to use the SmartAgriHubs project to boost digitisation in the agricultural sector. The aim of SmartAgriHubs, set up by and under the leadership of Wageningen University & Research, is to build a wide network of agricultural digital innovation centres to exchange knowledge, and to create a pan-European market for digital solutions for agriculture and food production. This is done with a network of 400 Digital Innovation Hubs (DIH). A DIH is a physical place where farmers and horticulturists can ask questions about digitisation in their businesses. One of the activities in SmartAgriHubs is the Innovation Experiments. These are specific cases to develop IT solutions on and around businesses. The DIHs support these projects and help to develop new services. More info at: smartagrihubs.eu

TNO

Better through-flow of people and commodities

In partnership with the Royal Netherlands Marechaussee, TNO is exploring the possibilities of risk-driven border surveillance. This is done in a pilot with real technology and volunteers. They make use of information that is already available for the moment that a passenger is physically at the border. The analysis of such a 'screening' provides an indication of the risk created by the passenger's border crossing. Based on this, 'checks' are adapted at border controls and made more proportional to such risk. This may result in border controls being stringent when necessary, but also less stringent where possible. If insufficient information is available to complete the screening, officials can still carry out the standard check. The lessons in these pilots will be enriched with computer simulations. For example, by including estimates of alternative border points in the calculations, and by examining variations in passenger flows that are difficult to achieve in real life through future changes, such as new legislation.

TNO

Smart glass saves energy in homes

At Brightlands Materials Center, a collaboration between TNO and the Province of Limburg, a smart coating has been developed for use on windowpanes. The coating reacts to outdoor temperature. If it exceeds 21 degrees, the coating blocks the sun's heat radiation. If the temperature of the glass pane is lower, e.g. in winter, the coated windowpane allows solar heat to pass through. That saves plenty of carbon emissions. In winter, homes need less heating and in summer they would need less cooling, so according to calculations, homes with this smart glass would use up to 20% less energy. 'The coating already works well on small windowpanes and has now been upscaled further to 1 x 1.5 m. The participating parties expect the technology to be suitable for commercial application within three years', says Eugene Veerkamp of TNO.

WUR

Green has a positive impact on humans

Green works for healthy, climate-friendly and nature-inclusive cities, provided that the right green is properly applied and managed in the right place to deliver the desired benefits. This is called 'functional vegetation', rather than 'decorative greenery' which mainly has aesthetic value. As more and more cities want the green benefits to maintain their viability, it is important to find out how this functional vegetation can be taken into account in urban development. Wageningen University & Research is collaborating with twelve cities such as Amsterdam, Utrecht and Eindhoven, with umbrella organisations for project development and construction, architecture and landscape architecture, as well as landscaping management on the project: Successful Implementation of Green Urban Development. The municipalities and developers provide practical knowledge and participate in a few pilots to develop knowledge and concepts.
More information available at www.groenestadsontwikkeling.nl

TNO

The right people for the right job through a combination of AI and skills ontology

A diploma does not say much about what knowledge, skills and characteristics a person has. Nowadays, that is far more important for an employer so that you can start the actual work immediately. Focussing better on these skills can help to improve the balance in the labour market. In job vacancies, employers often call for things that suitable candidates do not recognise right away. That discourages people from applying for jobs. TNO experts are collaborating with the UWV, CBS, CPB, SZW Inspectorate, HCA Roadmap Top Sectors and R&D funds on the Skills Matching Project. This project focuses on a combination of artificial intelligence (AI) and skills ontology to improve matching between vacancies and résumés. Skills ontology is a knowledge model in which the required skills can be found for each position. AI is used to filter, among other things, the relevant skills and to recognise any prejudices in job vacancy texts. This will improve matchmaking in the labour market between candidates and jobs and make it fairer.

NLR

Augmented reality at the airport

Air traffic controllers interpret traffic situations with aircraft faster and easier with an augmented reality device. This was apparent from experiments conducted at the Royal Netherlands Aerospace Centre (NLR) in a simulated test environment of the air traffic control at Amsterdam Airport Schiphol. This environment consisted of a realistic but scaled-down presentation of the airport with two workstations for air traffic controllers that mimic the current tower systems. The experiment concentrated on 'Attention capturing and guidance', to alert traffic controllers about the emergence of and guidance in the event of critical situations, such as crossing a runway while another aircraft is approaching. Augmented reality combines real-world images with computer-generated data in real time, improving visual information for tracking aircraft at the airport, for example. By the same token, augmented reality can also play a role in the event of poor visibility, by displaying virtual reality images that in reality are not visible or are difficult to see, allowing traffic controllers to make better decisions.

TNO

Customised drugs with a 3D printer

TNO is collaborating with partners on 3D printing technology of 'customised' drugs for a specific patient or group of patients, making them much more effective. Together with Erasmus MC they are working, for example, on drugs adapted for children. This target group is now often given drugs that were developed for adults. However, they weigh much less and the medication they need is therefore also less. At present, doses must be adapted manually by hospital pharmacists. The advantage of 3D printing is that you can print a customised drug dose for every child. To make more customised solutions possible and to ensure that these adapted drugs meet all the quality requirements, TNO invites pharmacists to seek solutions in accelerating the development of these drugs and to reducing costs. It is also important that such a new printed tablet complies with all laws and regulations. The goal is to eventually develop better drugs at lower costs to keep the healthcare sector affordable.

Deltares

Inland waterway corridor for boatmasters

Deltares is developing the 'Digital Twin Waterway Corridor' of the Rhine, an online platform that mimics the interaction between ships, the waterways network, infrastructure and logistics chain. This makes the impact on the logistics chain (sailing time, costs and emissions) visible. The 'Twin' provides information to weigh up alternatives and to make decisions for both inland waterway operators and waterway controllers for sustainable and future-proof transportation of commodities by water. This includes support for route planning, fleet deployment and the load factor. The platform also maps the effects of climate change or other developments in the transport sector, such as automation and SmartShipping. This is necessary, because climate change will further influence the transportation of commodities by water in future, and major changes are underway in the transport and logistics sector itself. Aside from Deltares, knowledge institutes MARIN, SmartPort, the University of Technology Delft and boatmasters, are also involved in the further development. By closely involving end users in these developments, the platform ensures a good connection to the practical needs.

TNO

TNO launches 25th spin off

A few years ago, TNO started the Tech Transfer programme, which aims to introduce as many TNO innovations as possible into the market. Within this programme, this is done by developing business cases, conducting market research, connecting entrepreneurs and involving investors. By implication, new companies are created, which will make use of TNO knowledge to create jobs and economic growth. In addition, these companies contribute to social challenges, like the energy transition, safety and health.
In November 2020, there was a milestone for the Tech Transfer programme to celebrate, because TNO launched its 25th spin-off: the enterprise Relement. By making use of TNO's knowledge, this start-up produces new chemical ingredients based on bioresidues rather than petroleum. These ingredients are also of a better quality than fossil fuel variants. For example, paint with these ingredients is more resistant to sunlight and insulation foam becomes stronger. This helps to make the chemical industry more sustainable.

Credits

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