TO2MORROW

Magazine on the TO2 Federation's results for

2026

TO2 federatie



How robust is our critical infrastructure?

What happens when critical systems fail simultaneously?

Innovating at a warfaring pace

From a conceptual idea to a sailing prototype in a matter of months



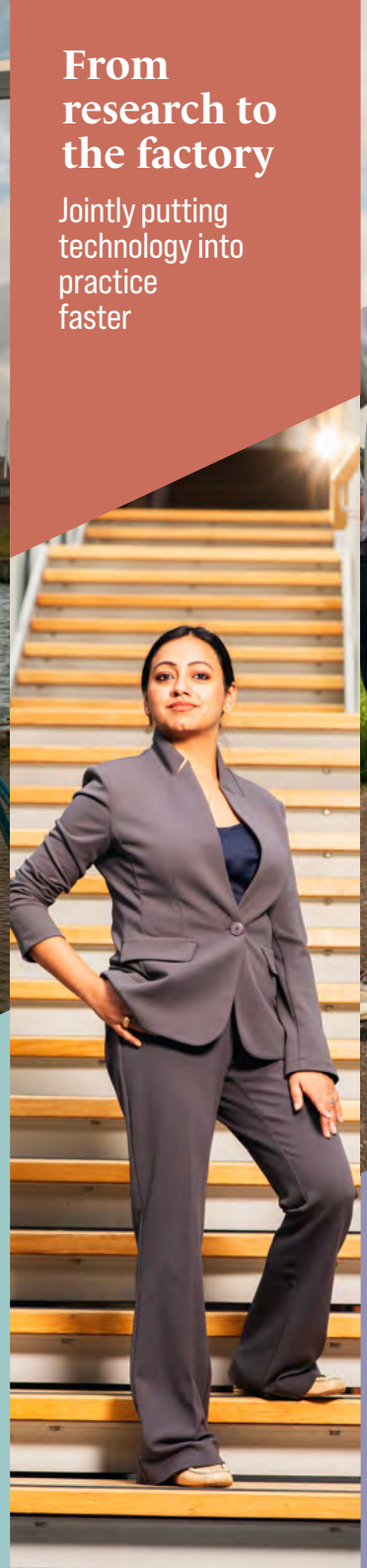


Salt marshes as a coastal protector

A natural buffer against high water

From research to the factory

Jointly putting technology into practice faster





On the verge of flying on hydrogen

The first manned test flight will follow in 2027

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Dear reader,

The Netherlands has an exceedingly strong knowledge base. Translating this knowledge into useful solutions for both businesses and Dutch society requires constant testing, demonstration and further development.

This is where our TO2 institutes get to shine. In this eleventh edition of TO2MORROW, they go beyond showing how they bridge the gap between knowledge and application. They also explain how they bring together various expertises, which leads to new ideas and solutions that make the Netherlands and Europe stronger and safer.

For example, within DigiLab Toegepaste Kennis (DigiLab Applied Research) the five TO2 institutes work collectively on the development of a digital infrastructure. Within this structure they can securely share data, models and computing power with each other and their research partners. This saves researchers time and gives them better insights. At GREENHOOD, Deltares and Wageningen University & Research (WUR) work together on new solutions that improve our water quality. They research how nutrients from manure and fertilizer can be captured, reused and broken down.

In the European project known as SATURN, MARIN is developing a tool to build ships with quieter propellers and lower fuel consumption. That way they contribute to the protection of marine life. Another form of climate protection can be found in the European TULIPS programme. Here, TNO researches how to reduce emissions at and in the vicinity of Schiphol. At its Quick Response Drone Facility in the Netherlands Aerospace Centre (NLR), the Ministry of Defence works together with knowledge institutes and businesses to speed up the development, testing and operational deployment of new drones and drone functions.

Whether it concerns the climate, energy, digitalisation or security, the TO2 institutes and their research facilities play an indispensable role in addressing societal challenges and working towards a resilient and sustainable Netherlands. The projects that help us to do this deserve their moment in the sun.

I hope you enjoy this edition! / I wish you an enjoyable read!

Heleen Herbert
Minister of Economic Affairs and Climate



In the overview below, each of the institutes that are part of the T02 federation, summarise their most relevant areas of activity and the key technologies they develop and apply.

The T02 federation consists of:

Deltares

Deltares

Deltares is an independent knowledge institute for applied research. We believe in the power of in-depth knowledge, innovative solutions and software for keeping delta regions all over the world liveable.

Our mission *'Enabling Delta Life'* focuses on the water and subsurface system. We concentrate on 5 'moonshots' to create an impact with our knowledge: habitable deltas, flood protection, healthy water and subsurface systems, greenhouse gas reduction, renewable energy, and resilient infrastructure.

Our 900 qualified employees are curious and passionate. Collaboratively, we work in conjunction with universities, research institutes, the business community, NGOs as well as national and international public authorities, and we share our knowledge with the world ('dare to share').

MARIN

BETTER SHIPS, BLUE OCEANS

MARIN

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

nlr

Accelerating the future of aerospace

NLR

The Royal Netherlands Aerospace Centre (NLR) connects the sciences, business community and public authorities in the Netherlands as well as internationally. This knowledge organisation conducts applied scientific research in the market segments: industry, civil aviation, aerospace and defence. NLR's work covers the full spectrum of 'Research, Development, Test & Evaluation' (RDT&E). Within its mission-driven innovation policy, NLR's research focuses on social themes: energy transition, sustainability, and safety. Examples of key technologies being given 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) sees its mission as connecting people and knowledge for the creation of innovations with significant impact for the sustainable well-being and prosperity of society. TNO believes in jointly creating value in both economic and social terms and, together with partners, focuses on innovations in six domains: Mobility and the Built Environment, Energy and Materials Transition, Defence and Security, Healthy Living and Work, High-tech Industry; ICT, Strategy and Policy.

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

WUR

Wageningen University & Research is a joint venture between Wageningen University and Stichting Wageningen Research (a foundation). Our approximately 7,000 employees and 13,000 students from more than 100 countries, work and study in the fields of nutrition, nature, climate, the circular economy and living environment. In cooperation with public authorities and industry, they jointly contribute to solutions on social issues. The mission of Wageningen University & Research is 'To explore the potential of nature to improve the quality of life'. Wageningen University & Research's strength lies not only in combining specialised research institutes and the university, but also in collaborations between various natural, technological and soccial 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 that are active in topics that include Food & Biobased Research, Bioveterinary Research, Livestock Research, Marine Research, Social & Economic Research, Environmental Research, Plant Research and Food Safety Research. ■

Less phosphorus and nitrogen, more biodiversity in water

Nitrogen and phosphorus derived from manure and fertilizer can enter ditches, lakes and the sea by way of groundwater or surface run-off. This leads to the growth of algae, oxygen deficiency and damage to nature. In the GREENHOOD project, Deltares, WUR and KWR are testing solutions that capture and reuse these nutrients. ▶

Deltares researchers Kim Gommans and Marc Nijboer are taking samples from the wood chip filter in Vinkenloop, for analysis in the lab, so that they can see how the wood chip filter works.

Deltares, WUR

Problem: rainfall and drainage can cause nutrients from manure and fertilizer to enter ditches, lakes and seas. This leads to the growth of algae, oxygen deficiency and damage to nature.

T02 solution: Deltares and KWR test solutions within the European GREENHOOD project that capture and reuse these nutrients or convert them into less harmful substances, such as wood chip filters, buffer strips and sediment basins. Not content with just mapping how the system works, they also determine what it takes to apply and maintain it in practice.

Impact: the results are included in the BOOT list, an overview of measures that can help the agricultural sector improve water quality. Farmers and water authorities will be better informed about what works in practice.

Green colouring of a ditch due to algae growth, or a swimming pool that is closed down because of the blue-green algae: many people know the consequences of too many nutrients in water. Excessive algae growth in open water causes an oxygen deficiency and the production of poison. 'The bottom line is that there is insufficient oxygen for other plant and animal species, which causes many of these species to die', says Marc Nijboer, a researcher at Deltares. In GREENHOOD, Nijboer researches applications that capture nutrients that have leached out and reuse them, where possible.

Manure regulations

Nutrients are food substances that plants need to grow. In agriculture, it mainly concerns phosphorus and nitrogen. In the event of heavy or prolonged rainfall, these substances can enter the surface water and eventually end up in the sea. Nijboer: 'Also, if farmers comply with the manure regulations, heavy downpours can cause nutrients to leach out into the groundwater.'

'Research has shown that many measures are promising'

European research

In partnership with KWR, Deltares researches techniques that capture and reuse or convert nutrients. By testing existing solutions such as wood chip filters, sediment basins and improved buffer strips in practice, GREENHOOD provides farmers and water companies with suggestions to better protect water quality. Each technique works differently on the nutrients. Thanks to carbon from the wood of the wood chip filter, the bacteria present break down dissolved nitrogen into harmless nitrogen gas. At the sediment basin, the watercourse is wider, causing water to flow slower. Sediment containing the nutrients sinks to the bottom. Both principles are combined for the improved buffer strip. The sediment is captured in a ditch near the watercourse. Here, any bacteria present ensure (bacteria is plural of bacterium) that residual nutrients broken down and absorbed by plants. European research is sorely needed. 'Research has shown that many measures are promising, but practical data are often lacking. We are now gathering that data', Nijboer explains. 'The agricultural knowledge at WUR is unique for Europe and is useful during our testing.'

No man's land

Field tests show that a technically effective measure is not automatically the best choice. A wood chip filter, which is a kind of subterranean container with wood chips through which water flows, and in which nitrate is converted into harmless nitrogen gas, can capture many nutrients but requires regular maintenance.
This makes it less attractive for use by farmers and water companies. Moreover, many of these measures are at the boundary between agricultural land and surface water. 'The strip of land between agriculture and water is actually a no-man's land. This makes it difficult to determine whether action is to be taken by the farmer or by the water company. Besides, such a strip does not directly contribute



'Some of the released nutrients are used as fertilizer'



to the farmer's production. Therefore, low-maintenance solutions, such as an improved buffer strip or sediment basin, are often attractive. For example, a sediment basin only needs to be dredged occasionally. The phosphorus that is released can be reused as fertilizer.'

BOOT list

The measures tested will eventually be included in the Open Cultivation and livestock farming administrative consultation list (Bestuurlijk Overleg Open Teelt en Veehouderij, BOOT-lijst); an overview of dozens of agricultural and practical measures to improve water quality, water quantity and soil quality. 'I hope that this overview will help farmers and water companies to choose more targeted measures in consultations', says Nijboer. ■

Who: Deltares, WUR, Knowledge Institute for Water (Kennisinstituut voor Water, KWR), water companies, agripreneurs and GREENHOOD's European partners.

Duration: 1 January 2025 to 31 December 2028.



Monalisa Goswami of TNO.

From a research programme to an innovation community

To make the energy and chemical sector sustainable and future-proof, TNO has been focusing on electrification for more than a decade already. At VoltaChem, they work with businesses, knowledge institutes and public authorities on new technologies, as well as on conditions for large-scale application. What started out as a research programme has become an innovation community. ▶

TNO

Problem: the energy and chemical sectors are still dominated by fossil-based energy and raw materials. Processes are needed for a low-emission industry that can rely on renewable electricity to meet its energy needs.

T02 solution: Ten years ago, TNO set up VoltaChem: a research programme in which businesses, knowledge institutes and public authorities collaborate on the development and upscaling of electrified chemical processes.

Impact: VoltaChem helps electrochemical technologies take the step from laboratory to industry. The programme provides new technology for the production of green hydrogen and sustainable chemicals. It brings businesses and knowledge institutes together, and contributes to a sustainable and future-proof chemical industry.

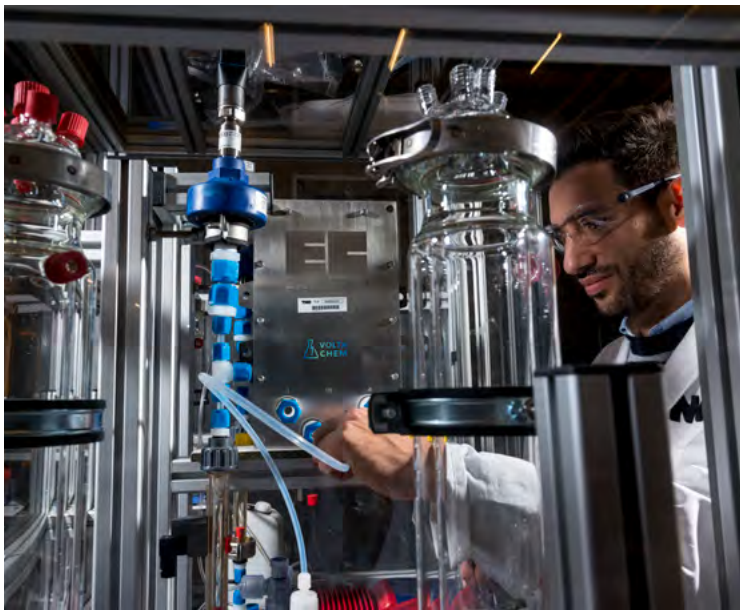
'When we started out ten years ago, electrochemistry was still in its infancy', says Monalisa Goswami, Chair at TNO VoltaChem. 'That is where TNO's strength lies: developing technology that the market has not exploited as yet, but which we know can become pivotal in the future.' VoltaChem was founded to accelerate that development. This not only concerns green hydrogen, it's also about the sustainable production of chemical commodities from water, carbon dioxide and biobased raw materials. Together with businesses, TNO developed an innovation agenda: what technological breakthroughs are needed to enable electrochemical processes on an industrial scale? Goswami: 'This approach has taken technology a considerable step further. Meanwhile, the first commercial hydrogen plants are currently under construction. The next challenge is to apply that technology on a large scale in industry.'

More than technology alone

This next step requires more than technological innovation alone. 'In the early years, innovation was mainly about the development of individual components, such as electrodes and catalysts', says Goswami. 'Nowadays, the question is how to apply this technology on an industrial scale. How do you ensure a factory becomes economically viable? How do you organise safety? How do you ensure that all parties in the chain work together?' Technology is no longer the only challenge. The electricity grid, permits, regulations and cooperation in the chain also determine whether electrochemical plants become a reality.

Innovation community

As technology has matured, VoltaChem's role has also changed. The research programme grew into an innovation community in which businesses, knowledge institutes, financiers and public authorities work together on the next phase of the energy transition. TNO fulfils the role of an independent liaison in this respect: it brings together parties who can further develop and apply the technology. Affiliates meet regularly during what is known as Power Sessions. At these meetings they share knowledge, discuss current issues and find partners for joint innovation projects. 'We have no commercial interest, but we do understand the problems of every part of the value chain', says Goswami. 'That is why we can bring together parties that would otherwise not meet of their own accord.'



From laboratory to factory

The plan of action has now yielded concrete results. In the SuperCell research programme and together with industrial partners, TNO developed a new generation of electrolysis cells, an essential part of green hydrogen-producing plants. Bosch Transmission Technology BV in Tilburg then used that knowledge to develop the Hybrion electrolyser, a commercial system for the production of green hydrogen. Internationally, TNO has also built up a strong position. At the research facilities in Petten the institute developed high-quality knowledge about Solid Oxide Electrolysers (SOEC), an efficient technology for the production of green hydrogen and Syngas. This knowledge was further introduced into the marketplace in collaboration with Elcogen (Estonia) and the Important Projects of Common European Interest scheme (IPCEI). 'We do not introduce products into the marketplace

'Technology has matured in the meanwhile'

ourselves', says Goswami. 'As TNO, we develop the knowledge that businesses need to be able to do so.' VoltaChem then supports businesses to apply this knowledge on an industrial scale. Fieldlabs and demonstration facilities allow new processes to be tested under realistic conditions before businesses invest in commercial installations.

Leading international position

In European research programmes, TNO is collaborating with businesses and knowledge institutes on the electrochemical production of sustainable fuels and chemical building blocks, such as eMethanol and eSAF. According to Goswami, this is an important opportunity for Europe. 'Technology has matured in the meantime. The next step is to ensure that Europe also benefits economically. Europe wants to be less dependent on fossil-based commodities and energy from other parts of the world. Electrification of industry can make an important contribution to this, on condition that the congestion problem on the grid is also resolved.'

After a decade, Goswami sees how the role of VoltaChem has changed. 'In the early years, we were mainly working on technology. Now we have a community in which businesses, researchers and public authorities collaborate on the system aspects of upscaling it. That is perhaps the biggest step that we have taken.' ■

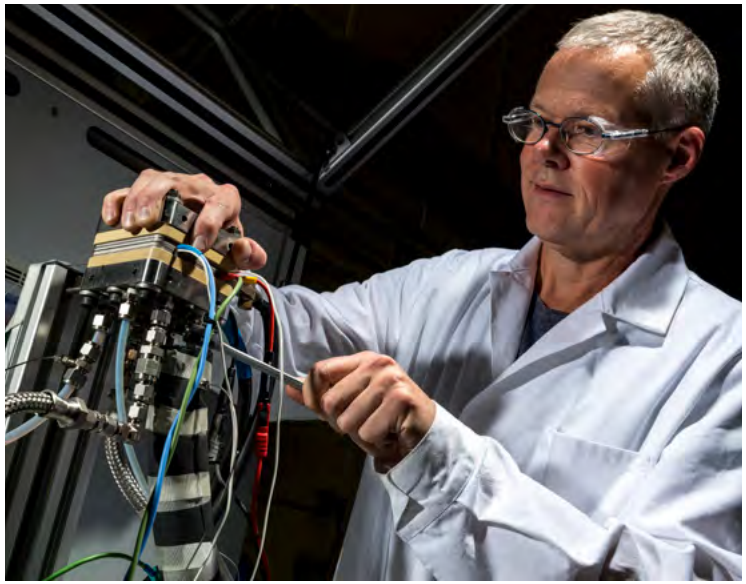
Who:
Shell, Eneco, Vattenfall, Johnson Matthey, Thermax, Teijin, Capgemini, among others.

Duration: ongoing since 2016.

Budget: financed through a combination of contributions from affiliated businesses, national innovation programmes and European research projects.

Follow-up: in the coming years, VoltaChem will focus more and more on system integration, collaboration in the chain and a healthy business case for new factories known as bankability.





voltachem.com

On the verge of emission-free flying using hydrogen

Flying on liquid hydrogen should reduce aviation's impact on climate. NLR's PHYREX (Pipistrel Hydrogen Range Extender) project is taking a step in the right direction. 'In 2027 we will test a manned hydrogen-powered aircraft.' ▶

Floris Bremmers (left) and Arjen Kloosterman of NLR.

NLR

Problem: aviation wants to be climate neutral by 2050. Switching from fossil-based jet fuel to other energy carriers plays an important role in this. Hydrogen is one of the most promising options, especially for medium-haul flights for which batteries could be too heavy.

T02 solution: together with Dutch partners, NLR is converting its battery-electric-powered aircraft into a plane that can fly on liquid hydrogen. In the PHYREX project, the electrically powered Pipistrel aircraft is equipped with a hydrogen propulsion system, allowing the pilot to switch to hydrogen power during flight.

Impact: in this project, NLR gains valuable knowledge and experience to accelerate the further development of hydrogen-powered planes and related safety rules. This will bring climate-neutral aviation a step closer to its goal.

Aviation must drastically reduce its carbon emissions and wider impact on climate over the coming decades. The Royal Netherlands Aerospace Centre (NLR) is working on various research and demonstration projects to achieve this. An important example is the development of a small manned electric aircraft powered by liquid hydrogen.

Flying on hydrogen

'In the Pipistrel Hydrogen Range Extender or PHYREX project, the electrically powered Pipistrel aircraft is equipped with a hydrogen propulsion system, allowing the pilot to switch to hydrogen power during flight', explains Arjen Kloosterman, the NLR project leader of PHYREX. The project is working towards a manned test flight in 2027. Floris Bremmers, Chief Design Engineer at NLR, adds: 'Liquid hydrogen is very promising because it allows aircraft to travel longer distances than on batteries alone. A hydrogen system is lighter than a battery with the same amount of energy. This allows the aircraft to continue flying or to take on more passengers.' Clearly, the project specifically looks at liquid hydrogen. 'Gaseous hydrogen would take up too much space', Bremmers explains. 'The choice for liquid hydrogen however, requires that we cool the hydrogen to 253 degrees below zero. So that makes the project all the more challenging.'

'The temperature in the hydrogen tank must remain at 253 degrees Celsius below zero'



Pipistrel modification

The construction of the two-seater Pipistrel has been reinforced to support the hydrogen tank and the fuel cell. 'The tank is double-walled and vacuum insulated, like a highly efficient thermos flask. This is needed to maintain the hydrogen at a temperature low enough to keep it liquid', Bremmers explains. Kloosterman says that the tank has been installed in the place of the passenger's seat in the cockpit. 'This poses additional risks: hydrogen is colourless, odourless, highly flammable and can form an explosive mixture if it accumulates in an enclosed space. We pay a lot of attention to managing these risks, for example by using automatic shut-off valves and detection systems and by installing ventilation options.'

Placed under the aircraft, in what is known as a belly fairing, the fuel cell operates by a chemical reaction between hydrogen and oxygen, which generates electricity for the electric motor. 'This reaction also releases water and a lot of heat', says Bremmers. 'In a conventional aircraft engine, the heat is dissipated through the exhaust via the large volume of air flowing through the engine. A fuel cell system works completely differently and needs to be cooled with a separate system, which also requires an air supply and drainage. We've

'Flying on hydrogen is feasible, and we need green hydrogen to do so'



designed such a cooling system and have also tested it now in our wind tunnels,' says Bremmers.

Green hydrogen

PHYREX focuses on the integration of hydrogen technology in aircraft. 'In order to contribute to climate-neutral aviation, it is important that this hydrogen is green, i.e. generated from renewable energy', Kloosterman points out. 'That lies beyond the expertise of NLR. However, through our developments, and those of other aviation parties, we have been sending out signals to hydrogen producers that flying on hydrogen is feasible, and we need green hydrogen to do so.'

Front runners

PHYREX is more than merely a demonstration project. It provides knowledge that can be used for the development of future hydrogen aircraft and for new safety rules. These aspects have not been achieved yet. Knowledge gained in the PHYREX project is also of interest to the aviation authorities. 'We are in dialogue with the Dutch Human Environment and Transport Inspectorate regarding rules and regulations for this innovation so that it can be applied in civil aviation as soon as possible', Kloosterman concludes. ■

Who: NLR, Zepp.solutions and Cryoworld.

Duration: From 2023 to 2027.

Budget: EUR 5 million, financed by NLR and Aviation in Transition (LIT).

Follow-up: knowledge gained in the PHYREX project is valuable for other projects, such as the HAPSS project, led by Conscious Aerospace and financed by the aviation growth fund programme Aviation in Transition (LIT). In the HAPSS project, an existing passenger aircraft, the DASH 8, is being converted to hydrogen-powered flying, but on a much larger scale than PHYREX. Lessons learned on safety, contribute to new rules and regulations for the use of hydrogen in aviation.

Shedding light on the invisible polluter

A methane leak is often invisible from the ground, but not from outer space. Together with its partners, TNO has built Sentinel-5, a new satellite instrument with which trace gases are accurately measured globally and sources of pollution are detected faster. ▶



The Sentinel-5 was launched aboard a satellite on 13 August 2025.

TNO

Problem: trace gases have an influence on air quality and climate, but are difficult to map out globally.

T02 solution: TNO helped develop the Sentinel-5 measuring instrument, which accurately measures trace gases from outer space.

Impact: methane leaks and other sources of pollution can be detected faster. It also gives a much more accurate picture of global greenhouse gas emissions.

Initially, no one noticed it, but 27,500 tons of methane leaked by accident into the atmosphere every year from an oil field installation in Hassi Messaoud in Algeria. Methane is a powerful greenhouse gas: the annual emission was equivalent to the carbon emissions of some 500,000 passenger vehicles. The gas plume appeared on satellite images; this was notified to the national oil company responsible, and the leak was closed. Since 2024, there has no longer been a plume on satellite images. That is progress, but there are thousands of methane sources globally, in oil and gas fields, pipelines, landfills and in factories. It is estimated that methane is responsible for one-third of climate change.

Sentinel-5

Satellites are increasingly being used to detect methane leaks. TNO contributed in building the Sentinel-5 measuring instrument, part of the European Commission's Copernicus Earth Observation Programme, a growing fleet of satellites mapping the state of the atmosphere. 'On 13 August 2025, Sentinel-5 was launched aboard the satellite MetOp-SG-A1. We are now working on its commissioning: providing modifications and getting to grips with the measurements', says Ton Marée, a business developer at TNO who is closely involved with the team that built parts for the outer space measuring instrument, which not only detects methane, but also ozone, nitrogen dioxide, sulphur dioxide, formaldehyde, glyoxal, aerosols and carbon monoxide in the atmosphere. Marée: 'These are all trace gases, which are gases that are present in the atmosphere in tiny concentrations, but which have a major influence on air pollution or climate change.' For example, nitrogen dioxide plays a role in air pollution and climate change, aerosols have an influence on the climate and weather processes, sulphur dioxide is an ingredient in flue gases and volcanic eruptions, and ozone acts as a protection against UV light. 'Measurement is the key to understanding', says Marée, 'These measurements can make people aware of the effects of gas emissions into the atmosphere, so that we can do something about them.'

Two-dimensional map

It's no easy task. The atmosphere consists mainly of oxygen (21 percent) and nitrogen (78 percent), and trace gases make up only a tiny fraction of it. 'The satellite is used to measure sunlight reflected by the atmosphere.



Ton Marée of TNO.

'Trace gases have a major influence on air pollution or climate change'

The trace gases absorb light from certain wavelengths, so one can deduce from the light which trace gases cause absorption,' Marée explains. In the satellite, the reflected sunlight is split into different wavelengths. This creates a unique 'fingerprint' of each trace gas. The fingerprints of the various trace gases can be detected in that wavelength profile. 'Every 24 hours, it maps the entire Earth', says Marée. Each time, Sentinel-5 only measures a thin band of the atmosphere, but because the satellite scans the Earth below, it creates a two-dimensional map.

Fourteen satellites

Sentinel-5 is not an isolated entity. The Netherlands has a long-standing tradition of measuring trace gases from outer space. TNO previously worked on instruments such as SCIAMACHY, OMI and Tropomi. Sentinel-5 is taking this forward and is part of the European Copernicus programme, which maps the earth and atmosphere with a growing constellation of satellites. After Tropomi, Sentinel-5 is the next step, equivalent to but more sensitive and powerful than its predecessor. 'Every time we make an instrument, our ambition is ▶

'Sentinel discovers the plume; then TANGO zooms in'

to measure things better', says Marée. For example, the mirrors of the telescope which direct light towards the spectrometer, are made of aluminium with a thin coating of nickel. Marée: 'That coating is now smoother than for Tropomi. Where the maximum surface roughness was initially 1 nanometre (one millionth of a millimetre), it is now 0.7. The smoother the mirrors, the less scattered light there is inside the telescope, and the better the signal, making detection more sensitive.' In addition, Sentinel-5 has two telescopes instead of one, and five spectrometer channels instead of four: two in infra-red light, one in visible light, and two in ultraviolet light. Unlike Tropomi, Sentinel-5 was tendered by the European Space Agency ESA on commission for the European Commission, with contributions from several countries. The meteorological EUMETSAT manages the satellite. Marée: 'Because the Netherlands has a vast amount of experience with astronomy, we have been approached for the telescopes, and for one of the spectrometer channels in the ultraviolet spectrum.' In addition to improvements and innovation, continuity of measurement data is also important. For this reason, three similar instruments are already in the pipeline to be launched in future. Marée: 'The official lifespan of the instruments is 7.5 years. There are two more copies – the next one will be launched in 2030 – so we are able to move ahead for a total of 21 years. Even so, you want things to be ready if something unexpectedly goes wrong.'

TANGO satellites

In addition to satellites that monitor the entire Earth, there is also the development of two TANGO satellites, which are to be launched as from 2028, and can be dedicated to focus on sources of carbon dioxide, methane and nitrogen dioxide. The Sentinel-5's resolution is not high enough to identify individual factories, pipelines or installations as sources: a pixel is 7.5 by 7.5 kilometres. Marée: 'The idea is that Sentinel satellites discover the plume, and that TANGO subsequently zooms in to ascertain exactly where the gas comes from.' In the meantime, the environmental branch of the United Nations, UNEP, has set up a programme in which countries and businesses are notified of methane and other leaks and sources of pollution, so that these can be closed off. Further, the Sentinels will increasingly map global greenhouse gas emissions more accurately, such as methane and other emissions, quantities that are still heavily reliant on estimates, calculations and models. Marée: 'Sentinel-5 yields a direct contribution with absolute information, for a future with less air pollution and climate change. As in Algeria: an invisible methane leak that could be detected and closed off, thanks to satellite measurements.' ■

Read more about Sentinel-5

Who: TNO, ESA, Airbus Defence and Space, SRON, KNMI, EUMETSAT.

Duration: Sentinel-5's nominal lifespan runs until 2030.

Follow-up: further extension of the Copernicus Earth Observation Programme.



A TNO colleague during the testing of one of the telescopes.

How to make an airport emission-free

Within the European TULIPS project and together with TNO and other parties, Schiphol tests solutions for clean hydrogen-powered aircraft tractors, mobile power units, emission-free zones and minimal vehicle usage at Schiphol. ‘What we learn at Schiphol, can also help make other airports more sustainable.’ ▶

Yashar Araghi of TNO.

TNO, NLR

Problem: emissions at airports are not only caused by air traffic. Transportation to and from the airport also contribute to carbon dioxide emissions. To achieve climate targets, these activities need to become much more sustainable.

T02 solution: in the European TULIPS project, TNO is researching how emissions at and around Schiphol can be reduced, both on the land surrounding the airport as well as in the air. By replacing fossil-fuelled vehicles in and around Schiphol with electric vehicles, encouraging train journeys, and bringing travellers' baggage to the airport, TULIPS is trying to make all travel activities to and from Schiphol emission-free by 2030.

Impact: the results and tested methods help Schiphol to make choices for a sustainable airport. Knowledge is exchanged with other European airports.

The Dutch aviation sector was responsible for 6.6% of all emissions in the Dutch economy in 2024. Fuel consumption by aircraft is the most obvious cause. Yet transportation to and from the airport by millions of passengers also contributes to emissions. '53 percent of these journeys take place by road,' says Yashar Araghi, economics and consumer behaviour researcher at TNO.

Emission-free zones

TULIPS focuses on activities both at the airport and transportation to and from it. 'Research activities include the use of electric *ground power units. This is a mobile power unit that supplies power to aircraft, so that when they are stationary, they do not have to use their own fuel engine for power.' In 2025, hydrogen-powered vehicles that relocate aircraft at Schiphol were also tested.*

In the project, TNO focuses on the enormous stream of passengers travelling to and from Schiphol Airport. About 43 percent already travel by public transport. Araghi and his colleagues at TNO, explored which measures could further improve that share and how many emissions could be spared.

Four scenarios

In order to improve this percentage, Araghi and his colleagues have estimated four scenarios in collaboration with partners such as BAM and Fraunhofer (the German TNO). An emission-free zone around Schiphol appeared to have a major effect. 'In this model we saw that the carbon dioxide emissions among the mobility sector surrounding Schiphol reduced by more than 32 percent.' Extending the North/South line from Amsterdam South to Hoofddorp and adding more intercity trains to Schiphol (rather than local trains) did not generate any additional gains. Another option would be having travellers complete check-in, including luggage, at their local railway station. 'That is then brought separately to the correct flight. This would encourage travellers, especially those who live further away from Schiphol Airport, to opt for travelling by train.' By banning fossil-fuelled vehicles around Schiphol, local emissions at Schiphol would diminish. But at the same time, the model shows an undesirable side effect: when drivers park their vehicles further away, some of the emissions shift to elsewhere.



'There is not a single airport that can undertake this kind of transition alone'

Lighthouse airport

Within the TULIPS project, Schiphol is known as a *lighthouse airport*; a testing ground where innovations are tested in practice. Turin (Italy), Larnaca (Cyprus) and Oslo (Norway) are also included in this project's learning curve, for understanding and discussing how they can apply this in their own regions. 'Other European airports that do not participate in the TULIPS project can also benefit from its results. For example, Chopin Airport in Warsaw, studiously followed the developments and results of TULIPS. They are preparing for large-scale expansions, including modernisation of the passenger terminal. The airport considered taking into account the scenarios and policies developed within TULIPS in its own development plans.' Ultimately, it does not involve just a single measure, but a combination of innovations and the ability to scale up successful solutions. Araghi: 'There is not a single airport or party that can undertake this kind of transition alone. It is precisely due to exchanging knowledge and taking on board the lessons learned that we can scale up innovations faster and move quicker towards a climate-neutral aviation sector.' ■

More details

Who: TNO, Schiphol, NLR, TU Delft, KLM, the partner airports of Oslo, Turin, Larnaca and other parties all over Europe.

Duration: January 2022 to December 2026.

Budget: 31.87 million. EU contribution 25 million distributed between 17 pilot projects, 3 airports and 31 parties.

Sustainable energy with an eye for nature

The energy transition is sorely needed. But what do wind turbines, floating solar collectors, subsurface extraction and aquathermy mean for nature? In the KEEN project together with KWR, TNO and WUR, Deltares examined how we can use renewable energy generation without harming ecosystems. ▶

Sacha de Rijk of Deltares.

DELTARES, TNO, WUR

Problem: new energy technologies often lack knowledge about their effects on nature and biodiversity. This knowledge is essential to make proper decisions on permits and to bring the energy transition into line with Europe's biodiversity ambitions.

TO2 solution: the ecological effects of aquathermy, solar collectors on land and water, and wind energy are being mapped by Deltares, TNO, WUR and KWR by way of fieldwork, calculations and transmitters attached to birds of prey.

Impact: this helps permit issuers, such as water companies, provinces and Rijkswaterstaat, to better assess energy projects. This will prevent renewable energy generation from having undesirable ecological effects or causing a slow-down in the energy transition.

Extracting energy from water, on land, and from the subsurface has consequences for the ecosystem. For example, floating solar collectors absorb sunlight and aquathermy removes heat from surface water. This could change living conditions for plants and animals. To better understand what these effects are, they have been measured in existing energy projects. Deltares researched, among other things, the influence of aquathermy (energy extraction by temperature differences in water) on water quality and underwater life.

Water quality

Knowledge is sorely needed. Water authorities, such as water companies, provinces and Rijkswaterstaat, want to know what impact new energy technologies will have on nature before issuing any permits. One of the techniques studied is known as aquathermy. In the process, water is pumped from a lake or pond and filtered, and heat is then extracted or added. 'This could change the temperature and composition of the water', explains Sacha de Rijk, an expert on ecology and water quality at Deltares and the project leader for KEEN. Deltares conducted fieldwork at the Van Buijsen pond near Pijnacker to see the effect of this temperature variation and filtration on plankton, the small organisms that form the food basis for many fish and other aquatic animals. 'Research has shown that filtration has merely limited consequences for plankton', says De Rijk. Actual measurements of the effects of temperature changes were not possible for the researchers in this first year. They were able to install the required measuring instrument – a cable with temperature sensors – at the bottom of the pond. To determine the living conditions of plankton, researchers used model calculations. A follow-up study could provide greater insight into the long-term effects of aquathermy on water quality. 'To be able to properly assess ecological effects, series of measurements over several years are needed', according to De Rijk. 'We should gain even more knowledge if we continue to measure in the spring and summer for a few more years.'



Measuring instrument

Not only temperature, but also the amount of light plays an important role in the underwater ecosystem. Deltares and TNO researched how much light still reaches the water under floating solar parks. In doing so, the researchers used the BIGEYE model developed by TNO to calculate the light incidence under various solar collector configurations. 'Since starting KEEN, we now know that to achieve healthy underwater life, 20 percent of the water's surface can be covered, as

KEEN's strength

In KEEN, TNO researched the effect of heat storage at high temperatures on groundwater quality, among other things. Furthermore, TNO developed models to better predict the ecological effects of new energy technologies. According to Mariëlle Koenen, the strength of KEEN lies in collaborations: 'Every partner contributes its own expertise and perspective. By combining this knowledge, we can better determine where and under what conditions new energy technologies can be applied safely, without losing sight of nature.'

'Filtration only has limited implications for plankton'



Deltares conducted fieldwork at the Van Buijsen pond to see the effect of temperature fluctuations on plankton.

compared to the 50 percent that is currently found in solar parks', according to De Rijk.

Buzzards and wind farms

KEEN also examined the effects of renewable energy on animals, both on land and in the air. Within the project, there was concern that birds of prey such as buzzards, would more often collide with wind turbines if solar collectors were in the vicinity. De Rijk: 'Unfortunately, birds sometimes fly into wind turbines, but if there are solar collectors in the vicinity, this would be an even greater risk.' Karen Krijgsveld of WUR: 'Solar panels are heated by the sun and generate rising currents of warm air locally. These thermals are attractive for birds of prey, such as buzzards. WUR attached transmitters to the buzzards and TNO developed models of local air flows. This allowed the researchers to determine how the birds move around solar parks and wind turbines. This showed that the warm air actually moves away from the wind turbines, making the buzzards safer than previously thought. The results help public authorities to design sustainable energy projects in such a way that the consequences for nature remain limited.'

Who: Deltares, TNO, the Water Research Institute KWR, WUR, the Ministry of Economic Affairs and Climate, TKI Urban Energy, and the Netherlands Enterprise Agency.

Duration: 2024–2026.

Budget: EUR 800,000.

Follow-up: research will follow for a period of five years, to ensure reliable statements can be made, e.g. to measure the effects of aquathermy on water quality in the long term.



Fast Track brings entrepreneurs and researchers together

Drawing on TNO's example, innovative small business entrepreneurs have recently been able to turn to WUR's Fast Track. Through a dedicated helpdesk, entrepreneurs have quick access to expertise and testing facilities. The aim is to accelerate the application of knowledge in new products and services, ultimately delivering benefits to society. ▶

WUR helped the company Grassa, which extracts proteins from grass for food, and reduces nitrogen emissions.

WUR, TNO

Problem: the Netherlands has an abundance of knowledge and high-quality research facilities, but innovative SMEs looking for support often cannot find them.

TO2 solution: via an intake interview, Fast Track rapidly connects entrepreneurs with the right experts, laboratories or other knowledge partners.

Impact: entrepreneurs can test, develop and market their innovations faster.



SMEs that develop an innovation often ask: are we on the right track and does the idea work? Here, Fast Track can help. This is an easy and quick working method for startups, scale-ups and other innovative SMEs. Wageningen University & Research launched the initiative this year, drawing inspiration from TNO. Both organisations are members of the TO2 Federation. 'We had heard very positive accounts of Fast Track from TNO,' says Gerlinde van Vilsteren, project manager for value creation at WUR. 'We already work a lot with SMEs and decided to follow this example, because the working method had already proved itself at TNO and fits in well with the needs of entrepreneurs.' TNO subsequently shared their experiences with WUR', says Nienke Dijkstra, market director for startups, scale-ups and SMEs at TNO and formerly an entrepreneur herself. 'I'm pleased that WUR has launched this initiative as well. Even better, it will enable us to help entrepreneurs even more.'

'It's not always easy to find the right expertise at the right time'

Practical solution

WUR mainly focuses on the agri-food sector and living environment, while TNO focuses on several other sectors and areas of knowledge. 'The Netherlands has a wealth of knowledge and facilities,' says Dijkstra. 'However, finding the right expertise at the right time is not always straightforward.' Van Vilsteren recognises that: 'If a referral takes too long, an SME may have already dropped out.' At Fast Track, it goes much faster. Employees have a good idea as to where which expert or which laboratory is located. Working with an SME is different from working with a large company, Dijkstra explains: 'Large

'If the enquiry is very complex, there will be a follow-up session'

businesses are used to long-term, costly research projects, but SMEs specifically want an affordable solution quickly.' Van Vilsteren adds: 'Entrepreneurs simply want to know: how do I get that knowledge applied to my product or market?'

Referral

During a short intake interview, employees refine the enquiry and then connect the company to the right experts. Often, a specific reference already helps, for example to an article, a report, course or symposium. Van Vilsteren: 'It is a question of help in seeking solutions, pointing people in the right direction. And, if the enquiry is very complex, there will be a follow-up session.' Sometimes WUR or TNO cannot help. Then the entrepreneur is given a warm referral to another organisation, knowledge institute or company.

Societal transitions

Those interviewed, emphasize that with Fast Track, WUR and TNO contribute to societal challenges. Previous partnering between WUR and SMEs have proven this. For example, WUR helped the company Grassa, which extracts proteins from grass for food, and reduces nitrogen emissions. Protein testing brought the company closer to the marketplace. WUR also helped Munckhof Fruit Tech Innovators, to prevent wastage of crop protection products and to save costs. The companies participating in the TNO Fast Track are also developing solutions to societal challenges. For example, Ore Energy develops sustainable batteries, The Protein Brewery makes alternatives to animal proteins and supports Momo Medical health-care workers with technology in nursing homes. Thanks to TNO's testing facilities and expert advice, these innovations can reach the market more quickly. Knowledge institutes also benefit from Fast Track. 'It is an effective valorisation process for applying knowledge faster in practice', Dijkstra explains. 'Colleagues are energised by such questions because they can add value straight away.' Van Vilsteren: 'Whether working in the field or in the laboratory, they share a common sense of purpose and pride.'

European independence

Van Vilsteren points out that SMEs are a driving force behind the economy and that Fast Track helps them innovate and grow more quickly. 'Startups and scale-ups also play an important role within the EU.' The European Commission is strengthening the position of startups and scale-ups with a variety of programmes and regulations to boost Europe's earning capacity and independence. Several SMEs have already joined WUR's Fast Track, and the first intake interviews have taken place. Last year, there were over 700 intake interviews at TNO and 182 projects were completed successfully. In closing, Dijkstra says: 'There are many entrepreneurs who are working hard to do good things for society. Doing that successfully is not that easy but we are able to support them with our knowledge and facilities.' ■



WUR supports Munckhof Fruit Tech Innovators to prevent wastage of crop protection products.

WUR Fast Track

TNO Fast Track

Who: Wageningen University & Research and TNO.

Duration: since 2026 at WUR, already three years at TNO.

Quieter sailing without extra fuel

It is noisy underwater. Relentless shipping noise disrupts marine life. In the European project SATURN, MARIN developed a design tool for quieter and more economical ship propellers and applied them to a ferry propeller design. It also examined the use of air bubbles to mitigate underwater noise. ▶



Johan Bosschers of MARIN.

MARIN, TNO

Problem: the shipping industry is causing more and more underwater noise. This disrupts marine life: animals become disoriented and have difficulty communicating with one another and in finding food. At the same time, measures to make ships quieter are costly or increase fuel consumption.

TO2 solution: in SATURN, MARIN developed a design tool that allows ship designers to find the best balance between a quieter propeller and low fuel consumption. MARIN also examined how air bubbles around the propeller and under the hull can mitigate underwater noise.

Impact: the knowledge gained helps shipbuilders and shipowners to make more informed choices for quieter ships.

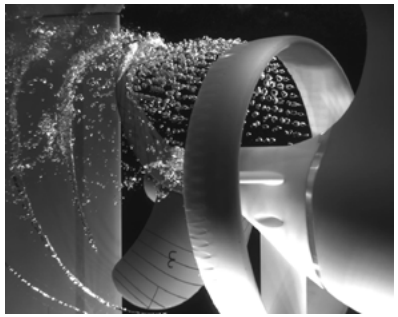
Researchers are becoming more and more aware of the implications of underwater noise for marine life. Loud noise sources such as pile driving, have been a concern for some time now because of the damage they can cause. 'Not much attention has been paid to underwater noise from ships for a long time', says Johan Bosschers, Senior Researcher at MARIN. 'Since 2008, European countries also have to take underwater noise into account when protecting the quality of seas and oceans (as established in the Marine Strategy Framework Directive). This has led to regulations for offshore pile driving. Regulations on shipping noise are still lacking, because it is not clear what level of noise is acceptable. 'The SATURN researchers were asked to find out what an acceptable noise level is and which solutions are the quietest and most fuel efficient.'

Imploding water bubbles

'Cavitation sound is currently one of the most important sources of underwater noise', Bosschers explains. 'When a ship's propeller turns, small vapour bubbles are created by pressure reduction. As soon as the water pressure rises again, the vapour bubbles collapse. That causes the characteristic underwater noise of a ship's propeller. This phenomenon is known as cavitation.' Cavitation noise can be mitigated by adjusting the propeller geometry, but such a propeller uses more fuel. MARIN examined a method to mitigate cavitation noise by blowing air bubbles into the water near the propeller. These air bubbles cause the vapour bubbles to implode less forcefully, causing a corresponding reduction in underwater noise. Model propeller tests at MARIN's Depressurised Wave Basin, a unique research facility where ship models are tested under realistic conditions, show promising results. 'However, the technique to bring the air bubbles to the proper place in the water flow needs to be improved further.'

Naval vessels

Air bubbles can reduce noise not only from the propeller, but also from the engine room. In the process, air bubbles are blown under the hull of the ship. The air bubbles form an insulating layer that prevents underwater noise from spreading via the hull. The technique is not novel, says Bosschers: 'American naval vessels are already using it, but there is little information publicly available on this. Underwater noise from naval vessels is actually confidential, because submarines can use that information to detect a ship.' The technique of blowing air under the hull is already used to reduce the vessel's resistance through air lubrication, but these tests show that air lubrication can also mitigate underwater noise. As a result, fuel consumption is lessened and underwater noise reduced.



'When a ship's propeller turns, small vapour bubbles are created by pressure reduction'

Carbon emission

Measures for quieter shipping are not always beneficial for fuel consumption. Some modifications mitigate underwater noise, but specifically increase resistance, thereby increasing, carbon emissions and operational costs. That is why MARIN developed a design tool that allows propeller designers to play with various design choices at an early stage. This allows them to find the best balance between noise reduction and fuel consumption before the ship is built. ■

Watch the video

Who: MARIN, TNO and various European maritime partners.

Duration: 1 February 2021 to 30 June 2025.

Follow-up: the project led to discussions with suppliers on the application of these techniques in future ship designs. The maritime sector is responding to this.

AI interface provides an overview of farming

Stricter ecological requirements, labour shortages, rising costs and climate change are make farming more complex. In order to work efficiently, farmers are increasingly using digital systems and robots. 'The problem is that systems on the farm do not communicate with one another; farmers have to connect the dots themselves', says senior researcher Paul van Zoggel. WUR therefore develops interfaces that merge all regular and AI information. ▶



Trabotyx combats weeds with a laser, without any chemical substances.

WUR

Problem: farmers are increasingly working with a variety of technologies and large volumes of data to effectively cultivate, as well as to manage labour shortages, legislative burdens, competition and climate change. That makes the work complex and time-consuming.

TO2 solution: WUR brings together data from machines, crops and the environment and uses AI to connect that information intelligently. System research provides comprehensive solutions for farmers who then work with robots on their farms via a single interface.

Impact: farmers spend less time in operating technology, they can work more efficiently, are better able to meet sustainability requirements, and make more reliable decisions.

At a farm in the east of the country, the Trabotyx laser targets and destroys weeds. Chemical substances are no longer needed for weed control. From detection to targeted intervention: technology is increasingly making it possible to see exactly what a crop needs. As a TO2 institute, we have been working with SMEs on this development for more than a decade. For example, on AI and imaging technologies that enable the early and accurate detection of plant diseases. One example is H2L's Potector300, an autonomous potato selection robot that detects and marks diseased seed potatoes and virus infections. The first production units are now rolling off assembly lines in the Netherlands. Wageningen validates both AI-driven data systems and the technologies underpinning smart machines to ensure they are interoperable and reliable for crop-growing businesses.

Environmental objectives

In this century, farm work has changed drastically. Farmers are no longer solely responsible for the growth and health of their crops, but also work with a rising number of machines, sensors and satellite data. In order to meet the environmental objectives of the European Union, farmers need to understand their progress towards biodiversity, soil and water quality goals. At the same time, farms have expanded, a large number of farmers are retiring, and there are very few successors willing to take over. 'It is hard work and rather complex,' Van Zoggel explains. 'Every year it becomes more difficult to meet increasingly stringent requirements.' He has noticed that machines, robots, software and data are increasingly helping to keep farming businesses future-proof. 'Technology eases the workload, makes operations more precise, faster and more sustainable.' Farmers are looking for technologies that suit their businesses and local conditions, and are increasingly experimenting with new solutions. By embracing innovation, they strengthen the long-term viability of their businesses. 'We are gaining a better understanding of what is happening in and around crops, and we can develop technologies that support that understanding.' Farmers can test new machines and software through a range of platforms without having to make major investments immediately. An example is the National Testbed for Precision Farming.

AI interface for every farmer

Technology and data are controlled through various software systems. These systems are being developed around the world but are not yet able to communicate effectively with one another. In addition, the rapid adoption of AI is leading to an ever-growing number of systems. Having to monitor ten screens at once is no longer unusual. Van Zoggel and his colleagues want to change this and are therefore developing a central interface that connects various data sources, systems and smart calculation models. WUR has partnered with the arable farming sector for many years. 'Just as people can now interact with ChatGPT or Copilot, farmers will soon be able to consult their own AI assistant,' Van Zoggel explains. For example, by taking a picture of a crop that appears unhealthy and asking: 'What should I do?' Instead of calling a consultant, farmers can already turn to AI for straightforward day-to-day advice.

International data streams

Dutch robot and software developers see the entire world as their market. Just as consumer technology is expected to work seamlessly, smart agricultural tools should be equally easy to use. WUR also contributes to various European research programmes through TO2 initiatives that test software, AI and machinery in real-world conditions and improve interoperability. Examples include CEADS, AgData Partnership, AgrifoodTEF and AgriScienceFM. 'These programmes are complementary and help coordinate technological developments,' says Van Zoggel. 'The aim is to reduce our dependence on non-European systems and commodities, so that farmers and value chains can continue to improve their sustainability while our food security is strengthened.'

1,500 farmers

Parties are working on solutions to these challenges at various levels, from municipalities to international programmes. 'Because we are involved in many of these programmes, we can move easily between different levels,' says Van Zoggel. 'Today, our group supports more than 80 technology providers and software developers with their smart data solutions, and these solutions are used daily by more than 1,500 farmers in the Netherlands alone.' According to Van Zoggel, connected systems and AI tools enable farmers to collaborate more effectively with others in the agricultural ecosystem. 'This delivers benefits not only for farmers, but also for society as a whole, both environmentally and economically.' ■

Who: Wageningen University & Research.

Duration: 2026–2030. Innovation programme *Robots heading for farming businesses.*

Salt marshes as a coastal protector

A combination of dykes and salt marshes can contribute to coastal safety while simultaneously offering space to nature. But how does that work? For decades, WUR has been researching how these vegetated areas of land at the seaside develop and can contribute to a climate-resilient coast. ▶

Marinka van Puijenbroek of WUR.

WUR, DELTARES

Problem: The Netherlands continues to protect itself against flooding, especially now that sea levels are rising. At the same time, it is important to protect nature and biodiversity. In this way, our coastal, delta and sea areas will remain safe as well as ecologically and economically sustainable.

T02 solution: WUR devises solutions in which technology and nature mutually strengthen each other. For example, by making use of knowledge about salt marshes for coastal protection and nature development.

Impact: salt marshes provide coastal protection and a habitat for flora and fauna, they store carbon and can grow apace with the sea level.

Researcher Marinka van Puijenbroek has donned her boots and, together with her colleague, walked through the fine reeds of the salt marshes off the coast of Ameland. A short-eared owl flies overhead. At the winding creek, they see oystercatchers and avocets. They monitor sedimentation by consistently measuring the distance from the soil surface relative to a fixed marker. In addition, they ascertain the specific coverage for each plant species. They use Google Earth to go to the next measuring point. WUR monitors the sedimentation and vegetation of more than 9,000 hectares of salt marshes in the Dutch Wadden Sea. Salt marshes are regularly flooded at high tide. Like dunes, they can also dampen wave action. Some parts of the salt marshes have come about naturally and other parts have been constructed. In the past, this was done to reclaim land; nowadays, it's done for nature and coastal protection.

Nature as a solution

WUR is not only examining salt marshes but also other solutions using natural processes such as seagrass and shellfish beds, as well as smart sand management. This approach is also called *Building with Nature*. Salt marsh researcher Van Puijenbroek talks about the benefits of salt marshes. 'They are very important for biodiversity. Many protected birds breed here and specific plant species are present. As a result of salt marshes, in some cases fewer high and broad dykes are needed, and they also reduce the likelihood of a dyke breach.' Furthermore, salt marshes fulfil varying functions. They store carbon, as plants absorb carbon dioxide, and then some of this carbon is stored in the sediment. At the same time, salt marshes form a natural buffer against salty sea water. They inhibit the amount of seawater that ultimately reaches farmland via the soil bed, which is beneficial for agriculture. They also offer space for grazing, farmers like to graze their livestock on it.

New salt marshes

This knowledge has already been applied in practice. At Marconi Buitendijks near Delfzijl, a new salt marsh landscape was constructed in 2018. The project combines an adapted sea dyke with a salt marsh, a city beach and space for nature and leisure. WUR scientists researched whether it was technically and ecologically possible to construct a salt marsh there. In turn, they examined how the salt marsh could best be constructed with the volume and type of sediment, and how best to develop the vegetation. Van Puijenbroek: 'We were able to reuse sand and sludge from navigable waterways



'The salt marshes sometimes make fewer high and broad dykes possible'

'We were able to reuse sand and sludge from navigable waterways that needed to be dredged'



Roggenplaat replenishment in the Eastern Scheldt

Roggenplaat nourishment, a mudflat plate in the Eastern Scheldt, is another example of *Building with Nature*. In 2019, around 1.1 million m^3 of nourished sand was brought onto seven sections of the Roggenplaat mudflat plate to combat the effects of sand hunger. This allows the mudflat plate to remain dry for longer and the vital foraging area for birds is retained.
Five years of monitoring has shown that this approach works. This vital area for birds promptly rose in significance by 21%. After five years, approximately 17% of the nourished sediment had disappeared, particularly at areas that are highly exposed to the swell. At sheltered, finely sanded areas, soil life recovered within about two years and birds gradually returned too.
The Roggenplaat mudflat plate, as a whole, has retained its function as a foraging and resting area for birds and seals. The results provide valuable knowledge for future nourishments and other natural solutions for tidal areas.

that needed to be dredged, and sowed a single plant species. Soon, many different plant species appeared.' WUR worked with Deltares on this project. WUR contributed the knowledge on vegetation and ecology while Deltares focused on water, waves, sediment and safety. Van Puijenbroek says that there is a great deal of interest in these research results from countries with similar coastal ecosystems, like Germany, Denmark and England.

Sea level rise

According to Van Puijenbroek, salt marshes can play a significant role in mitigating the effects of rising sea levels.
By retaining sediment, salt marshes can increase in height and thus keep up with the rise in sea levels. If sea levels rise faster than a salt marsh's ability to adapt accordingly, plants could eventually disappear. A possible measure is to bring additional sludge – in the right composition and quantity – to an existing salt marsh. Her new research explores how and when that works. ■

Who: Wageningen University & Research and Deltares.

Duration: Unspecified, since the 1980s.

Read the full report and results here

NLR

International NATO exercise with drones at NLR

In May 2026, NLR hosted the international NATO exercise – Counter Unmanned Aircraft System Technical Interoperability Exercise (C-UAS TIE) in Marknesse. During the exercise, military personnel, knowledge institutes and businesses from various NATO countries tested the latest technologies for detecting, tracking and neutralising drones. The emphasis lay on interoperability: making systems from different countries work seamlessly together. It was the first time that this large-scale exercise had taken place on terrain Aerospace Centre (NLR). The unique testing facilities in Marknesse provide a safe environment for testing new technologies under realistic circumstances. This means that NLR makes a direct contribution to the development of innovative defence technology and the reinforcement of collective security within NATO.

Check out the video of the NATO exercise at NLR.



NLR

NLR opens upgraded ACM3 facility

NLR will soon officially open the upgraded ACM3 facility. Thanks to an investment of almost EUR 10 million from the first round of the Applied Research Facilities (Faciliteiten voor Toegepast Onderzoek, FTO) scheme, NLR has been provided with new equipment for advanced production with metals and composites.
The facility offers businesses and researchers the opportunity to develop, test and apply innovative production techniques, like 3D printing of metals. This could, for example, help to develop lighter, stronger and more sustainable components for aviation and high-tech industries. The investment contributes to the international competitiveness of industry in the Netherlands. In ACM3, NLR works closely with universities, other knowledge institutes, industry and SMEs.





TNO, NLR

The Netherlands strengthens its military position in outer space

Guaranteed access to outer space and a strong intelligence position, are crucial for successful operations in all other military domains: land, sea, air and cyber. To accelerate innovations for Defence, knowledge institutes TNO and NLR have intensified their collaboration of more than a decade with a new strategic agreement, by further integrating military aerospace expertise and capabilities. This pooling of forces, focuses primarily on encouraging the sovereign, autonomous aerospace capabilities of the Dutch armed forces. This helps to build a common and rapidly scalable R&D environment in support of the Ministry of Defence's objectives for military use of outer space.
The operational power is now taking definite shape. This means the BRIK II, and the MilSpace 2 satellites launched to gather intelligence in 2023, were expanded upon. PAMI-1 has been scheduled to be launched in 2027-2028 as a precursor to an Electro Optical ISR capability. These Dutch satellites are also equipped with innovative laser satellite communications for extremely fast and secure data transmission. Furthermore, intensive work is being done on mapping the aerospace domain to understand what is happening in outer space and which threats need to be taken into account. This is also known as Space Domain Awareness.

Deltares, WUR

Nature as an ally against climate change

Climate change is putting seas and coastal areas under pressure worldwide. Rising temperatures, acidification and changes in biodiversity threaten marine life and also the people who depend on it. FutureMARES, the European research project in which Deltares took part, focuses on how nature itself can help to cope with these consequences.

More than thirty international research and knowledge institutes worked on Nature-based Solutions. These include the recovery of seagrass meadows, shellfish beds and mangrove forests; habitats that are known to capture lots of carbon dioxide and thus contribute to the reduction of climate change. They also explored ideas for improving the protection of vulnerable nature and renewable, nature-inclusive fisheries and aquaculture. By using field research, climate models, and socio-economic analyses, researchers determined which measures are most effective. Deltares conducted pilot studies on the effects of large-scale cultivation of seaweed and shellfish in various climatic scenarios. It appears that seaweed in particular can extract large quantities of nutrients from the system in such a way that this can affect the growth of phytoplankton. This happens in each climate scenario, but the degree of impact varies from one scenario to another. The study included how climate change affects the chances of recovering oyster banks in the North Sea. It showed that some of the old oyster beds already lack sufficient growth potential, which makes recovery of oyster banks more difficult. The results will help OR are helping policy makers to make seas and coastal areas more climate resilient while simultaneously protecting biodiversity.

FutureMARES



Deltares, WUR

Cultivating seaweed amongst offshore wind turbines

Can offshore wind farms also be used for sustainable cultivation of seaweed and shellfish? And simultaneously contribute to the recovery of nature and health? The European ULTFARMS project, led by Deltares, explores how both functions can be combined safely and sustainably. At six locations in the North Sea and the Western Baltic Sea, new cultivation methods are being tested to include seaweed, mussels and oysters. Deltares is developing models to predict where these forms of aquaculture are possible and what the consequences would be on the ecosystem. The cultivation methods are also examined in practice. In conjunction with Ghent University and IMPACT-9, Deltares tested in a research facility how much force waves and currents exert on the long lines on which seaweed is cultivated. This knowledge helps to design systems for cultivation that can withstand offshore conditions, and highlights the opportunities for commercial upscaling. A scientific paper will follow at the end of 2026.

ultfarms.eu



Researchers compared empty, full-size seaweed nets on which mature seaweed substitutes had been cultivated in the wave basins at Deltares, to see how much force the waves and currents had exerted on the structures.



TNO

New factory accelerates production of photonic chips

Photonic chips use light rather than electrical signals to process information, enabling faster, energy-efficient data communications and advanced sensors. Although Europe is at the forefront of global knowledge as regards this technology, the leap from laboratory to large-scale commercial production is often problematical.
The Dutch Photonic Chip Pilot Line at the High Tech Campus in Eindhoven, an open innovation facility in which TNO plays a key role, eases this problem and accelerates market introduction. To achieve this leap in scale, the factory connects the entire high-tech ecosystem: TNO works closely with knowledge institutes such as TU Eindhoven and the University of Twente, as well as with trend-setting partners, including ASML, SMART Photonics and Aixtron. Working together, they are transitioning from 4-inch to 6-inch wafers for the production of indium phosphide chips. By producing on these larger discs, businesses can scale up more efficiently and cost-effectively, providing a strategic contribution to economic competitiveness and European technological autonomy, as part of the PIXEurope initiative.



WUR

Restoring European forests starts by looking ahead

How does one ensure that European forests are also resistant to drought, storms and plagues in the decades ahead? In the European project SUPERB and together with international partners, Wageningen University & Research is researching how thousands of hectares of forest can be recovered and prepared for a changing climate. By planting various species of trees and creating more variety, the forest becomes less vulnerable to drought, plagues and storms. Researchers map how forests develop under varying conditions and climate scenarios. This clarifies which measures will help to make forests more resilient. In doing so, the knowledge and experience from various European countries are combined. Forest owners, public authorities and local residents are actively involved in decision-making. For example, forest regeneration should not only benefit forests today, but also ensure they are resilient and adaptable for future generations.

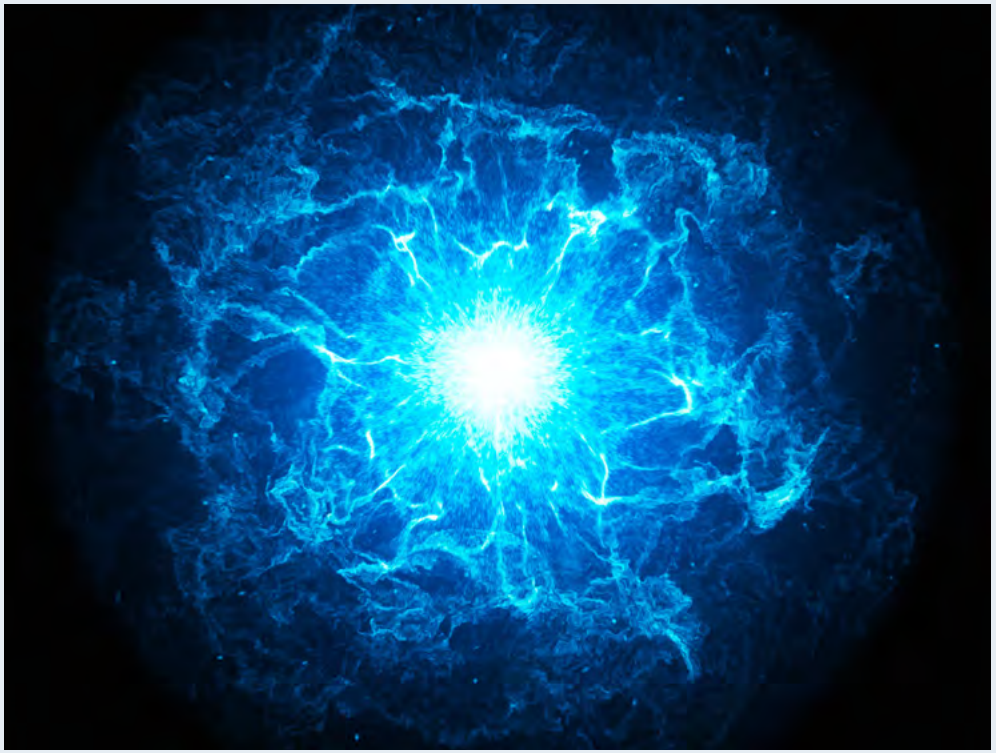
WUR

WUR

Who will be given room to manoeuvre in Europe?

Agriculture, nature, housing, roadways and renewable energy all need room to manoeuvre. But manoeuvrability is restricted. So, Wageningen University & Research explored how different choices can change the European landscape up to 2050. Drawing on historical and current data on agriculture, nature and urbanisation, researchers developed and analysed a range of future scenarios. For example, they are able to show where functions clash and what policy choices mean for food production, water quality, soil, nature and carbon emissions. In the absence of supplementary policies, agricultural land in the EU could possibly diminish by more than 8 million hectares by 2050. At the same time, research has shown that targeted measures can bring about environmental and climate benefits without putting enormous pressure on food production. These insights shed light on regional tailor-made policies and spatial planning in which food production, nature, climate and liveability are in balance.

WUR



TNO

Plasma technology for a cleaner chemical industry

The chemical industry still uses a lot of fossil-based raw materials and this causes carbon emissions. The new startup Thoriant, established by TNO, Maastricht University and Ebert HERA, aims to change this with plasma technology.
The technology uses electrically generated plasma – an extremely hot ionised gas – to convert methane into hydrogen and acetylene.
These substances are key building blocks for plastics and other chemical products, among other things.
The process runs entirely on green electricity and does not cause direct carbon emissions.
Industrial waste gases can also be converted into valuable raw materials. The technology has already been proven on a laboratory scale. Thoriant is now going to scale it up and test it in a pilot plant, with the ultimate objective being application in the chemical industry.

WUR

Smarter crop protection with fewer chemicals

Can a camera detect whether a plant is diseased? Through the European OPTIMA project, Wageningen University & Research and its international partners have explored how diseases in agricultural crops can be detected earlier and more accurately, resulting in fewer chemically-based crop protection products being needed.
WUR researchers used special cameras and smart software to track down disease symptoms in apples, grapes and carrots early and accurately. By combining expertise in plant health, data and AI, biological crop protection, and precision technology, they can determine not only whether a crop is diseased, but can also determine where and when intervention is needed. This allows farmers to effectively protect their crops, while using fewer chemicals and reducing the impact on the environment.

WUR

MARIN

Sailing smarter with wind

Wind can help ships to save fuel and to reduce carbon emissions. Yet, shipowners are still reluctant to invest in wind propulsion on a large scale. For example, it's not always clear how much fuel a system saves in practice and how it can be used optimally.
In the European project AWESOME, MARIN works with partners on methods to dispel these uncertainties. The project also focuses on better fuel economy predictions and design guidelines. Additionally, modifications of ships and smart systems are being devised to help the crew make optimal use of wind propulsion en route. Methods are also being developed to reliably measure on-board performance. AWESOME is set to make it easier for shipowners to take the step towards wind propulsion.

AWESOME



Twenty years of ‘Taste Lessons’ at school: early learning to eat healthy

‘Taste Lessons’ (Smaaklessen), is a free programme that teaches primary school children about healthy and sustainable eating, i.e. from growing to cooking and tasting. This is meaningful, because many eating habits become ingrained during childhood. What does the programme consist of and what has been achieved after twenty years?

Fieke Franken of WUR.

WUR

Problem: twelve percent of children are overweight, which increases the risk of diabetes, heart disease and other conditions. Unhealthy food products are available everywhere and not all parents have sufficient support, time, resources or know-how to teach their children healthy eating habits.

T02 solution: WUR helped develop 'Taste Lessons', a free programme that teaches primary school children about healthy and sustainable eating, i.e. from growing to cooking and tasting.

Impact: more than a million children have attended a 'Taste Lesson'. The programme increases children's knowledge about nutrition. They are more open to tasting unknown products and to eating healthier and more varied food.

According to figures by Statistics Netherlands, about twelve percent of children are overweight. This increases the risk of diabetes, heart disease and other illnesses. 'It is difficult to change food preferences, eating patterns and eating habits', says Fieke Franken, team leader of Smaaklessen; the 'Taste Lessons' programme, developed by Wageningen University & Research. 'This makes it meaningful to develop healthy and sustainable eating habits at an early age, so that children can benefit from this for the rest of their lives. Not only is a lot learned at home or from friends, but also at school.' She says that in the past decades, the food supply has become a lot unhealthier. 'Unhealthy food products are available everywhere and we see that not all parents are able to provide sufficient support, time, resources or know-how to teach their children healthy eating habits.' Through 'Taste Lessons' children discover in a playful and hands-on way where food comes from, what it tastes like, and what healthy eating means.

A million children

'Taste Lessons' started twenty years ago. By now, more than eighty percent of schools are using the programme. Franken: 'More than a million children have attended a 'Taste Lesson'. Education about healthy eating also contributes to equality of opportunity, she explains, because almost all children in the Netherlands attend school. The 'Taste Lessons' programme consists of nine basic lessons for groups 1–2 and five basic lessons for groups 3–8. Franken: 'The lessons are well in line with what children understand and remember at a certain age.' In this, tasting and experiencing is key. 'Children primarily learn by doing. In that way the study material will be remembered.' In addition, there are more in-depth teaching modules, e.g. on topics such as food waste. An online portal enables teachers to find the teaching modules and a guideline. Schools can take the children on an excursion to an arable farm, an orchard, or a dairy farm, and a guest lecturer can pay a visit. WUR tries to reach schools in different ways and supports them with educational materials and activities. For example, they can ask for seed packets for vegetable garden classes, and a real chef could come to the classroom to prepare a dish together with students. Schools can choose



'The lessons are well in line with what children understand and remember at a certain age.'

to use part of the teaching materials or to integrate several classes into their programme.

In conjunction with teachers

'Taste Lessons' was developed by WUR and is continuously evaluated to assess its effectiveness, Franken emphasises. Teachers and children make an active contribution to this.
'They really help to find solutions. It is an interaction between research and practice.' That, she believes, is one of the reasons why the number of schools using the programme has grown in recent years. "We do not only evaluate the content and its impact; we also look closely at how the programme is implemented. How do teachers use it in practice, and how can we make it easier for them?" For example, teachers who prefer printed materials can use a teacher's handbook.

Free vegetables

'Taste Lessons' is free for schools. Funding is received from the ▶



'Healthy and sustainable food, like language and arithmetic, should be a routine subject as part of the school experience'

government and industry, i.e. supermarkets, trade organisations and chain organisations. Franken: 'Businesses provide us with know-how from the sector, or products such as seeds and groceries that are required in the classroom. We have very strict arrangements on how we cooperate. In this way, no specific brands of products are allowed in class.' Some of the schools that work with 'Taste Lessons' are given free fruit, vegetables and sometimes dairy products for twenty weeks, which they use during class. This is arranged via the national EU School Fruit and Vegetables programme and EU School Dairy, for which the WUR organises the communications, registration and education, and which is partly funded by the European Union.

Impact classes

The 'Taste Lessons' programme was updated in 2024. Over the past year, senior researcher Gertrude Zeinstra and colleagues from across WUR have assessed the effectiveness of the updated programme. Through interviews and questionnaires, they gathered data from pupils, teachers and parents at participating schools who did and did not make use of 'Taste Lessons'. They visited the schools before class, immediately afterwards and a few months later. The results are expected by the end of 2026. Previous WUR studies showed that 'Taste Lessons' increases children's awareness of healthy eating and nutrition. Children are more likely to try unfamiliar foods and adopt healthier and more varied eating habits. Franken: 'Teachers and classmates appear to be role models and pupils encourage each other to taste new things.' In addition, the combination of EU School Fruit with 'Taste Lessons' appears to increase the consumption of fruit and vegetables. 'This is especially beneficial for children who are exposed to less healthy eating habits at home.' According to Franken, food education alone is not enough. 'What people eat depends on many factors. So, aside from education, we also need an environment that stimulates healthy behaviour. Parents and the food supply play a key role in this. Ultimately, we want to contribute to a generation that makes healthier choices and passes on those habits to the next generation.'

Food education

WUR will also continue to encourage teachers to stimulate food education in forthcoming years and will therefore make the teaching materials as accessible as possible. To promote food education more widely, WUR shares its expertise and experiences with Dutch and international organisations, schools and municipalities, as well as through European research programmes. When it comes to cross-border food education, Franken says that the context is different everywhere: 'Every country has its own food culture and nutritional guidelines, so a programme like 'Taste Lessons' cannot simply be translated word for word."
Food education is not currently a compulsory subject in primary schools. "Not yet," says Franken. 'Together with other organisations, we are advocating for food education to become a compulsory part of the primary school curriculum. Healthy and sustainable food should be a regular part of every child's education, just like mathematics and language.' ■

Who: Wageningen University & Research.

Duration: The programme has already existed for more than 20 years.

More details on the 'Taste Lessons'

Stress test for our critical infrastructure

Extreme weather, such as heavy rainfall or prolonged drought, has a profound impact on our society. Not only directly, due to floods or natural fires, but also indirectly when vital services such as electricity and telecommunications fail, and roads are impassable. Deltares mapped these chain effects so that the Netherlands can make informed choices in designing the living environment. ▶

Margreet van Marle and Bart Maas of Deltares.

Deltares, TNO

Problem: climate change increases the risk of extreme weather, drought and flooding. Due to the strong dependence among vital functions such as electricity and water management, failure of one system can quickly lead to problems in other infrastructure.

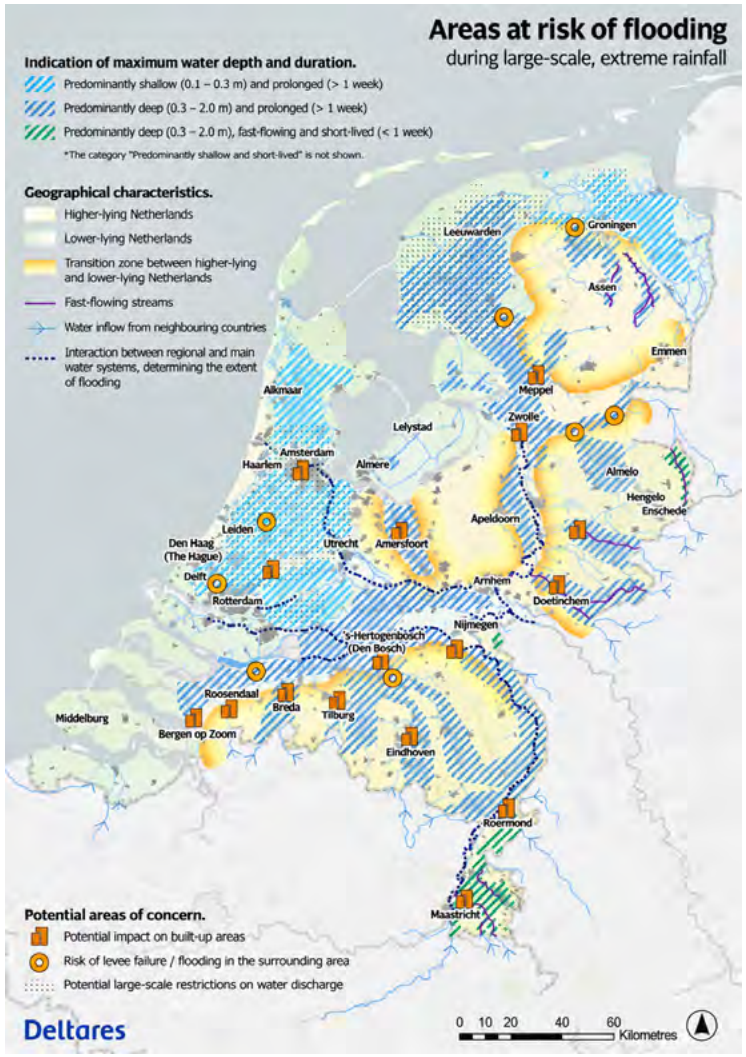
T02 solution: Deltares uses stress tests to map the dependencies among vital functions.
For example, this will make it possible to see what chain reactions can occur and provide government departments and authorities with tools to limit risks and improve cooperation.

Impact: by understanding the dependencies vital services, government departments and authorities can make better choices for crisis preparation, investment and recovery. In this way, the Netherlands will be better prepared for the consequences of extreme weather.

Imagine that an area floods in the Netherlands, similar to what happened in Limburg in 2021. Residents had to evacuate, streets turned into fast-flowing rivers, and scooters and traffic signs floated through the streets. And imagine that not only is there damage to houses and roads have become impassable, but that the flood also causes electricity to fail, which means that water pumps don't work either. As a result, the water rises in an increasingly large area, making it even more difficult for emergency services to enter the area. To make matters worse, a telecommunications mast has been damaged, making communications difficult. Such chain reactions, where failure of one infrastructure leads to problems in another, are known as a cascade effect.
The fact that these chain reactions occur has everything to do with the fact that our vital infrastructure is highly interdependent, explains Margreet van Marle, researcher of wildfires and climate resistance at Deltares. Water management, electricity, transportation, telecommunications and healthcare are so interconnected that downtime in one sector can have a major impact on other sectors. A concurrence of failing types of infrastructure can lead to threats to public security and societal disruption.
'With that in mind, it is important to know how vital functions depend on one another, so that we can prepare better.'

Resilience

Deltares works on the resilience of critical infrastructure in various projects and programmes. One of the outcomes is the Climate Resistant Critical Infrastructure Guide, commissioned by the Ministry of Infrastructure and Water Management. This will provide infrastructure authorities with a standardised method of identifying climate risks. It combines climate data, infrastructure data and usage data to determine which parts of a network are vulnerable to climate threats such as flooding, heat and drought. Subsequently, potential damage, functional failures and societal consequences were analysed.
In the Climate Security programme, together with TNO and the Netherlands Institute for Public Security, Deltares also developed scenarios for climate threats, cascade effects and scarcity. These are intended for the security regions, so that crisis response and national security can be improved.



'If several infrastructures fail simultaneously, this could seriously disrupt society'



'People realise that a disaster can really happen'

Van Marle: 'The "what if" scenarios and analyses that we undertake at Deltares, are designed to show the places where measures serve a purpose.'

Wake-up call

Extreme weather will occur more frequently as a result of climate change. That is why, in 2023, the Ministry of Infrastructure and Water Management initiated the knowledge programme on flooding (Wateroverlast), which includes scrutiny of possible cascade effects due to climate change, such as extreme rainfall or drought. The consequences of prolonged drought may include disrupted inland shipping, failed harvests, salinisation of freshwater buffers such as the IJsselmeer and diminished dyke safety. There is also the likelihood of more wildfires, with accompanying chain reactions such as pressure on scarce emergency services, nature impacts or power failures. In order to develop knowledge about this, it is vital that the various organisations responsible for critical infrastructure work together and are able to learn from one another. This is why stakeholders such as municipalities, ministries, suppliers of critical infrastructure and other parties are connected to the programme.

'As an independent knowledge institute, Deltares serves the collective societal interest of making the Netherlands more resilient', says Bart Maas, flood risk researcher at Deltares and, just like Van Marle, involved in the knowledge programme.
Deltares gathers knowledge from different regions and collaborates with universities on methods that better visualise cascade effects, quantify their impact, and weigh up the costs and benefits of various options for climate adaptation. Van Marle: 'In this way, we show how large-scale rainfall affects the accessibility of areas. We also provide an insight into where infrastructure investments can inhibit the chain effects. These methods apply not just to climate threats, but also to cyberattacks or sabotage.' It might make sense to first repair certain roads, because those are important for the emergency services and recovery of the electricity supply. 'If these dependencies are defined, other sectors could also benefit from them', says Maas.

Practice for calamities

One of the most important tools for gathering knowledge in the flooding programme is the supra-regional stress test.
This method examines which cascading effects occur if prolonged extreme rainfall reaches a large area, which could cover several provinces. The interdependence between electricity, telecommunications, traffic and water management proved to be much greater than had been supposed. The stress tests are a good exercise for predicting bottlenecks in the crisis management of difficult-to-predict threats, Van Marle explains. 'Not only does one learn about vulnerabilities, but also about one another's roles and interests, because multiple partners have to talk to each other.'

Holistic perspective

The research results make parties realise that they should not act in isolation, but that an integrated approach is necessary. Maas: 'Otherwise, measures within one sector may have negative consequences for other sectors.' It is one of the key lessons in the knowledge programme: a holistic perspective is essential. One has to rise above the subject matter and not approach problems and solutions in a sectoral way. Van Marle: 'Every organisation has its own goals, but as a society we have overlapping goals. These competing interests become visible during the stress tests and it is precisely because of this that organisations learn from each other.'
Maas sees that the emphasis in dyke design now lies on flood prevention, whereas recovery from flooding is given much less attention. 'While specifically wanting a flooded polder to be restored as quickly and safely as possible after a dyke breach, one could take that into account in the design of a dyke.'
This broad view is also needed in the design of our living environment, because extreme rainfall as well as drought are becoming more common. 'By combining measures against flooding and drought, the landscape can be designed in such a way that water is captured and retained during wet periods for use during dry periods. At the same time, nature should be developed in such a way that it is more resistant to prolonged drought,' Van Marle analyses.

Developing awareness

The knowledge programme aims to raise awareness among public authorities, emergency services and other agencies about their mutual dependencies. They must also realise that extreme events as a result of climate change can really happen. According to Maas, this goal has already been partially achieved. 'The organisations involved realise that floods in unwanted places are a real risk. If this awareness leads to public authorities, emergency services and other agencies adapting their plans, crisis preparations and investments in them, then that is a significant step forward.' ■

An accumulation of climate threats requires a comprehensive preparation and response | Deltares

Summary of research by Deltares-TNO-NIPV

Who: municipalities, ministries, water companies, T02 institutes Deltares and TNO, Rijkswaterstaat, ProRail, KNMI, security regions, universities and engineering agencies.

Follow-up: Provinces visualise the consequences and impact for their region. Deltares translates the key lessons into insights at national level.



Breaking free from the American cloud

At the moment, European cloud services are struggling to compete with American big tech organisations. ECOFED is working on the solution. ‘Instead of a single major provider, we’re creating a mosaic with several European parties,’ says Peter Verkoulen, director of the Centre of Excellence for Data Sharing & Cloud. ▶

TNO

Problem: Europe depends on American big tech organisations for many cloud services. European providers are smaller and have difficulty in competing with the scale and investment capacity of American parties. Users are also often 'stuck', i.e. switching to another provider takes a lot of time and money.

T02 solution: at ECOFED (see insert), together with Dutch cloud businesses, TNO is building a European cloud federation of small providers with a shared technical architecture. Users can more easily switch cloud providers and combine various services. The latter intensifies the available computing power.

Impact: users are given more choice and control over their data and are less dependent on a single provider. Moreover, by connecting European cloud services greater scale will come about and will enable the European cloud sector to compete more effectively with major American providers.

Every day, a huge volume of personal, corporate, and government information is stored on American cloud servers. This makes digital infrastructure dependent on hyperscalers, i.e. big tech organisations such as Microsoft, Google and Amazon, says Bjorn Hakansson, senior business development manager at TNO. 'European initiatives do not offer the same scale and computing power, and switching costs time and money.' Time, because the services from various providers do not align with those of competitors. And money, switching from a hyperscale cloud to a smaller European cloud entails migration costs. This makes it more difficult for users to switch or to combine services from various providers.

Geopolitics

This European dependency poses a risk: 'another party can exert a lot of geopolitical pressure', Hakansson explains. American legislation (the Foreign Intelligence Surveillance Act, FISA) gives American intelligence agencies broad powers to access data of non-Americans, as long as they proceed through an American provider. 'It is not wise for a geopolitical dispute to lead to unwanted access to personal data. This would have been a potential risk if the take-over by an American party of the company that runs DigiD had not been stopped.' According to Hakansson, that dependency could pose a risk to critical digital systems in times of geopolitical tensions. Given their smaller scale and more modest investment opportunities, European cloud providers are struggling to compete with American big tech organisations. 'The best European start-ups are also regularly taken over by American companies. More investment capital is available in the United States, allowing talented companies to scale up faster,' says Hakansson. In this way, knowledge and expertise go abroad and IT facilities become part of non-European management.

Patchwork

The solution is a federated cloud ecosystem. 'Instead of a single major provider, we want to create a mosaic as it were, with several European parties,' says Peter Verkoulen, director of the Centre of Excellence for Data Sharing & Cloud (CoE-DSC). 'In 2020 we started a series of webinars on cloud topics to get the industry on board. Initially, about fifteen businesses showed an interest, and eventually the ECOFED project came into being,' says Hakansson.
To connect these various parties and their services, open standards are needed. 'All systems must use the same conventions', explains Peter Verkoulen, who is committed to a federated cloud ecosystem as part of CoE-DSC. 'Conventions make it easier for services to connect and for users to switch. To achieve this, CoE-DSC is collaborating with NEN, the Royal Netherlands Standardisation Institute.'
'Once everything has been harmonised, Europe will have more computing power, a wider range of cloud services and greater scale,' says Verkoulen. This alternative to big tech organisations allows users to choose by service or data set the one that best suits their requirements regarding price, speed, and sensitivity of data. This gives them more control of their data. ■

What is ECOFED?

ECOFED (European Cloud Services in an Open Federated Ecosystem) is a Dutch project within the European IPCEI-CIS (Important Projects of Common European Interest – Cloud Infrastructure and Services) for cloud infrastructure and cloud services. The objective is a more independent, federated cloud infrastructure that gives European organisations more control over their own data and makes them less dependent on non-European tech giants, such as Amazon, Microsoft and Google.

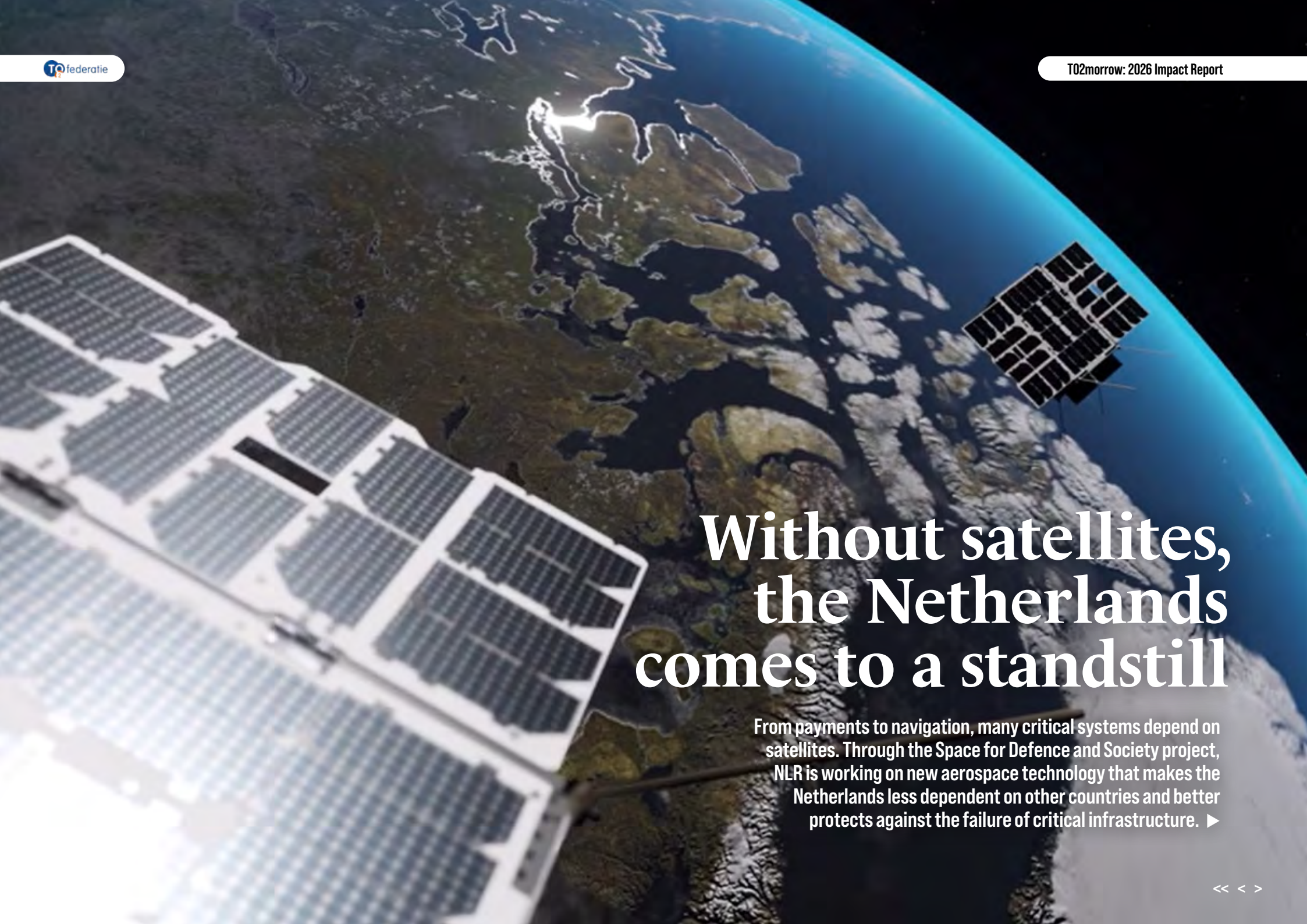
Who: TNO, Info Support, BIT, i3D.net and AMS-IX.
Duration: 2024 to 2029.
Budget: EUR 21 million.

What is CoE-DSC?

The Centre of Excellence for Data Sharing & Cloud (CoE-DSC) is the central point of contact for questions regarding data sharing and cloud issues in the Netherlands. It bundles knowledge, experience and results from initiatives such as ECOFED and combines that with European developments. TNO is the coordinator of the CoE-DSC commissioned by the Ministry of Economic Affairs and Climate (EZK). The knowledge institute is therefore responsible for the coordination of activities at the knowledge centre, while also being a contributor to it.

Who: TNO, Innopay, NimbleNova and others.
Duration: multiannual.
Budget: approx. EUR 3 million per year.

More details



Without satellites, the Netherlands comes to a standstill

From payments to navigation, many critical systems depend on satellites. Through the Space for Defence and Society project, NLR is working on new aerospace technology that makes the Netherlands less dependent on other countries and better protects against the failure of critical infrastructure. ▶

NLR, TNO

Problem: the Netherlands is becoming increasingly dependent on satellites and other aerospace technology. At the same time, outer space is becoming more congested and geopolitical tensions are rising. How do we ensure that this critical infrastructure remains secure and reliable in future?

TO2 solution: with the Space for Defence and Society programme, NLR develops knowledge and technology for aerospace. Together with other parties, NLR is working on innovations that make the Netherlands less dependent on other countries.

Impact: the programme will strengthen the Dutch aerospace sector, reduce dependency on other countries, and improve the protection of critical amenities such as communications, navigation, the energy supply and payment services.

Rik Bosma is the programme leader of Space for Defence and Society of the Royal Netherlands Aerospace Centre (NLR). The aim of the programme is to make better use of aerospace for safety and everyday life and to make the Netherlands and Europe less dependent on other major powers. Outer space has a lot of direct influence on our lives on Earth. With that in mind, if one has power in outer space, it influences one's power on earth. It is not without reason that NATO considers outer space as an official warfighting domain. Bosma: 'This makes knowledge about space a prime target for espionage.'

A smidgin of SpaceX

If satellites were to malfunction, for example, due to a collision with space debris or a hypothetical space war, then we have a major problem with our critical infrastructure, says Bosma. 'We use satellites for climate monitoring, keeping watch on dykes and for agriculture.' In addition, satellites are essential to timing on Earth. Our energy supply, payment services, communications, navigations, logistics, climate monitoring and ultimately almost the entire economy depend on that timing signal, Bosma explains. 'If the timing is out of kilter, there is a risk of a chain reaction. For example, water purification does not function without electricity and eventually you wouldn't be able to flush the toilet any more. You can flush it three more times and then that's it.'

Eight launches

More aerospace capacity also means more influence on the world stage. Dutch satellites are already providing highly accurate global climate data on emissions, pollution and substances in the atmosphere. Other countries want to use them, and that gives the Netherlands negotiating power. Conversely, one wants to be as independent as possible. 'The Netherlands and Europe do not want any other country denying us access to outer space, which might then cause a problem on Earth. Nowadays, Europe carries out eight launches a year, whereas the United States does more than a hundred. That makes us vulnerable.' Bosma has noticed that the Netherlands has recognised this need and therefore expects that, in five to ten years' time, there will be many more Dutch-owned satellites. He also hopes that the Netherlands will take over 'a smidgin' of SpaceX, Elon Musk's space company. 'Sometimes their rockets explode, but one can only learn from that. By tradition, we are very cautious in the Netherlands but if we want to be included, then risks and bravado are necessary.'



'Europe carries out eight launches a year, the US launches a hundred. That makes us vulnerable'

Rik Bosma of NLR.

Space debris

Space has been rather crowded for years now. As a consequence, the risk of satellite failure is quite realistic. In fact, the waste now 'orbiting' satellites, is space debris mainly made up of old or broken materials, such as discarded satellites and loose components from rockets that orbit around Earth at an amazing speed. 'Even a one-cubic-centimetre fragment of space debris can destroy a satellite.' It is particularly congested in sun-synchronous orbit; this is very popular because solar panels on the satellites there capture sunlight almost continuously. Space for Defence and Society is therefore looking into alternative orbits, like the Very Low Earth Orbit. It is very close to Earth, making communications faster and resolutions higher, allowing sensors to measure more accurately and provide better images. In the Very Low Earth Orbit, the atmosphere is denser, the resistance is greater, and the air is electrically charged. There, the conventional square satellite shape is less suitable. So, Bosma is thinking more of improved aerodynamic forms, like a droplet, a bicycle helmet or a bullet shape. 'Besides, we don't yet have rockets specifically designed for these orbits, simply because there has been little need for them so far. To move on from assumptions to actual knowledge, we carry out research.'

'This programme can serve as a breeding ground for new technologies'



The MilSpace2 satellite system where the Birkeland and Huygens satellites work together to better detect geolocations.

More influence

Space for Defence and Society was initiated in 2025. The big difference with the past is that research back then, was mainly promoted by the European Space Agency (ESA), for example. 'Nowadays, we use far more of our own discretion to determine which technologies are important for Dutch society. We dare to take the plunge, especially in the field of Research and Development. Ideally, we develop something new for which there is a need, and then hand it over to industry as soon as a viable business model emerges.'
The start-up programme is an important asset. 'A new idea that could mean a lot to space exploration, will often require massive investment before it can be put into space. That is why we need a programme that serves as a breeding ground for such technologies.'

Amongst the best in the world

Bosma is ambitious. In his view, the Netherlands is 'amongst the best in the world' in fields such as high-tech, agriculture and water management. Aerospace must become a new pillar. Aside from developing and launching satellites, he expects the Netherlands to excel in future in robots that repair and maintain satellites in outer space. 'America sends people to the moon, while Europe focuses far more on robots. And, in the Netherlands, we are already very good at robotics technology. Our programme can accelerate such innovations.' ■

Space for Defence and Society

Who: NLR works in conjunction with dozens of Dutch and hundreds of European partners and businesses, including ESA, Thales, Airbus, ISISpace, TNO, Defence and the universities of Delft, Twente and Eindhoven.

Duration: the programme has run for one year and has no end date.

Budget: about EUR 3 to 4 million per year.

Follow-up: every year, NLR draws up a research plan and progress report. This is partly the basis on which NLR defines the aerospace strategy for the future.

Innovating at wartime speed

How do you set up a short-cycle innovation trajectory, in which something brand new is designed in fast development steps? That was the demand for SeaRush, MARIN's project in which a 3D-printed USV was developed within a few months: an Uncrewed Surface Vessel, or an unmanned vessel. ▶



The Uncrewed Surface Vessel's prototype undergoing testing.

MARIN, NLR, TNO

Problem: technological developments in warfare are progressing faster and faster, while conventional development trajectories at Defence take forever. This makes it difficult to respond quickly to new threats.

TO2 solution: as part of SeaRush, MARIN researches how innovation can proceed much faster by designing, building, testing and improving an uncrewed surface vessel (USV) in short cycles.

Impact: SeaRush ensures that Defence has experience with short-cyclic innovations and specific knowledge about 3D-printed vessels, and Dutch maritime suppliers that can contribute to rapid development.



'Defence is not used to fast development trajectories', says project manager Just Settels, 'while the geopolitical situation is becoming increasingly threatening. That led to the idea that things should be different; that we should be able to respond quickly to changes in the world around us.' This idea gained further momentum due to Russia's war against Ukraine. That is where warfare on the water has changed significantly due to the deployment of unmanned units, and USVs play an important role. Drones, USVs and other weapons are sometimes modified and enhanced in just a few weeks.

Rapid development

Settels: 'The ideology of the SeaRush project is: let's see if we can quickly produce a small, relatively inexpensive, unmanned boat. Further, we also wanted to map out the maritime manufacturing industry in the Netherlands, because the ultimate goal is to ensure that in times of tension and scarcity of money, personnel and time, we can still make USVs quickly and scalably.' The first step was to opt for 3D printing. 'This is a good way to achieve a prototype quickly based on an idea, and to then make modifications.' The 3D printing specialist is the firm IMPACD Boats in Woudsend. The hull is printed from a glass-fibre reinforced synthetic material, positioned horizontally on trestles, while the printing robot travels over an underlying rail.

6-metre prototype

The exact missions the boat had to perform had not been established at this stage. Settels: 'The easiest option, of course, was to load it with explosives, making the boat itself the weapon. But one could also consider firing rockets and ammunition, or get drones to take off from the deck and land there again.'
Joint research is being conducted with TO2 partner NLR on the latter option. The initial plan was a 6-metre-long USV, says Settels, but it turned out to be too small to accommodate all the necessary equipment. After the 6-metre prototype, which successfully withstood the mechanical tests, the team developed an 8-metre boat within a matter of months that actually sailed in 2025.

'The USV must sail independently in formation with a mother ship'

Testing offshore

Subsequent to this successful development, at the beginning of 2026 there was a request to participate in the mid-year military exercise MUST (Maritime Uncrewed Sea Trials) in the North Sea, but with a larger prototype. Settels: 'The North Sea has harsh conditions and it can get quite stormy, so 8 metres is actually too small.' The deadline was tight, so development of the 12-metre boat went even faster. Settels: 'The USV must be able to sail independently in formation with a mother ship and predictably determine its behaviour.' In 2022, MARIN had already started developing the operating software, KNOWONE, together with knowledge partner TNO. That software, which had been extensively tested at MARIN, was eventually modified and used on board the two 12-metre prototypes, FENDER 1 and 2.

Resolve problems quickly

Settels: 'The engines were converted BMW car engines by Diemmax, a relatively small business in Kootwijkerbroek. That choice was intentional: the Research & Development department at a major supplier often finds it complicated to make modifications, but with Diemmax issues were resolved quickly. They had two software engineers working on it and made their software protocols fully available to us.' With a great deal of effort, the deadline was met. Settels: 'The exercise was successful, the USVs sailed in formation. We've learned a lot from it. During testing, we sometimes had to repair or modify technical components on the spot. That was an intense learning curve. Any system might break down during an exercise. For example, we had problems with the steering system and learned how vulnerable electric plug connections can be. They could disconnect through vibrations at any time, especially if a boat on the North Sea encounters rough conditions.'

80-Hour working weeks

Commitment to short-term cyclical innovation has worked out well, but it does demand an awful lot from people. 'We fast-tracked the development of these prototypes, but you cannot expect people to put in 80-hour working weeks on an ongoing basis', says Settels. But SeaRush will be continued albeit at a slower pace initially. 'The next step is to take part in a major international exercise in Portugal, for which we must continue to work on the control of vessels.' In future, swarms of USVs – each with their own speciality – must sail with a frigate and will have to carry out tasks independently and then rejoin the formation. Settels: 'That future is still a long way off, but we did provide the prototypes. We also noticed that ideas about what can be done with it only emerge when actually starting to work with it. You can spend a long time thinking about things but ultimately you should just go for it.' ■



Who: MARIN, IMPACD Boats, CEAD Delft, Diemmax, UltraFlex, Holland Nautic, TNO, NLR.

Duration: since 2024.

Follow-up: to participate in a naval exercise in Portugal in which the FENDERS sail independently in formation, and the further development of independent USVs that can take part in military missions. MARIN develops prototypes, but actual military missions come under the Royal Netherlands Navy.

From years down to weeks: faster innovation for Defence

Developing military technology often takes years, while drones and associated software may be modified within a matter of weeks. Defence asked knowledge institutes how they can accelerate military innovations. At NLR, this led to the Quick Response Drone Facility (QRDF). ▶



NLR, TNO AND MARIN

Problem: drone technology is developing superfast, while conventional research and development processes often take years. The Ministry of Defence has a need for much faster innovation.

T02 solution: with the Quick Response Drone Facility, NLR brings together knowledge, experts and testing facilities to promptly address urgent requests from Defence.

Impact: new drone functionalities and prototypes can be developed, tested and delivered within a matter of weeks. The aim is to achieve results within four to six weeks.

The reason is clear, according to Jorrit van den Eerenbeemt, project manager in the field of unmanned systems at NLR. 'The world is changing. The Netherlands is preparing for a situation in which we no longer routinely live in peace. Then knowledge institutes were asked: what can you do if the Netherlands gets involved in an armed conflict?' That question was asked at exactly the right time. NLR was already examining how projects that normally take six months to two years could be implemented much faster. 'With drones, we noticed that we had to quicken the pace anyway. This is where development is progressing dramatically.'

Get started right away

The premise of QRDF is that a pressing issue does not have to be processed by an organisation for months before researchers can get started. Budget is available and capacity can be freed up quickly within NLR. Van den Eerenbeemt: 'When a request comes in from the Ministry of Defence, I look at what expertise is needed and who is immediately available for this purpose. Within one or two days, we want to have a clear picture of what the problem is and how we can solve it as quickly as possible. Once approval has been reached with Defence, we start right away.' The aim is to deliver results within four to six weeks. That doesn't always have to be an entirely new drone system. 'It could be a prototype or new functionality, but it could also be technology that a company has developed and which needs to be tested very quickly to determine whether a next step can be taken.' This tempo also calls for a different way of working at NLR. 'Normally, people work on five or six projects simultaneously. At QRDF, we give full priority to queries from Defence. Other projects are set aside and dedicated staff work on this full-time.'

Startups

In the process, NLR does not assume the role of companies. 'Ultimately, we do not make end products; that is what companies do. We are a research institute. We can deliver a prototype quickly, or work with a company on further developing an existing product.' For start-ups and smaller businesses in particular, that can be important, according to Van den Eerenbeemt. They often lead the way with drones, but they don't always have all the specialist knowledge or testing facilities at hand. 'Imagine that a company is in production and suddenly there appears to be a technical problem. Then we can work with them to solve that problem, or make an improvement, without it having a huge impact on their own capacity.'



'We want to get to grips with the problem within one or two days'

Marknesse

NLR's location in Marknesse plays an important role. The restricted airspace over and around the site also allows experimental drones to be tested that have not been fully certified yet. In addition, NLR has a runway as well as the Drone Centre. Prior to the official launch of

NLR examined how quieter drones can be produced and with 3D printing technology



A few drones in the NLR fleet at the launch of the QRDF.

QRDF launch

QRDF in May 2025, several projects had already been carried out. For example, software was tested which allows drones to autonomously avoid obstacles and determine their position without GPS. NLR also examined how drones can become quieter and how a 3D-printed drone can be produced.

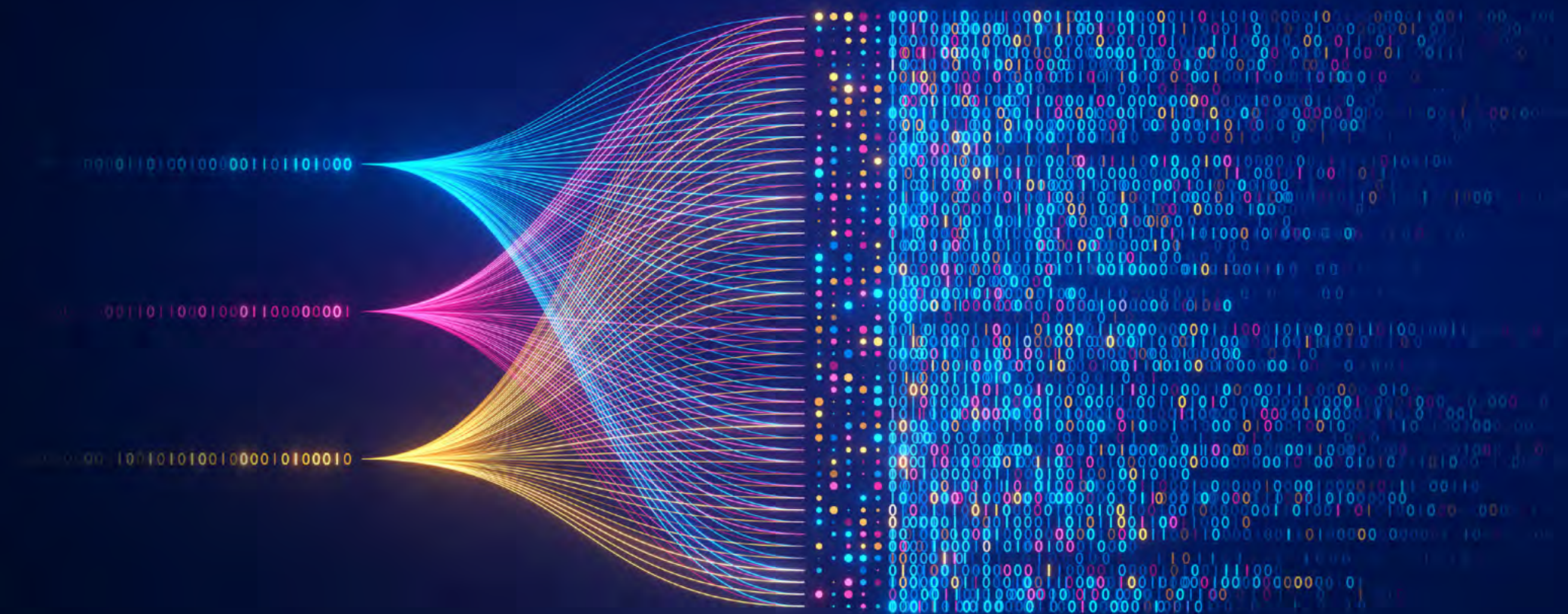
Learning together

QRDF does not operate in isolation. Defence also asked TNO and MARIN to explore how they can contribute quicker to military innovation in times of conflict. MIND, which is part of COMMIT, which stands for Commando Materiel and IT, initiated pilot schemes with the three knowledge institutes. 'MIND, in principle, has been and still is our commissioning party', says Van den Eerenbeemt. Each of the institutes participate based on their own expertise.

Together with ISR, TNO focuses at the Edge on the faster processing of sensor data using AI on board unmanned systems. MARIN develops unmanned vessels in SeaRush (refer to article on page 50) that can quickly be built, tested and modified. The knowledge institutes also seek contact with each other. For example, at SeaRush, NLR introduced knowledge about materials and production techniques. Experiences are shared with TNO about what this short-cyclic method of working requires of a research organisation. ■

Who: NLR, TNO, MARIN, the Ministry of Defence, as well as startups and industrial partners, like Smooth Stone Dynamics that deals with advanced visualisations and 3D technology.

Duration: ongoing.



The power of shared data, models, and computing power

More and more data offers new opportunities for research. DigiLab TK helps scientists to safely share and combine data from various organisations. This will help them find answers to questions on climate, mobility and cultural heritage quicker. ▶

TO2 FEDERATION

Problem: researchers have access to more and more valuable data, but it is often spread out among various knowledge institutes. Combining data sets, models and computing power takes a lot of time, as organisations each have their own systems, standards and conventions. As a consequence, opportunities are being missed for developing new knowledge quicker and to scrutinise complex societal challenges. Nationally and internationally (across Europe), this constitutes an obstacle to accelerated innovation and growth.

TO2 solution: DigiLab Toegepaste Kennis (DigiLab TK) develops a digital infrastructure in which the five TO2 institutes and five knowledge institutions can safely share data, models and computing power with each other and their research partners. Organisations retain ownership of their own data and determine who gets access to which digital information and resources and for what purpose.

Impact: researchers can collaborate quicker on issues that several knowledge institutes are working on, including climate, water, biodiversity, health, the environment, resilience, mobility, the energy supply, infrastructure challenges and cultural heritage. That delivers time savings and better insights.

No individual research institute has all the knowledge or data in-house for resolving the major challenges of our time on its own. That is why DigiLab TK brings researchers closer together. 'By specifically combining data, models and computing power smarter, researchers are able to gain new insights faster,' says programme manager Bas van Vossen of DigiLab TK. It is a joint initiative of the five TO2 institutes and five national knowledge institutions: the Royal Netherlands Meteorological Institute (KNMI), the National Institute for Public Health and the Environment (RIVM), Naturalis, the Cultural Heritage Agency of the Netherlands (RCE), and the Netherlands Forensic Institute (NFI). With an investment of EUR 50 million, the consortium will develop a digital research environment over the next five years in which collaboration will become simpler and more natural.

Convention system

On hearing the name DigiLab TK (DigiLab Toegepaste Kennis), one might think of a new research complex full of servers and data centres. 'DigiLab TK is not a building', Van Vossen explains. 'It is shared digital infrastructure and computing power with all the necessary conventions by which institutions maintain their own data and infrastructure, but harmonises them more closely and securely connects them digitally. Data is widely discoverable and can be accessed by researchers and their automated processes and computer algorithms under controlled conditions. Aside from conventions about infrastructure, there are also conventions about what is possible and allowed, who determines that and how.' All participants remain in control of their own data. Precisely that, is an important starting point. Researchers will no longer need to manually request sundry data sets nor repeatedly make time-consuming arrangements about file exchanges. The digital infrastructure must ensure that data, models and computing power are accessible where needed, without organisations losing control of their data.

Greenhouse gases

A good example is the monitoring of greenhouse gases above the Netherlands. For this purpose, atmospheric measurements are gathered by KNMI, RIVM, Wageningen Research, TNO, Deltares and Naturalis. These measurements are used in their models and analyses. In the Sustainability project of the Applied Research Facilities (FTO), these organisations have already been upgrading their monitoring facilities for several years. In order to achieve national monitoring, measurement data from the various institutes must be able to be interconnected in a useful manner. Here, DigiLab TK can help by making data, models and computing power accessible in a standardised and secure manner, while keeping organisations in control of their own data. 'If we can combine such data, we will gain much faster insight into how greenhouse gases behave and what effect measures have on the climate.' The same is true for biodiversity. Huge volumes of data are compiled on flora, fauna and ecosystems. By linking this information to data on nitrogen, water quality or climate, we get a more complete picture of the effects. According to Van Vossen, that is precisely the strength of DigiLab TK. More data is rapidly becoming available in all fields, partly through sensors and advanced measuring techniques, ranging from quantum and nanosensors to satellites. AI and machine learning are gathering pace, making models more diverse, sophisticated and interconnected. Computing and analysis capabilities by way





Bas van Vossen and Stephanie Rolvink of DigiLab TK.

'When we combine data, we gain faster insight into how greenhouse gases behave'

'No one wants to drag data around any longer'

of computing power at the source of large volumes of data are becoming increasingly relevant.
DigiLab TK is a solution for these developments and offers the possibility to work effectively with the data, algorithms, models and computing power. Thus, DigiLab TK constitutes an essential link to increase innovation power and to make an even greater impact.

Cultural Heritage

It is specifically the collaboration between various knowledge institutes that opens up surprising new opportunities. Consider the Cultural Heritage Agency of the Netherlands. Ostensibly, it may seem to have few aspects in common with organisations that deal with climate or water. Yet, that connection is most certainly present. The Netherlands has thousands of heritage buildings that have been erected on wooden foundation piles. Changes in groundwater levels can have major consequences on the condition of these buildings. At the same time, the Agency has extensive digital information about soil deposits and heritage buildings. By combining this data with models at Deltares or climate data from the KNMI, new insights emerge about historical relationships between society and how to deal with water and climate change, and what we can learn from all this for the future. 'These are typical connections that can be made faster with DigiLab TK.'

Computing smarter

DigiLab TK is not just all about data, but also about models. For complex issues, for example in terms of Defence applications such as the ability to operate drones as autonomously as possible on moving ships at sea, various organisations work with Defence models and large volumes of computing work. Nowadays, files are sometimes literally transferred (Van Vossen: 'with a USB stick') physically, because safety rules require it. In future, it should be possible for researchers to work safely within each other's digital environment, without having to copy all the data. 'Actually, no one wants to drag data around any longer', says Van Vossen. 'It is much smarter to bring the model to the data, perform the calculations or computations there, and simply send back the results.' This not only makes collaboration safer, but also far more efficient. The spread of AI underlines the importance of DigiLab TK. Developing smart applications requires large volumes of reliable and easily accessible data. DigiLab TK makes it easier for researchers to retrieve, combine and use data. 'If researchers can retrieve and use data more easily, there will be far more scope for using AI in a responsible

MARIN: combining simulations and measurements smarter



'For MARIN, DigiLab TK makes it possible to safely combine its own data, simulations and models with those of other knowledge organisations and clients, with proper security and well-defined arrangements about who has access to which data. For example, data on vessels can be linked to knowledge about meteorology, ecology and spatial planning. That helps MARIN make shipping safer and more sustainable. Through DigiLab TK, MARIN also invests in new computing capacity and in the process, collaborates with WUR and NLR. This collaboration helps to keep sufficient computing power available for research. At the same time, DigiLab TK brings researchers from various knowledge institutes closer together. As a consequence, they can easily engage with one another even outside of digital projects.'
Timo Verwoest, Manager Digital Services at MARIN

NLR: collaborating safely with confidential data



'With DigiLab TK, we are able to share data, models and computing power safely, while each institute stays in control of its own data. Nowadays, ad hoc solutions are often needed for this purpose. DigiLab TK provides a common infrastructure and conventions on, for example, ownership and security.
For NLR, it is especially important that we can also use this infrastructure in the long term for classified or confidential research data, e.g. based on defence research.'
Laurens van Rijn, Manager Supporting Services at NLR



DigiLab TK was officially launched at the kick-off at Deltares on 2 March 2026.

manner. DigiLab TK means more than merely new technology to institutes. It also calls for a change in culture. Researchers should make data and models available more often. It starts with an awareness at every level in the organisations of how the explosive growth of data and computing power is changing both the way research is done and its impact. In the coming years, data management must be a top priority for management at every level if they are to keep pace and continue to meet expectations.'

Learning together

DigiLab TK is not just all about technology, but also about people. Collaboration brings researchers from various organisations closer together. They exchange knowledge, learn from each other's experiences and connect with one another faster on new issues. 'We all find ourselves facing the same questions. By solving them together, one can go much further than if any organisation does it alone.' At the same time, this is not only a technical task. It also requires trust between organisations and the willingness to actually share data, something that is not self-evident in practice as yet.

At the press of a button

Where will DigiLab TK be in five years' time? Van Vossen: 'It would be nice if researchers did not first have to spend three months per project making arrangements for on data access, but the collaboration could be arranged within a few days or preferably at the press of a button.' Researchers would get a rapid overview of available data and its quality, how they could access it, and what conventions would apply to it. They can focus on what it is ultimately about: finding solutions faster to complex societal questions, or innovation issues with industry. DigiLab TK is being developed not only for the relevant knowledge institutes, but is also to be deployed with and by partners and clients of their applied research. In its work, DigiLab TK also looks beyond national borders. Through SURF, it connects to the European Open Science Cloud, the EOSC node; a European network for sharing and using research data. In the long term, this will make it easier for researchers to use knowledge and data from the Netherlands as well as from other European countries. ■

'We notice that we all find ourselves facing the same questions'

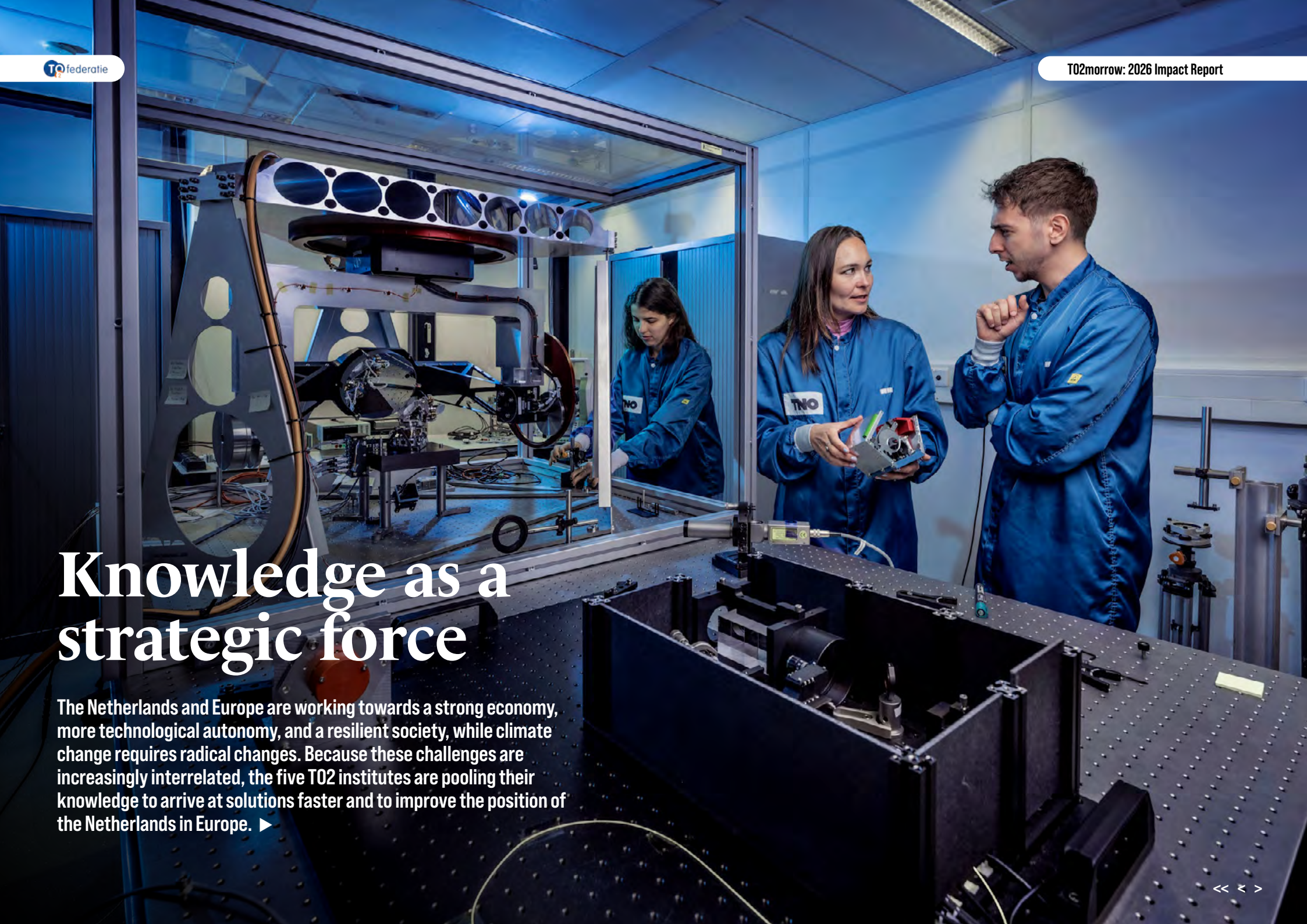
Who: T02 institutes (Deltares, MARIN, NLR, TNO and Wageningen Research) and KNMI, RIVM, Naturalis, the Cultural Heritage Agency of the Netherlands and the Netherlands Forensic Institute.

Duration: 2026- 2030 (5 years).

Budget: EUR 50 million (Ministry of Economic Affairs and Climate).

Follow-up: in the coming years, DigiLab TK will continue to develop practical applications and conventions will be adopted for secure data sharing, standards and digital infrastructure. In this regard, the consortium works closely with knowledge partner SURF, which links to the European Open Science Cloud (EOSC). DigiLab TK will also be connecting to the European digital research infrastructure.

More information: DigiLab TK



Knowledge as a strategic force

The Netherlands and Europe are working towards a strong economy, more technological autonomy, and a resilient society, while climate change requires radical changes. Because these challenges are increasingly interrelated, the five TO2 institutes are pooling their knowledge to arrive at solutions faster and to improve the position of the Netherlands in Europe. ►

'TNO developed Fast Track which gives businesses quick access to knowledge and facilities'

Europe wants to be less dependent on other parts of the world for important raw materials and technology, e.g. batteries and computer chips. At the same time, the competitiveness of the European economy is under pressure and climate change calls for major adaptations. It is precisely in this complex landscape that the five TO2 institutes – Deltares, MARIN, NLR, TNO and WUR – come into their own. With their various fields of expertise, they can pool their knowledge and translate it into solutions for public authorities, businesses and society as a whole.

10,000 employees

Jointly, the institutes have more than 10,000 employees. Their work domain ranges from climate and food to energy, digitisation and safety. What they have in common is applied research: translating knowledge into solutions that businesses, public authorities and society can use. More and more expertise from various disciplines is required for this purpose. Deltares, for example, researches how extreme weather contributes to critical infrastructure. Failure in one place could affect other facilities. Resilience brings together a range of different fields. It's not just about defence, it's also involves energy, the food chain and infrastructure which must continue to function under difficult conditions. It is precisely on such issues that the TO2 institutes reach out to each other faster.



Focused choices

This does not mean that every project will be conducted by all five institutes in future. Much research should obviously go to a particular institute. Collaboration becomes particularly important where disciplines interface with each other – and where the Netherlands has to make choices. Which major research facilities will be needed in the years to come? What can be done jointly? Which new technology should the Netherlands focus on? And for which European developments is a common position meaningful? The TO2 Federation wants to make such choices together more often. Not only to avoid duplication of effort, but also to place people, knowledge and valuable facilities where they can make the most difference.

From knowledge into practice

That is also key for the business community in the Netherlands. SMEs, startups and scale-ups in particular often lack access to specialist knowledge, testing or research facilities themselves. So, TNO developed the Fast Track approach, which gives businesses quick access to knowledge and facilities. This approach is already being applied in a similar way at WUR. At TNO, there were over 700 intake interviews last year and 182 projects were successfully concluded. The transition from research to application is taking place in many fields. In the European project OPTIMA, for example, techniques were developed by WUR to identify plant diseases sooner. These allow farmers to intervene more effectively and use fewer chemicals. Innovative activity in the energy, food, high-tech and defence sectors can also contribute to an economy that is less dependent on technology and knowledge from outside Europe.

Europe as an integrated area

The Netherlands cannot establish this role on its own. Many technologies are now so complex and costly that European cooperation is essential. Dutch researchers and businesses will be given access to knowledge and expertise elsewhere in Europe, while Dutch

'The institutes want to enable easier use of each other's knowledge, facilities and experiences'





technology finds its way to other countries via the same networks. Schiphol, for example, was a testing ground for more sustainable aviation within the European TULIPS project. NLR worked with partners on solutions that could likewise be used at other European airports. In SeaRush, MARIN develops and tests unmanned vessels in short cycles. Rapid prototyping and modification is enabled using 3D printing. NLR provides knowledge about materials and production techniques within the same project. Technological autonomy does not mean that Europe should be able to do everything by itself. However, essential knowledge and technology must remain available when necessary.

A voice in Brussels

This European collaboration is not just about research projects. TO2 also wants to be more involved at an earlier stage when choices are made in Brussels. That is now the case regarding FP10, the European research and innovation programme for 2028–2034. The priorities and budgets for this will be determined before long. With that in mind, the TO2 Federation has prepared a common position paper, in which it draws attention to applied research.

That is the key factor for TO2. There is often a long and hard slog of testing, demonstration and refined development between scientific knowledge and an innovation that works in practice. It is precisely for this phase that research facilities and practical tests are necessary. The federation also wants to present a more united front whenever possible in its dealings with Brussels and The Hague on issues such as climate adaptation, defence and food security.

Jointly achieving more

Collaboration within TO2 does not necessarily have to lead to a single major research institute. The strength lies precisely in the various specialities of Deltares, MARIN, NLR, TNO and WUR. We want the institutes to enable easier use of each other's knowledge, facilities and experience. This not only applies to research projects, but also for personnel and collaborations with startups. DigiLab is one example of this. The institutes keep control of their own knowledge and data, but can safely share and combine them when an issue so requires. This is precisely where the federation's strength lies: not doing everything together, but achieving more, together. ■

Strategic framework 2026-2029

Credits

T02MORROW is a publication by the collaborating organisations for applied research, united in the T02 Federation. They are the link between knowledge and innovation in service of public authorities, the business community and society.
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More information:
www.to2-federatie.nl.

Text and editors:
T02, the Dutch Ministry of Economic Affairs and Climate (EZK) and Maters & Hermsen.

Final editing and design:
Maters & Hermsen

Images:
Deltares, MARIN, NLR, TNO, WUR, T02, iStock, Ivar Pel, Niels Blekemolen, Guus Schoonewille, Kim Gommans

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