

# › INNOVATION FOR LIFE

2020 ANNUAL REPORT

Pop-up lab at RAI Amsterdam testing facility with the TNO LAMP COVID-19 rapid test

**TNO** innovation  
for life

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## 2020 GAME CHANGERS

The boxed sections throughout this report highlight the game changers for 2020 – that is, the technological innovations that TNO developed along with its partners during the reporting year. For more information about a game changer, just click each box below to find out more on the TNO website.



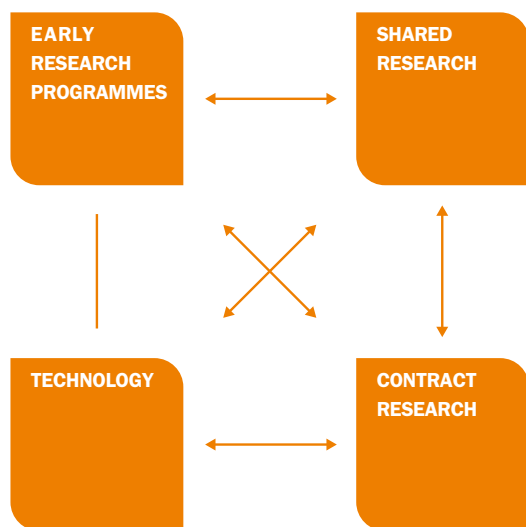
## 2020 financial statements

[2020 financial statements](#)

## PROFILE AND MISSION

TNO connects people and knowledge to create innovations that boost companies' competitiveness and that sustainably increase wellbeing across society.

This requires both in-depth expertise and the skill to connect and integrate the various knowledge domains, systems and sectors of society. The power of innovation lies primarily in making smart connections across the boundaries between scientific domains and various sectors of society.



This is where TNO stands out: it is a multidisciplinary research organisation with dedicated people who work in dynamic partnerships, coalitions and alliances. It offers the kinds of solutions that its customers and partners are looking for. By providing these solutions, TNO contributes to the success of its customers and partners and to a safe, healthy, liveable, competitive and sustainable Netherlands.

### INNOVATION CYCLE

The research TNO does can roughly be broken down into the development of knowledge on the one hand and, on the other, its application – two fields that differ from each other in terms of objectives, management and financing.

#### The development of knowledge

##### Early Research Programmes (ERPs)

TNO develops its new areas of knowledge within its ERPs. In 2020, 18 of these large multi-year programmes were underway. They focused on such diverse areas as decarbonisation (reducing dependence on fossil resources in the chemical industry), *hybrid artificial intelligence*, laser-satellite communications and *personalised health*. This type of research is closest to the basic research carried out by universities, and follow-up steps are still needed to get to the point of practical implementation and commercial application.

##### Shared Research

This knowledge is further developed in pre-competitive collaboration with partners such as in TNO's Demand-Driven Programmes (DDPs), which are financed from a combination of public and private funds. To this end, TNO sometimes sets up joint research initiatives and centres with other knowledge partners. Examples include Solliance (for solar cells), the Holst Centre (for flexible electronics), ESI (for software in high-tech systems) and BTIC (for innovation in construction).

#### Applying knowledge

##### Contract Research

When questions from customers and partners cover the specific and possibly competitive application of knowledge generated by TNO, and if there is a need for customisation, the research is usually done on a contractual basis and is paid for entirely by the customer. In this way TNO helps its customers bring products and services to market.

##### Technology Transfer Programme (TTP)

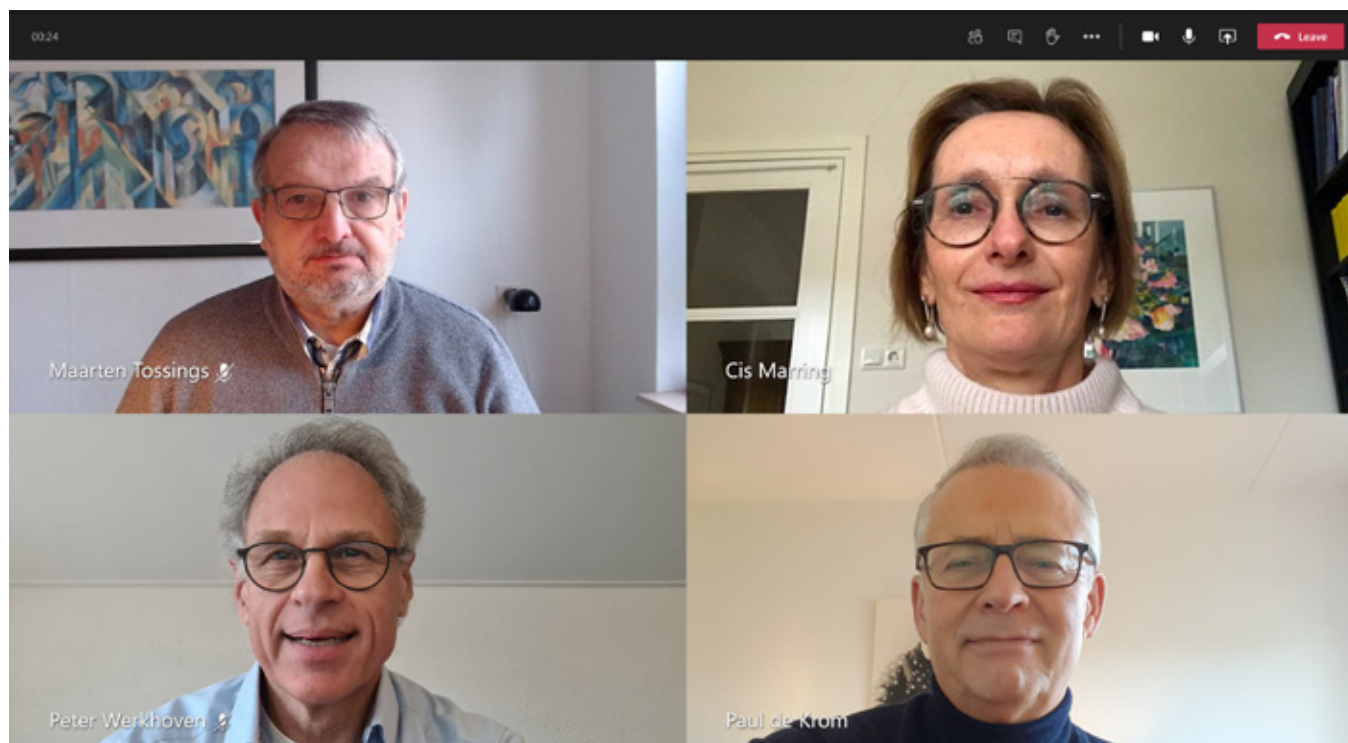
Technology transfer is the final phase in TNO's innovation cycle. In this programme, TNO takes knowledge to market by licensing it to existing companies and setting up spin-offs. TNO holds approximately 900 active patent families that are used in different projects and that are also commercialised through licences. A number of these patents are used in the Technology Transfer Programme.

The cycle of the four aforementioned successive phases allows TNO to create substantial value. For more details on how TNO works, please visit our website ([www.tno.nl](http://www.tno.nl)), where you will also find more information on the use of the portfolio of intellectual property rights and our research programmes.

#### SPECIAL-PURPOSE FUNDING

As an innovation leader for the Dutch Ministry of Defence, the Dutch Ministry of Social Affairs and Employment, and the Dutch Ministry of Economic Affairs and Climate Policy, TNO fulfils this role in a unique way. Knowledge-intensive government duties (statutory duties) in defence, safety and security, participation in the labour force, and geological surveying have been delegated to TNO.

## THE EXECUTIVE BOARD



### THE EXECUTIVE BOARD

CLOCKWISE FROM TOP LEFT:

- › MAARTEN TOSSINGS, CHIEF OPERATING OFFICER (COO)
- › CIS MARRING, CHIEF FINANCIAL OFFICER (CFO)
- › PAUL DE KROM, CHIEF EXECUTIVE OFFICER (CEO)
- › PETER WERKHOVEN, CHIEF SCIENTIFIC OFFICER (CSO)



## REPORT OF THE EXECUTIVE BOARD

The year 2020 was shaped primarily by the socially disruptive consequences of the COVID-19 pandemic. That is true for companies and organisations, and TNO is no exception. With a proactive policy, the consequences of government measures – including working from home, social distancing and hygiene – have been mitigated as far as possible. As soon as the first lockdown was announced, a crisis team was set up to safeguard the continuity of operations as well as the health and safety of TNO employees. Working from home en masse was facilitated among other things by expanding IT capacity, offering an allowance for the purchase of home office facilities, and offering the option of taking special leave to employees with responsibilities for taking care of children or other family members. In addition, internal communication was intensified to keep employees well informed of the consequences of the pandemic for TNO, and to allow them to keep in touch with the organisation and each other.

Overall, 2020 was a year of pushing ahead and persevering on all fronts, for individuals and businesses alike. So many things that we had thought were the most normal in the world in 2019 suddenly seemed a lot less so in 2020. Despite this, TNO employees have gone beyond the call of duty in responding quickly and effectively to the new situation, and in so doing have shown considerable commitment, agility and creativity. As a matter of fact, the general employee satisfaction rating went up from 7.3 to 7.5. Thanks to its employees, customers and partners alike could continue to count on TNO. And TNO, for its part, is really grateful that it could continue to count on the trust of all its customers and partners in these turbulent times. It is thanks to that joint effort that it has been able to achieve great things. In 2020, our researchers were regularly featured on television, radio and online, as well as in newspapers and magazines.



In 2020, TNO was frequently mentioned in the media. Media attention was focused on foldable phone screens, the discovery of a volcano in the North Sea, working during the COVID-19 crisis, the potential of the 5G network, the effect of heat on our bodies, the use of solar cells on walls and vehicles, the use of AI in tracking down criminals, and the launch of the twenty-fifth TNO spin-off.

### BRAINS4CORONA

Of course, TNO's innovative prowess was also used to help combat the coronavirus crisis with practical solutions. Twenty successful projects were initiated and completed via the 'Brains4Corona' programme.<sup>1</sup> The multidisciplinary approach the TNO experts took, their creativity and their enthusiasm to help solve problems all proved useful. A lot of public attention was paid to the LAMP test: a quick test that gives a definitive diagnosis of infection by coronavirus within 45 minutes. The test led to working visits by Deputy Prime Minister de Jonge and Mayor Halsema in Amsterdam. In 2020, Prime Minister Rutte and Minister Van Engelshoven visited TNO sites in Leiden and The Hague, respectively.

Because of the impact of Brains4Corona, the Executive Board decided to continue the project with a series of 'Brains4X' challenges that aim to make contribution over the short term to solving an urgent social problem. In the latest project, which also serves as a pilot for the programme as a whole, TNO experts are focusing on the nitrogen problem ('Brains4Nitrogen'). The objective is to come up with solutions that lead to lower nitrogen emissions.

### IMPACT AND SOCIAL RELEVANCE

TNO works on societal issues in energy transition, sustainability, safety, circularity, health, and transport & mobility to strengthen the competitiveness of companies and society in a sustainable way. Through the development and deployment of key technologies in such areas as IT (including AI, cybersecurity, and quantum technology) and materials, the impact of TNO became

<sup>1</sup> A full list of Brains4Corona projects and the impact that they have had can be found later in the present report.

tangible in countless innovations. Ten of these are major *game changers* that are referred to at various points in this annual report.

#### EXAMPLES OF GAME CHANGERS IN 2020

- **PREDICTIVE TWINS**, digital replicas of physical structures that can be used to predict required maintenance and the optimisation of energy consumption. See page 12.
- **THERMOCHROMIC COATINGS** can be applied to windows to ensure that the sun's thermal radiation is harnessed when needed and blocked when it gets warm enough. See page 29.
- **HIGH ENERGY LASERS** can be used to make unwanted drones and other objects harmless with powerful beams of light. See page 36.
- **QUANTUM INSPIRE**, Europe's first quantum computer in the cloud. See page 39.

We now know from external research as well as our own that investments in applied research pay off many times over for both society and businesses. Knowledge Position Audits show consistently high scores. TNO customer satisfaction scores above the norm. The report by the Bureau for Economic Policy Analysis entitled *Kansrijk innovatiebeleid* ('Promising Innovation Policy'), which was published in 2020, offered a positive assessment of the effects of state funding to institutions of applied research. In fact, according to a 2020 publication by the European Patent Office (EPO), TNO is the largest of the Dutch research institutes and universities in terms of patent applications for Fourth Industrial Revolution (4IR) technologies, with 138 filed patents between 2000 and 2018. 4IR technologies are related to smart connected objects such as the Internet of

Things (IoT), big data, 5G and artificial intelligence (AI). TNO ranks tenth in the world in terms of the number of patents filed. This makes it one of the three leading European research institutes alongside Fraunhofer in Germany and the Atomic Energy and Alternative Energies Commission (CEA) in France.

#### THOUGHT LEADERSHIP

TNO aspires to be a *thought leader* on how major societal transitions can be shaped in ways that are technologically feasible and socially acceptable, and that contribute to the earning power of businesses in the Netherlands. Thanks to its expertise, its independence, its multi-disciplinary approach and its systems thinking, TNO is ideally positioned to guide these transitions and to facilitate debate on them. To this end, various units in TNO develop what are known as Novel Points of View (NPOVs), in which inspiring frameworks for action are sketched out and innovative insights are key.

#### TECHNOLOGY TRANSFER PROGRAMME (TTP)

In 2017, the TNO TTP was launched to take innovations that have been developed at TNO to market faster. The aim is to get an innovation or a new technology to market within a year of its being registered with the TTP, either by licensing it to an existing company or by setting up a new company. Nine spin-offs were set up in 2020. Three years after the start of the programme, TNO also celebrated the launch, together with State Secretary Keijzer of the Ministry of Economic Affairs and Climate, of the twenty-fifth spin-off.

#### CORONAVIRUS AND THE ECONOMY

In 2020, TNO's position paper *De economie na het coronavaccin* ('The Economy after the Coronavirus Vaccine') presented its vision of how the Netherlands can emerge stronger from the crisis through investment in research and innovation. New or

improved products, services and production processes create value and increase labour productivity. This will strengthen the competitive position of Dutch companies and boost the economy's earning power. Together with the Knowledge Coalition and the T02 Federation, TNO will be approaching the new Dutch Cabinet, due to be formed in 2021, with a proposal to bring Dutch investment in research and development to the same level as that in Germany – 3% of its gross domestic product (GDP) – within 10 years.

#### EXAMPLES OF NPOVS IN 2020 INCLUDE:

- **Developing tomorrow's drugs**. The key question here is how personalised medicines can be developed more quickly and cheaply through technological innovation (for example, the early detection of degradation agents with AMS technology, and the personalised 3D printing of medicines).
- **Relationships between lifestyle and metabolic dysregulation**. This paper outlines how healthy eating, exercise, work, and sleep can strengthen resistance to infection.
- **Smart combinations of sustainable energy options lead to a climate-neutral and affordable energy system**. A number of scenarios outline how a smart energy mix can achieve the targets for CO<sub>2</sub> emissions at lower costs than under the current energy system.
- **Don't waste it! Tackle the drawbacks of plastics with urgency**. This paper outlines a view of how plastics, thanks to their unique properties, can continue to be used, but in a circular manner.

## NATIONAL GROWTH FUND

Over the next five years, the government will set aside EUR 20 billion for investments that contribute to economic growth. The budget from the National Growth Fund is invested in the development of knowledge, in infrastructure and research, and in development and innovation. TNO is pleased with the government's ambition, but it has also made known its concerns about the Fund's structure, which could increase the red-tape and transaction costs of research and innovation. Nevertheless, TNO is committed to ensuring the success of the cabinet's investments. It has worked with others in various coalitions to prepare project proposals that can be implemented with the fund.

## STRATEGY

TNO's current strategic plan runs until 2021. With the support of consulting firm Arthur D. Little, preparations were therefore made in 2020 for the 2022–2025 Strategic Plan. Input is being gathered through a series of interviews with outside experts, and with customers and partners. The organisation itself is also closely involved and is being consulted. A Strategy Panel has been set up that allows more than 60 TNO employees to contribute to the strategy. In the spring of 2021, once it has been approved by the Supervisory Board, the plan will be presented to the Minister of Economic Affairs and Climate Policy.

## SMES

TNO wants to make a broad commitment to small and medium-sized enterprises (SMEs). Together with MKB Nederland, an organisation that represents SMEs, TNO is calling for substantial investments in knowledge vouchers so that a more innovative SME sector can help the Netherlands to grow its way out of the crisis. Digitalisation is one of the biggest challenges in society, and thus also for SMEs. In 2020, a new roadmap, *Digitalisering maakindustrie* ('Digitalising the Manufacturing Industry') was

drawn up. In it, TNO focuses on topics such as *flexible manufacturing, the digital factory and connected suppliers*.

## TO2 EVALUATION COMMITTEE

In 2020, a TO2 evaluation committee set up by the Ministry of Economic Affairs and Climate Policy started the four-yearly evaluation of applied research institutions. The committee chair is Wim van Saarloos. The TNO subcommittee is headed by Amandus Lundquist. In December 2020, the subcommittee held extensive discussions with the Executive Board, unit managers and Strategic Advisory Councils (SACs), among others. The evaluation will be completed in 2021.

## COOPERATION

The European research funding programme Horizon 2020, under which TNO carried out research worth almost EUR 160 million, came to an end last year. It will be succeeded by Horizon Europe in 2021. In 2020 TNO intensified its cooperation with a number of European partners. Strategic cooperation with Germany's Fraunhofer research organisation on intelligent energy systems and artificial intelligence was intensified. In addition, a partnership was started with Fraunhofer, Forschungszentrum Jülich (Germany), SINTEF (Norway), and CEA (France) with the aim of making it possible to produce green hydrogen on an industrial scale and at an acceptable cost. The ambition is to further deepen and expand international cooperation within Europe.

The Artificial Intelligence (AI) Taskforce became the Netherlands AI Coalition (NL AIC) in early 2020. TNO is a member of the strategy team consisting of representatives from industry, government, Topteam ICT, the Association of Universities in the Netherlands (VSNU), the Association of Netherlands Municipalities (VNG), and consumers. TNO is also active in national coalitions and partnerships in such areas as quantum technologies, blockchain and photonics.

## HUMAN RESOURCES

In 2020, the new appreciation and remuneration system, Empower, was launched. The ambition of Empower is to arrive at a more equitable relationship between the organisation and its employees. Rather than the annual performance review that takes place between appraiser and appraised, often felt to be an obligation, Empower encourages both sides to give and receive feedback on an ongoing basis so they can better and more transparently align mutual expectations regarding personal development and performance. And that, in turn, gives employees more control over their own development. Salary increases are no longer linked to the assessment. The budget for bonuses has been expanded so as to adequately reward excellent performance ('cash on the nail').

TNO wants to be an organisation where everyone gets the chance to be the best version of themselves. A diverse workforce and an inclusive organisation are key prerequisites for this, not because it's required, but because it is the right thing to do, because the organisation benefits from it, and because working in a diverse environment is simply more inspiring and more challenging. In 2020, about 11% of TNO employees had an international background. This number is expected to keep growing in the future. Special attention is paid to the ratio of men to women within the various units, various initiatives and workshops are offered, and TNO offers Dutch and English language courses to facilitate communication. To make clear just how important this subject is, since 2020 the Diversity Steering Group has been chaired by the CEO. A Diversity Officer was also appointed.

## RESEARCH FACILITIES

Modern research facilities are crucial to facilitating the work that TNO researchers do. These are mostly of an experimental nature. In TNO's financing model, it is difficult to get financing for these

and to recoup any investments made. TNO is therefore pleased that ad hoc contributions from the Ministry of Economic Affairs and Climate Policy can be used to upgrade research facilities for energy research. In other areas, it remains a challenge to obtain the investments needed for facilities.

**FINANCES**

TNO realised a good financial result in 2020. Thanks to increased government funding in recent years, it has been able to grow after an earlier period of retrenchment, and to build up a sufficient volume of work. However, the volume of work is now starting to become a matter of concern, because orders from parties in the private sector are declining as a result of the economic crisis.

In 2020, one-off earnings were posted from the sale of participating interests. These earnings will be used in the coming years to partly cover any shortfalls from funding instruments. This includes the purchase and financing of innovative experimental facilities that are needed for research but whose revenues are insufficient to cover the investment and other costs. It should be noted that this is only a partial solution to a long-standing problem.

**COMPOSITION OF THE EXECUTIVE BOARD**

The composition of the Executive Board was unchanged in 2020. CFO Cis Marring has indicated that she will leave TNO as of May 2021. The Supervisory Board has initiated the process of finding a suitable successor.

**AND FINALLY...**

The Executive Board would like once again to thank all customers and partners, in both the public and private sectors, for putting their trust in TNO. The Executive Board is also proud of the approximately 3,500 employees who work day in, day out with great passion, energy and dedication to fulfil TNO's mission and have continued to do so in this difficult year marked by the coronavirus. Our thanks also go to the Works Council, the Supervisory Board and the SACs for the constructive contributions they make to TNO policy. The Executive Board looks forward to continuing and intensifying cooperation with all our stakeholders over the coming year.



## BRAINS4CORONA

The coronavirus crisis left a deep mark on society and the global economy in 2020. With the 'Brains4Corona' initiative, TNO is being truer than ever to its slogan, 'Innovation for Life'. Short-cycle innovation projects were set up based on various fields of knowledge and each contributed in its own way to combating the coronavirus crisis. TNO's innovative strength, its multidisciplinary and the enthusiasm of its employees came together in Brains4Corona.



In mid-March 2020, CSO Peter Werkhoven called on all TNO employees to submit project proposals on how to mitigate the effects of the crisis. That led to the submission of more than 70 proposals, from among which the Brains4Corona team made a selection based on the following criteria: the societal need for the project being proposed, a timeframe of about two months to implement the results of the project, and the avoidance of overlap with an existing innovation or one that had already been started. The 21 Brains4Corona projects that were selected got support in terms of manpower and budget so that quick results could be achieved. This led to a series of innovations that regularly made the news in 2020. TNO introduces six of them in these pages.

The success of Brains4Corona has prompted TNO to develop a follow-up initiative. There are in fact many more societal challenges that TNO can tackle via short innovation paths. Thus in October 2020 a first step was taken with 'Brains4Nitrogen'. Once again TNO employees were challenged to submit proposals – this time on how to cut nitrogen emissions. TNO will select no more than 10 projects, through which it hopes to come up with innovations that will help fight climate change, maintain biodiversity, and protect health and the environment. TNO thus expects to be able to help address an important societal challenge in 2021.

Although the coronavirus crisis generated a lot of positive energy among TNO employees, there were of course far-reaching consequences for the organisation's day-to-day operations. For example, the vast majority of employees started working from home, with support from IT, whose capacity was expanded. TNO employees with young children were offered the option of taking special leave so they could take care of them. Employees were also offered reimbursement of up to EUR 1,000 each for the purchase of home-office amenities. Coronavirus measures also led to a reduction in both travel expenses and the number of staff on sick leave.

### QUICK LAMP TEST

The coronavirus pandemic poses an immediate danger to persons in weaker health. Being able to efficiently determine whether someone is a carrier of the virus is of great importance in limiting the spread of this infectious disease. Standard diagnostics for the virus are performed in a laboratory and depend on specific test reagents, equipment and specialised personnel. As a result, the method is time-consuming and plagued by shortages.



TNO has developed an alternative test method for coronavirus that is not only faster, but also simpler and less dependent on specific test reagents. Unlike the regular PCR (polymerase chain reaction) test, the rapid test developed by TNO uses the LAMP (loop-mediated isothermal amplification) method. While the PCR method requires controlled heating and cooling of the test samples to maintain the reaction, the LAMP test takes place at a constant temperature of 65 degrees Celsius. Because the LAMP test is faster than the PCR test and the preparation is simpler, the result is available after one hour.



After technical and clinical validation in laboratory conditions, the LAMP rapid test was put through its paces in a testing facility run by the Public Health Service of Amsterdam (GGD Amsterdam) in the RAI Amsterdam Convention Centre. Over a period of two weeks in October 2020, almost 900 samples were assessed for the presence of coronavirus by both TNO (using the LAMP rapid test) and the GGD (using the PCR test). The results were compared, and 99% of them were the same. Now that the test has been clinically validated, the rapid LAMP test developed by TNO will be used nationwide to test for coronavirus.

The rapid LAMP test was developed at the request of the Dutch Ministry of Health, Welfare and Sport and in cooperation with GGD Amsterdam, the National Institute for Public Health and the Environment (RIVM), DSM, Micronit, Leiden University Medical Center (LUMC), and the University Medical Center Groningen (UMCG), with funding from ZonMW.

**UNLOCK**

One strategy for reopening society during the coronavirus crisis is to create ‘bubbles’: environments with a low risk of contamination. One possibility here is the ability to digitally demonstrate that one has had a negative coronavirus test or vaccination. With exactly that in mind, the uNLock application was developed by a not-for-profit consortium including Rabobank, CMS, TNO, Ledger Leopard, Uniek-Arbo, EY, the Dutch Blockchain Coalition, the Rinis Foundation, Leiden University and Delft University of Technology.

uNLock is based on the decentralised technology that was designed to protect privacy, known as self sovereign identity (SSI). SSI offers individuals new opportunities for the secure and



efficient digital exchange of privacy-sensitive information. In this case, the person concerned receives the result of the coronavirus test in the *wallet* on their smartphone. Scanning this QR code at the entrance of a *bubble* serves as digital proof that the holder of the phone meets access requirements, without their having to share personal information and without other parties knowing which locations they visit.

At the end of 2020, the uNLock application was tested on a small scale in cooperation with Fieldlab to investigate whether it is a suitable method for providing safe access to events. Further pilots are expected in 2021. In addition, an ethical review is being carried out to determine the conditions under which such an application might be appropriate.

**PUPPY**

Because of the threat posed by coronavirus, many elderly people in particular were unable to leave their homes to go shopping in 2020. As a result, local businesses saw their revenue drop sharply. TNO’s Pop-Up, Pick-Up and Home Delivery (PUPPY) project was developed for these businesses. A cost-effective logistics collaboration model is thus being created to collect and deliver products to consumers locally. PUPPY was created to reduce the number of contact moments in shops, while enabling local businesses to keep selling their products.

How does it work? Consumers can place orders with different merchants through a portal. The merchants prepare the orders, and a delivery service then picks them up and takes the groceries to the central collection point in the neighbourhood. From this hub, the items are delivered to the consumer by the same delivery company, or the consumer collects the goods they have ordered. After a first pilot was run in Dronten, a second was set up in Kampen. The knowledge gained from the pilots is being made public right away so that as many municipalities and entrepreneurs as possible can benefit from it.

### COOLING VESTS IN HEALTHCARE AGAINST HEAT STRESS

Due to the highly contagious nature of coronavirus, healthcare personnel must work in protective gear. While it is essential, this clothing limits the transfer of heat to the environment, and that means that a lot of healthcare workers experience heat stress while they work. In turn, that reduces cognitive and physical performance, and can make people more agitated. In this innovation project, building on the Thermo Tokyo project, TNO and university medical centre Radboudumc looked into whether healthcare personnel would benefit from aids such as cooling vests that can be worn during working hours.



In addition, medical staff and their management were supported with *best practices* on the most effective ways to design a work environment to prevent heat stress. Several other hospitals have also expressed interest. This project has thus directly and indirectly had a positive impact on the working conditions of healthcare providers at Radboudumc and elsewhere.

### THE 'HOW AM I' APP

Since the outbreak of coronavirus, a lot has changed for working people in the Netherlands. Many employees have to work from home, or must work more and longer hours in crucial occupations. Working from home was often challenging, for example because there were children around while schools and daycare centres were closed, or because the home office was far from ideal. How do you manage all of this as an employee?

Employees were invited to share their experiences and creative solutions in TNO's 'How Am I' app. After completing a basic questionnaire about their work and domestic situations, participants received a brief questionnaire each day about how their day was going. Subjects that came up each day were the participant's situation at work and elsewhere, how their day was going, and how they felt.

TNO used the app to gain insights into employees' situations under these special circumstances, and it shared its findings in blogs. What measures are companies taking, and what effects are they having? How resilient are we, and what creative initiatives are emerging? The blogs thus shared results, initiatives and advice from experts. In total, over 900 employees participated in the survey with the How Am I app.

### FROM EARTHQUAKE MODEL TO PREDICTIVE MODEL FOR ADMISSIONS TO INTENSIVE CARE

When RIVM indicated at the start of the coronavirus crisis that it did not yet have a model for estimating what the demand for intensive care would be, Jan-Diederik van Wees threw himself into this. Van Wees, a Professor of Earth Sciences at the University of Utrecht and a researcher at TNO, saw an opportunity to rebuild an existing 'earthquake model' to predict the number of admissions to intensive care.

The type of mathematical models used to predict earthquakes also proved suitable for the coronavirus problem. Changes are taking place underground, caused, for instance, by the extraction of gas. There is a great deal of uncertainty. Similarly fundamental characteristics also apply to the coronavirus problem. There are only a few parameters that one can latch onto as a researcher. Still, with limited information and some help from the assimilation of data, good predictions can be made.

TNO, together with Amsterdam University Medical Center, Erasmus Medical Center, and Leiden University Medical Center, has further developed Van Wees's model to predict the number of admissions to intensive care: the 'Susceptible, Exposed, Infected, Removed' model (SEIR). SEIR takes into account uncertainties for parameterisation (expressing COVID-19 in parameters) and social distancing measures. The model shows users the drastic effects that small changes can have. The model and the predictions themselves were subsequently made public.

## 2020 GAME CHANGER

## PREDICTIVE TWINS

The construction and infrastructure sector is facing a number of major challenges. In addition to the replacement and renovation of existing civil infrastructure, circular and energy-neutral construction is now required. The current level of digitisation in the construction industry is insufficient to adequately meet these challenges. 'Predictive twins' offer a solution.

A predictive twin is a digital replica of a physical structure such as a bridge, a tunnel, a house or an office. Because the predictive twin is connected to its physical twin, it can simulate and predict the behaviour of the built structure and how this will be used. That allows TNO not only to track the service life of these built structures from a technical standpoint, but also to provide insights into future energy consumption. And this, in turn, contributes to lower CO<sub>2</sub> emissions and a better climate.

[You can read more here.](#)



**BUILDINGS, INFRASTRUCTURE & MARITIME UNIT**



REPORT OF THE  
EXECUTIVE BOARD

STRATEGY

REPORT OF THE COUNCIL  
FOR DEFENCE RESEARCH

REPORT OF THE  
SUPERVISORY BOARD

RISK MANAGEMENT  
AND CONTROL SYSTEM

A RESPONSIBLE  
IMPACT

FINANCES

APPENDICES

## STRATEGY FOR 2018–2021

2020 was the third year of the current 2018–2021 strategy period. As in the earlier years of this period, TNO made significant progress in 2020 too. The following pages discuss this in more detail. Before we turn to that, TNO would like to say a few words about the United Nations Sustainable Development Goals (SDGs). Contributing directly or indirectly to these goals is, after all, the starting point of TNO's strategy and activities.

### TNO'S IMPACT

The SDGs are a universal reflection of the social challenges facing the world. TNO's research contributes to the ability to meet these goals. TNO focuses primarily on seven SDGs (see the goals that are enlarged in the figure below). These are subjects where TNO can achieve the greatest societal impact, thanks to its knowledge and position. In this way it is committing to the global agenda for sustainable development and is having a positive impact on society.



TNO will have this impact if it can contribute to solutions to major societal challenges and if its innovations can strengthen the economy. TNO measures its impact on the basis of five categories, each of which has various indicators:

- **Cooperation:** Key indicators in this category are the number of partnerships, revenue from third parties, and customer satisfaction.
- **Entrepreneurship:** Entrepreneurship is assessed on the basis of private-sector revenues, the number of licences that have been granted, and the number of spin-offs created.
- **Science:** A key indicator of TNO's scientific impact is the number of scientific publications.
- **Policy and Politics:** For its impact on policy and politics, TNO looks at the number of mentions in policy documents at the regional, national and European levels.
- **Communication:** The extent to which TNO succeeds in reaching the general public and prospective employees is monitored by measuring the number of mentions in national media, the number of followers on social media, and the number of visitors to its website tno.nl.

Category	Indicator	2020	2019
Cooperation	Number of public-private partnership projects	1,006	985
Cooperation	Customer satisfaction <sup>1</sup>	4.4	4.3
Entrepreneurship	Current licences	275	267
Entrepreneurship	Spin-offs	9	6
Science	Publications (scientific) <sup>2</sup>	482	618
Communication	Mentions on Radio & TV	140	131

<sup>1</sup> On a scale from 1 to 5

<sup>2</sup> Peer-reviewed articles and dissertations

## CUSTOMERS, PARTNERS AND COOPERATION

### Closer cooperation

The major social and economic challenges we are facing increasingly demand that parties form alliances and work together. In 2020, positive steps were taken in strengthening cooperation with a number of Dutch universities. Here are a few examples: TU Eindhoven, Fontys and TNO worked hard together on the 'Eindhoven Engine' with a view to cooperating with industry on a number of programmes in the Brainport region. In the field of integrated photonics, PhotonDelta, Twente University, TU Eindhoven and TNO have set up the Photonics Integration Technology Center. TNO, together with Maastricht University and Fontys, and with support from the Province of Limburg, is involved in a new initiative in the field of logistics: Brightlands Institute for Supply Chain Innovation.

### Strengthening customer focus and account management

TNO assesses the quality of its customer relationships through customer satisfaction audits. The average score customers gave TNO was 4.4 out of 5, thus continuing the high scores of recent years. TNO is proud of the high regard our customers hold us in.

It invests in its relationships with its main customers through account management. For each of these relationships, a team is set up, led by an account manager who has a coordinating role that spans TNO in its entirety. The aim is to offer the customer a single TNO-wide point of contact that is efficient, effective, customer-oriented, and in line with the pursuit of their strategic goals. In 2020 TNO expanded its account management to cover 28 of its key customers and partners, up from 15 the year before.

### Involving SMEs

Coronavirus has already led to an unprecedented slump in the Dutch economy. TNO published a position paper in 2020 arguing that additional research and innovation are the most important factors in helping the Netherlands to realise its capacity for growth.

Additional investments in research and innovation must be made jointly by the public and private sectors. Research by TNO shows that the required further growth in private investment in the Netherlands must come from the 'robust middle segment' of SMEs or from new activities and new sectors.

This research shows that applied research institutes such as TNO can play an important role in innovation on the part of SMEs. It is difficult for small or start-up companies to build and maintain research-and-development (R&D) knowledge and capacity. Joint projects with TNO allow SMEs to make use of its existing research infrastructure, which can substantially reduce the costs of innovation for these SMEs. The likelihood that research projects will succeed also rises, thanks to the specific knowledge and experience that researchers at applied research institutions have. The insights from this report form the basis for the further development of TNO's SME strategy.

### Consolidating our international position

The reporting year was the last of Horizon 2020, the European research programme in Europe's eighth framework programme. TNO has been particularly active and successful within Horizon 2020, performing very well in terms of both size (EUR 160 million in grants received) and success rate (26%). European cooperation is a prerequisite for success, and reflects the international visibility and excellence of TNO.

Each year, the European Research Executive Agency, which manages Horizon 2020 research and innovation projects as well as grants, selects the ten most impactful innovation projects from the many funded by the European Union (EU). In 2020, two of these ten breakthrough projects were from TNO: DRIVER+ (crisis management) and CHE (monitoring CO<sub>2</sub> emissions).

Partly in view of geopolitical developments, cooperation within Europe – particularly aimed at technological sovereignty – is becoming increasingly important. As is done collectively within Horizon 2020, TNO is also actively seeking bilateral cooperation with peer institutions. In addition to the existing cooperation in the Holst Centre with IMEC in Belgium, a strategic cooperative initiative with the Fraunhofer in Germany has been started. The first step consists of two multi-annual programmes in intelligent energy networks and reliable AI. Exploratory talks are also being held with the French company CEA about a strategic partnership in hydrogen technology.

**RESEARCH**

**Early Research Programmes**

The first step in knowledge development at TNO is taken in its Early Research Programmes (ERPs). These are the testbeds for our DDPs. These multi-year programmes bring together expertise from different parts of TNO. University research groups are also getting involved more and more at this early stage, and in many cases so are future buyers of the technology that is to be developed. In 2020, TNO had eighteen ERPs in operation. In addition, TNO has a testbed of one-year ‘seed ERPs’ (of which there were six in 2020). Some of these will continue as multi-year ERPs in 2021. The development of this portfolio can be illustrated by the following examples:



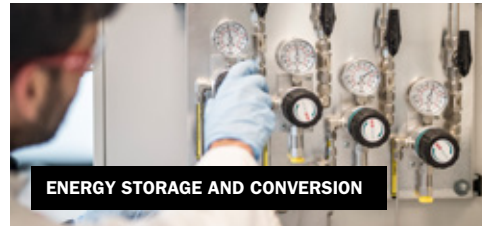
**3D NANOMANUFACTURING**

The structures in current computer chips are essentially planar: made up of layers. The semiconductor and chip industries are introducing three-dimensional structures in integrated circuit (3D IC or 3D chips) in order to achieve even faster and more compact electronics. Within this programme, TNO is developing concepts for devices that will be needed for the future 3D chip. Equipment for measuring 3D structures, even at some distance below the surface, is one example. In 2020, TNO put into operation a globally unique concept that makes it possible to take measurements that could not be taken with optical techniques.



**SOCIAL EXTENDED REALITY (SOCIAL XR)**

Virtually moving to another place in the world is a science-fiction dream that has come partly true, for example in the form of video conferencing. This ERP focuses on technology to bring the experience of that digital contact even closer to a physical encounter. This is done by means of a 3D image that is displayed almost in real time, and through the use of other senses. In 2020, TNO realised a working set-up in which people can meet in a virtual environment through volumetric video (spatial 3D capture).



**ENERGY STORAGE AND CONVERSION**

In this programme TNO is developing technology for the chemical industry to convert the feedstocks carbon dioxide (CO<sub>2</sub>) and hydrogen into energy carriers such as carbon monoxide (CO), methane (CH<sub>4</sub>) and formic acid (HCOOH). The energy required is obtained directly from sunlight or electricity – green or otherwise – and is used to reduce our dependence on fossil fuels. In 2020 TNO improved its ‘photons-to-chemicals’ processes. In addition, TNO worked with partners to design a ‘mini-factory’ that will enable it to assess the technical and economic feasibility of these processes in 2021.



**OPTICAL SATELLITE COMMUNICATION**

The need for digital communication continues to grow. A promising approach is wireless optical communication (free-space optics or FSO) over long distances. This allows for a major expansion of communication capacity and security. TNO is developing technology that allows ground stations, satellites and aircraft to be linked via laser communication. This allows large amounts of data (up to 10 Tbit/s) to be sent and received.



**LARGE-AREA ULTRASOUND**

In medical diagnostics, *ultrasound imaging* is being used more and more often. Unlike X-ray imaging, ultrasound does not damage human tissue. In this ERP, TNO is focusing on the development of flexible ultrasound arrays that are integrated into a patch and can be applied to the skin for a long time. The goal is better imaging and easier application. In 2020 TNO developed the manufacturing process, greatly improved performance, and built a first flexible array.

### Demand-driven programmes

The Mission-Driven Top Sectors and Innovation Policy (MTSIP) was formally launched in 2020. Twenty-five missions have been defined for five core topics with which the Netherlands aims to solve important social issues and create economic earning capacity for companies. The mission-driven approach requires, to a greater extent than before, *holistic* cooperation among government, top sectors and knowledge institutions.

In 2020, TNO was actively involved in shaping this cooperation and in drawing up integrated knowledge and innovation agendas based on it. This mission-driven approach fits in seamlessly with the programming of research, which at TNO is geared towards having a social and economic impact and uniting these two strands, as well as towards connecting government and industry.

2020 was also the first year of the Knowledge and Innovation Covenant 2020–2023, in which government, knowledge institutions, and the business community will commit around EUR 4.9 billion in research and innovation resources to the MTSIP. More than half of all state funding for TNO is involved here. In 2020, the TNO research programmes were therefore geared specifically towards contributing to the integral topics of the MTSIP. TNO's 40 research programmes cover *all* mission-driven topics: energy and sustainability (with the sub-agendas climate and energy, future-proof transport & mobility systems, and the circular economy), health and healthcare, safety, agriculture, food and water, and key technologies. Energy and sustainability, and key technologies, are by far the most significant topics for TNO, followed by health and healthcare, and then safety.

TNO was closely involved in translating the MTSIP into concrete Multi-Year Mission-Driven Innovation Plans. Below is a brief account of how some of the research programmes contributed to the missions in 2020.



**ENERGY AND CLIMATE  
– OFFSHORE WIND FARMS**

The TNO Wind Energy R&D programme fits in seamlessly with the multi-year innovation plan 'Renewable Electricity at Sea', part of the 'A zero-carbon energy system by 2050' mission. TNO Wind Energy is leading in the development of innovative products and solutions for offshore wind farms. In this research programme, TNO and its partners are developing knowledge and technology that will enable the realisation of large-capacity offshore wind farms. The business community is involved at an early stage via the Top Sectors. The highly developed Dutch offshore industry is involved in 80% of all offshore wind farms in Northwest Europe.



**KEY TECHNOLOGY – NEW GENERATIONS  
OF BATTERY TECHNOLOGY**

A key result is the successful development in 2020 of a first *proof of concept* of the 3D Li-ion solid-state battery at the Holst Centre. These batteries are intrinsically safe. They are lightweight, they charge very quickly, and they have a long life. Applications include flexible batteries in wearables and, at a later stage, larger batteries for electric cars. This success is thanks to an integrated approach that builds on innovations in design, materials, and process technology.



**HEALTH AND HEALTHCARE  
– MICROTRACING WITH AMS**

The development of a potential medicine, going all the way from laboratory to patient, takes about 13 years on average and costs between USD 1.3 and USD 2.5 billion. This process can be accelerated through the use of innovative technologies. Within the 'Biomedical Health' DDR TNO has developed just such an innovative technology: microtracing in combination with accelerator mass spectrometry (AMS). The use of AMS can speed up the development of new drugs by about two years. Research in 2020 by the Fair Medicine Foundation shows that the use of this technology also leads to substantial cost savings.



**FUTURE-PROOF TRANSPORT & MOBILITY  
SYSTEMS – CONNECTED AND AUTOMATED  
TRANSPORT (CAT)**

CATALYST is a living lab for CAT (connected automated transport) innovations, the aim being to make heavy road transport safer, more efficient and more sustainable. With TNO as the leading partner, a consortium of over 50 of the most important partners in the transport sector was brought together in one year to work on sustainable innovations and to create an impact in the field of CAT.





This TNO research programme contributes to the multi-year innovation plan 'Sustainable heating and cooling in the built environment'. The ambition of the programme is to make one and a half million homes more sustainable by 2030. Based on this DDP, TNO is the leading the WarmingUP innovation plan, which started on 1 January 2020. TNO is developing knowledge and innovations for design and control tools for heat networks, cost reductions, safety and social innovations intended to make living without natural gas a reality.

**Developing and upgrading the knowledge portfolio**

In 2020 TNO further professionalised the management of its portfolio. Each unit in TNO used the portfolio methodology, which had been introduced earlier, to make its selections for the portfolio. This involved starting up, developing, winding down and transferring topics. Examples include the launch of a new 'Smart Industry' roadmap and the clustering of TNO research on energy into four roadmaps: 'Renewable Electricity', 'Towards CO<sub>2</sub>-neutral Industry', 'Sustainable Subsurface' and 'System Transition'. The optimal spending of resources and increasing TNO's impact were central here. In addition, in the context of TNO's 2022–2025 Strategic Plan, the entire portfolio was analysed in terms of roadmaps. This analysis of history, ambitions and opportunities will guide the development of the TNO portfolio in the coming years.

**Knowledge position**

So that TNO can meet the demand for applied research and innovation in the Netherlands, both now and in the future, it must have a strong knowledge position. And to guarantee the quality, impact and vitality of that position, each of TNO's research groups goes through a Knowledge Position Audit (KPA) over a four-year cycle. The KPA is performed by a committee of outside experts.

In 2020, KPAs were conducted at the Circular Economy and Environment unit and at the Energy Transition unit. The audit committees were impressed by TNO's knowledge position in these crucial research areas. It was partly for this reason that the growth potential of the Circular Economy and Environment unit was assessed as high. For Energy Transition, this was the first audit after the merger with ECN in 2018. Its success here was underlined by high scores for the 11 integrated research groups. Of these, 7 were awarded marks of *very good* and *world-class quality*.

The audits of the Circular Economy unit and the Environment and Energy Transition unit closed the 2016–2020 KPA cycle. In 2021, a new cycle will start, with audits of the Industry and the IT units.

**Facilities**

Innovation increasingly takes place in ecosystems where research facilities are a critical factor. However, there is no ongoing budget for applied research facilities in the Netherlands. Because current funding instruments are inadequate, TNO has to charge its customers higher fees. A shortage of investment in applied research facilities can also mean that TNO is hampered in performing its tasks, and that it cannot compete internationally with other top institutes. And that, in turn, can make the Netherlands less appealing to companies as a location for their R&D activities.

While there is no long-term solution to this problem, the government does make one-off funding available for research facilities. In September 2020, for example, the Dutch Cabinet released EUR 18.3 million for an investment at the Energy Transition unit. Together with partners from industry and other knowledge institutions, TNO can use this to establish five research laboratories. In these new laboratories, research will be done on a new generation of solar-energy applications, carbon capture and utilisation, industrial electrification, industrial drying technology, and the ecological and safety-related effects of solar and wind-energy projects. Several pilot and demonstration projects are being developed and tested that have the potential to be applied on a larger scale in the future. The five new research facilities should thus help accelerate the energy transition, help improve the knowledge position of Dutch industry, and boost business activity and employment.

**HOUSE FOR TALENT**

**Empower: a new approach to performance appreciation and remuneration**

The introduction of the new performance management system Empower in February 2020 was an important step in establishing TNO's new HR strategy. Empower is based on the knowledge that employees' control over their own careers, and the use and expansion of talent in a stimulating work environment, help staff stay motivated and perform well at work. Entering into a continual dialogue about results and development links employees' own values and goals to those of the organisation. That, in turn, creates an equal relationship based on mutual value creation in which employees can discover, develop and use their talents. Empower thus supports TNO's mission – to have an impact on society. In 2020, all managers and employees were introduced to Empower through a training course that HR had developed. The initial and first follow-up meetings were held, and each team is now looking at how Empower can be developed further.

**Diversity and inclusion**

Diversity and inclusion are high on the agenda and are thus among the strategic priorities for 2021 and in the 2022–2025 Strategic Plan.

In November 2020 a TNO Diversity and Inclusion (D&I) Officer was appointed. This person is responsible for the further development of the D&I policy and its translation into practice.

In 2020, a steering group led by CEO Paul de Krom worked on further increasing diversity within TNO. Among other things, it prepared an outline for the D&I strategy 2022–2025. A strategy provides more coherence and sets clear goals so that D&I gets the right level of attention at the organisational level too. In 2021, this first step will be developed. Equal opportunities for every TNO employee are an important focal point here. An investigation into equal pay between male and female TNO employees was already launched in the autumn of 2020.

On average, men earn more than women at TNO. That being said, the extensive research into equal pay at TNO shows that there are no significant differences in the salaries of men and women when correcting for factors such as age, starting salary, job grading level, type of appointment, part-time factor, absence history, assessment history, starting age and unit/SO. Finally, no significant difference between men and women was found in terms of salary rises over a 10-year period. Salary differences between men and women are caused primarily by differences in salary scales and in starting salaries. This will be investigated in greater depth in 2021. The focus of TNO’s D&I strategy will also cover cultural diversity, *disabilities and* sexual orientation.

In addition, language assessments and training were organised in 2020 as part of the ‘English Fit for Purpose’ programme. Use of

the English language is important so that non-Dutch-speaking internationals can be offered an inclusive work environment without language barriers. The programme is available to all TNO staff to improve their English language skills.

In 2020, 11.5% of TNO staff were *internationals* (not Dutch). As for gender, 69% of staff were male; 31%, female. At the highest level of the organisation (Supervisory Board, Executive Board, and managing directors), it was 52% male to 48% female.

**Sustainable, vital and future-proof**

The Fit for Your Future programme has been promoting the mental and physical health of employees since 2019. The importance of this programme was underscored in 2020, when staff worked primarily from home as a result of the COVID-19 pandemic. As part of this programme, the ‘Safe, connected and fit work’ website was launched in the summer. The ‘Vital leadership’ training course for managers, including project managers, was also offered.

All recruitment activities in 2020 were online, including selections for the trainee programme and ‘Get to Know TNO’, the in-house day that offers students and recent graduates a first look at what TNO is like. At the ‘Get to Know TNO 2.0’, which was held as a webinar and was on the energy transition, 306 viewers attended, and 86 applications were subsequently submitted. TNO sees this as a new formula for success. It will soon be followed by a webinar on transport & mobility. In addition, online assessments were first used in selection procedures in April 2020. This scientifically based tool facilitates a more qualitatively oriented selection procedure and reduces the tendency towards bias.

In 2020, two new teams were established within HR. The first was a sickness absence and occupational rehabilitation team

that supports managers and business partners in managing complex cases of long-term sickness absence. In addition, an HR Innovation & People Analytics team was launched. It focuses on creating a future-proof and data-driven HR organisation. The team supports the HR organisation in working in innovative and *evidence-based ways*.

**Employee engagement survey**

A majority of TNO employees took part in the annual employee engagement survey in 2020. The response rate was 72.5%, an increase of 12.5% over 2019. Overall satisfaction increased to an average score of 7.5, up from 7.3 in 2019. In addition to the positive trend in terms of satisfaction with meaningful leadership, salary, fringe benefits and image, there were also points requiring attention. For example, the percentage of ‘burnout-related complaints’ remains unchanged compared to 2019, and the levels of satisfaction both with follow-up on the 2019 employee engagement survey and with performance appraisals went down. These points will be worked on, with particular attention going to further reducing the number of complaints related to burnout. Ways of reducing bureaucracy will also be examined throughout the organisation.

**GOOD FINANCIAL HEALTH**

Healthy finances are essential to guaranteeing TNO’s continuity. A positive financial result is needed as a buffer to absorb setbacks, to ensure operational continuity, and to be able to keep investing in the organisation’s knowledge base and portfolio. In 2018, a programme was launched to strengthen financial performance during the present strategy period. The biggest *bottleneck* here is the limited return on investment that research facilities offer. The lack of a level playing field at both the national and international levels and the relative decline in investments by the business sector in R&D are additional challenges.

OUTLOOK

The 2022–2025 Strategic Plan

While TNO is still working hard to realise the strategic goals for the 2018–2021 period, the foundation has been laid for the next strategy period. In 2020, the process for the 2022–2025 strategy began. Based on external and internal analysis, and extensive consultation with stakeholders, the priorities for the next five years are being determined. In 2021, the new strategy will be completed and presented to the Ministry of Economic Affairs and Climate Policy.

TNO/T02 evaluation

Every four years the T02 institutes go through a collective external evaluation. The TNO evaluation committee made a virtual visit to TNO in December 2020, and it was impressed both by the quality of TNO’s research and by the progress it had made in many areas such as organisational development, portfolio management and its relationships with universities. The evaluation report will be published in early 2021, and the recommendations it contains will be incorporated into the 2022–2025 Strategic Plan.

Innovation as an engine for sustainable growth

From the start of the coronavirus pandemic, TNO has stressed that the Netherlands must innovate its way out of the crisis. After all, it is innovation that offers the greatest opportunity for sustainable growth. The Dutch government and the European Commission share this view, as evidenced by the introduction in 2020 of the National Growth Fund and the European Recovery Plan. Both funds will lead, among other things, to additional one-off investments in research and innovation. TNO participates in a number of coalitions that have submitted proposals within the framework of the Growth Fund. Together with the Knowledge Coalition, however, TNO stresses the importance of additional

funding over the long term for research and related facilities, the aim being that the Netherlands increases its spending on R&D to 3% of its GDP.

The elections to the Lower House of the Dutch Parliament and the formation of a new government will be important events in 2021.

At the European level, the new Horizon Europe framework programme will be starting. Both thematically and in financial terms, these events will offer opportunities for TNO and will be of considerable importance. However, the outlook for TNO in 2021 is also influenced by the uncertain impact of coronavirus. The impact of an economic crisis on TNO is uncertain. The level of contributions and investments from the private sector in joint projects and programmes was already decreasing, in relative terms, in 2020. Although this was partly offset by additional government contributions in 2020, there is a real risk that fewer orders will lead to a reduction in the volume of work and in productivity. The extent to which this risk materialises depends in part on economic developments and on the policy of the new government.

Summary

TNO has been in existence for almost 90 years and plays a unique role in Dutch society. With its focus on applied research, it contributes to the practical application of knowledge and innovation, and helps businesses bridge the valley of death. TNO is looking to the future with confidence: strategically it is well positioned, and financially it is in good shape. The increasing focus on research and innovation and the extra funding – one-off and otherwise – that will become available for this purpose offer plenty of opportunities for the years ahead.

## 2020 GAME CHANGER

## A NEW GENERATION OF WIND TURBINES

While the measurements from the Haliade-X, the world's largest wind turbine, are still being taken, TNO experts are already working on the next generation of turbines. They are working within the STRETCH programme, in cooperation with General Electric and with financing from the Netherlands Enterprise Agency. Many turbines do not meet the demand for energy. But that answer is not simply to produce larger blades, for example, because these would then be too heavy or too expensive for large-scale use.

That is why the researchers in the STRETCH programme are trying to use *add-ons* to improve the technology that goes into the blades. In their design they are trying to find the perfect balance between a limited load on the wind turbine and a high wind yield. This is a complex puzzle for which here are no models yet. The research being done by TNO and its partners is thus on the cutting edge. In five years' time, the first of these new wind turbines must already be in operation offshore. And that will bring a sustainable future that much closer.

[You can read more here.](#)



ENERGY TRANSITION UNIT



REPORT OF THE EXECUTIVE BOARD

STRATEGY

REPORT OF THE COUNCIL FOR DEFENCE RESEARCH

REPORT OF THE SUPERVISORY BOARD

RISK MANAGEMENT AND CONTROL SYSTEM

A RESPONSIBLE IMPACT

FINANCES

APPENDICES

## TNO TECH TRANSFER

Technology Transfer is the final step in TNO's innovation cycle. In this phase, TNO takes knowledge to market by setting up spin-offs and licensing knowledge to businesses.

Despite the restrictions caused by the COVID-19 pandemic, 2020 was quite a success for Tech Transfer. Nine new companies were created, the highest number since the programme began in 2017. The programme has in the meantime created 28 start-ups that between them represent a value of EUR 62 million and that have led to the creation of 210 new jobs. An international benchmark shows that TNO has a higher number of spin-offs per 1,000 employees than many other European research and technology organisations (RTOs).

In September 2020, the 25th spin-off company, Relement, was founded. This memorable event was celebrated by TNO with a [digital visit by the State Secretary of the Ministry of Economic Affairs and Climate Policy](#). Relement makes new chemical building blocks based on bio-residues instead of oil, with a view to making the chemical industry more sustainable. During the visit, the State Secretary launched the digital publication '[25 TNO Spin-Offs in the Spotlight](#)', which includes all 25 spin-offs created since 2017, along with an explanation of each, a quote from the entrepreneur in question, and some figures.



In November, the first Tech Transfer event took place. During this fully digital event, two entrepreneurs gave a presentation on starting your own business, and there were three round-table sessions with outside speakers who had extensive experience both in branding and in investing in start-ups.

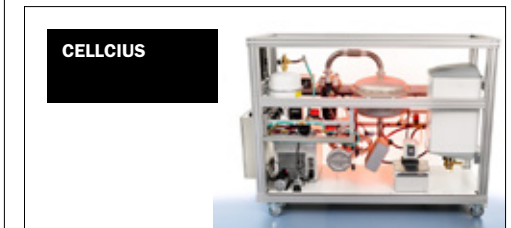
Cooperation with 4TU has been further shaped by the start of two joint programmes within the topic-specific technology transfer programme of the Ministry of Economic Affairs and Climate Policy on the Smart Systems and Circular Technologies topics.



Carbyon is developing a machine that can extract CO<sub>2</sub> from the air. This innovation is a unique combination of thin film technology and mechatronics. The thin, porous film, which is a few microns thick, adsorbs the CO<sub>2</sub> very effectively. Hardly any energy is needed.

Closing the CO<sub>2</sub> cycle in this way can fundamentally transform and neutralise the effects of the global energy and materials economy on the climate.

[You can read more here.](#)



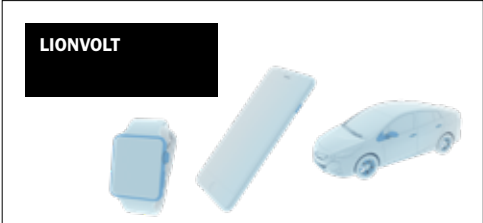
Cellcius, the result of cooperation between TNO and TU Eindhoven, is developing a compact device for storing heat in the home. This heat battery takes advantage of the reaction between water and a certain type of salt, and stores the resulting heat for heating and tap water in the home. In addition, the device helps heat pumps and solar collectors to perform better. The cost of the system is at least ten times less than that of current electric batteries in the home.

[You can read more here.](#)



With the technology for which Keiron is developing a production machine, a wide range of materials can be applied to any surface. That also makes the technology interesting for adding microelectronics in lab-on-a chip applications. Major advantages of the technology include contactless printing and a laser that can print any desired pattern on a substrate at lightning speed.

[You can read more here.](#)



LionVolt's revolutionary battery, which features a 3D substrate and Spatial Atomic Layer Deposition, is safe and compact, and has a long service life. This solid-state battery is produced in 3D by applying layers of thin film materials to a surface, thus allowing for lightning-fast charging. The first batteries will be found in wearables, smartphones and tablets, and possibly later in road transport, ships and aircraft.

[You can read more here.](#)



OQS (Orange Quantum Systems) wants to accelerate the introduction of quantum computers by developing relevant products and services for corporate R&D laboratories and TO2 institutions. In time, this should lead to the first off-the-shelf quantum computer that can be used by companies for commercial applications and that can solve major social problems more quickly.

[You can read more here.](#)



Pharmaprint wants to make it possible to print tailor-made medicines in a single pill. Using 3D printing technology makes it possible to tailor each medicine, in terms of ingredients, dosage and drug release, according to each individual's needs. At the moment, tailor-made medicines are not yet economically viable. Discussions with professional groups, doctors, insurers, the government and the healthcare inspectorate are ongoing.

[You can read more here.](#)



Relement is contributing to the chemical industry by making sustainable chemical building blocks from bio-residues instead of oil. The ingredients are also of better quality than the fossil-fuel variants. For example, paint with bio-ingredients is more resistant to sunlight, and bio-residues make insulation foam stronger.

[You can read more here.](#)



In cooperation with TNO, Retinascope has developed a portable camera that can quickly detect eye problems caused by diabetes. The camera is easy to operate, and allows general practitioners to have the images analysed remotely by a specialist. The camera is particularly suitable for diagnosing eye diseases such as retinal degeneration, glaucoma and impaired/blurred vision.

[You can read more here.](#)



The AI software from Studio Automated enables the livestreaming and analysis of events such as sports matches and concerts, not to mention business presentations. Besides large organisations, amateur clubs also use the software for automatic game analysis and training. Studio Automated also applies this technology for security purposes, for the timely recognition of suspicious behaviour or undesirable situations, for instance.

[You can read more here.](#)

## REPORT OF THE COUNCIL FOR DEFENCE RESEARCH

In its Defence Vision 2035 'Fighting for a safe future' published by the Dutch Ministry of Defence in October 2020, the Ministry states that by 2035 it wants to be a smart, technologically advanced organisation with a significant capacity to adapt to new situations and act on the basis of the best information. The focus is therefore on research and development, and on translating both into actual innovation and implementation in the armed forces. This offers opportunities to build on the more than 70 years of intensive cooperation between the Ministry of Defence and TNO. The prospects in the field of national security are also excellent.

With Marja Eijkman taking up her post as Managing Director of the Defence, Safety & Security (DSS) unit on 16 April 2020, the Council for Defence Research (CDR) once again has its full complement of members, following the departure of Henk Geveke on 1 October 2019. The CDR held five meetings in 2020, four of them online. The CDR also held an online 'retreat' in November.

2020 was dominated around the world by the scourge of the coronavirus pandemic. The world has not seen concerns on this scale about safety and security for a long time. The consequences were a frequent topic of discussion in the CDR. The CDR also discussed the deployment of the DSS unit within the 'Brains4Corona' programme, in which TNO was developing short-cycle solutions that help combat the consequences of the pandemic. The impact of COVID-19 on the work and results of the DSS unit has so far been limited, although businesses are reluctant to take on new research assignments, especially at the international level. The impact on employees themselves and on the way they work has been all the greater. The financial results achieved were nevertheless higher than had been budgeted for, making 2020 another good year for defence research. However, it seems the growth seen in recent years came to a halt in 2020, partly because of the impact of the pandemic.

The renewal of the portfolio (to respond to a changing future), the strengthening of joint programming with government stakeholders (to keep meeting their need for knowledge as far as possible), and the strengthening of the knowledge component in the four DSS roadmaps (to continue to have the right knowledge and expertise in the future) – these were major priorities for research on defence and security in 2020. In addition, the Ministry of Defence and TNO joined forces in addressing such broader topics as Mission-Driven Innovation Policy, the Growth Fund, the Broad Social Review, the European Defence Fund, the European Defence Industrial Development Programme and the European Recovery and Resilience Facility.

During the annual 'retreat', the CDR used the guiding documents that had been published in 2020 – including the 'Defence Vision 2035' and *Defensie Strategische Kennis- en Innovatieagenda 2021–2025* ('Strategic Knowledge and Innovation Agenda for Defence, 2021–2025') of the Ministry of Defence, and the 'DSS Knowledge Plan' and *Defensie Technologieverkenning 2020* ('Defence Technology Foresight in 2020') of TNO – to come up with starting points for the way forward. The key thing is to organise the accumulation of knowledge for the long term in such a way that capability pull and technology push are in line with, and mutually reinforce, each other. Technological possibilities must be given direction and focus on the basis of the emphases in the 'Defence Vision' and the 'Strategic Knowledge and Innovation Agenda'. In 2021, the DSS roadmaps will be refined accordingly.

The close cooperation between the Ministry of Defence and TNO has been a guiding principle in the discussions on the TNO Strategic Plan 2022–2025, which will be published in 2021. There is a special bond between the Ministry of Defence and TNO, a bond that has continued to evolve over the past 70 years, that has brought so much to both institutions, and that has, in a certain sense, made them mutually dependent. TNO cannot do without the Ministry of Defence, and the Ministry cannot do without TNO. The new Strategic Plan will reflect this bond.

With the more than impressive results from the 2019 Knowledge Position Audit (KPA), the DSS unit undoubtedly has an excellent starting point from a qualitative standpoint. However, that does not mean that there is no room for improvement. The roadmaps deserve more attention, and in some areas the balance between basic and applied research needs adjusting. In addition, the junior, mid-grade, and senior staff structure creates too much of a workload for senior employees, while the balance between short-term innovation and long-term research needs to be monitored. Moreover, the approach that has led to excellent KPA scores for the radar technology and acoustics and sonar teams

should be widely followed. The basis for the success of these departments is the ecosystems in which they work closely with governments and industry, with each party taking account of the other's interests on the basis of a shared long-term vision.

In 2020, the further deepening of various partnerships figured prominently on the agenda. For example, together with the Netherlands Aerospace Centre and the Maritime Research Institute Netherlands, an agreement with the Defence Materiel Organisation is being drawn up to give more structure to cooperative efforts and to streamline research activities. A framework for cooperation has been developed with the Ministry of Justice and Security and the National Police to make it possible to keep up with technological developments and to respond to them in good time. It is expected that, for the DSS unit, the relationship with the Ministry of Justice and Security and the Police in the years to come will form a second pillar – the first being that with the Ministry of Defence.

In 2020, the reference document *Relatie TNO-Defensie* on the strategic partnership between TNO and the Ministry of Defence was also updated. For those activities of TNO that are related to defence (in the DSS unit), the document sets out what that strategic partnership entails, what its consequences are, and how it will be implemented. The previous version was from 2015 and no longer did justice to the practice that had evolved since then. In conjunction with this, the reference document from the same year *Programma-aansturing Defensie-TNO* on the management of the Defence-TNO programme was also updated.

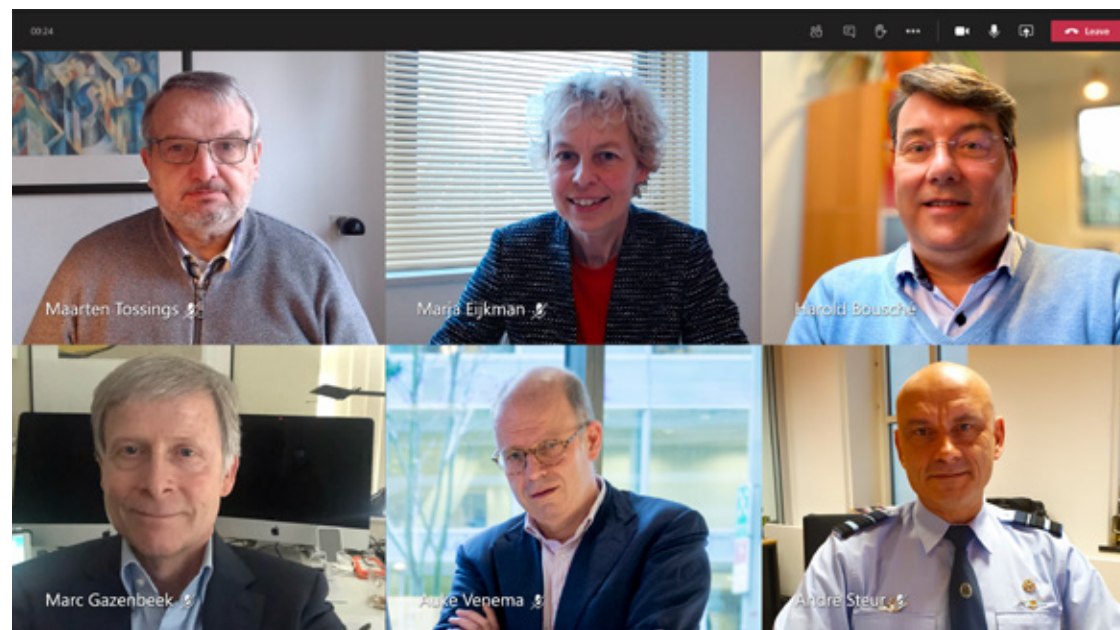
Because of the pandemic, there have been a limited number of events in 2020. Unfortunately, the ninth edition of the annual 'Innovation in Defence' event could not take place because of the pandemic. In early 2021 it will be determined how those TNO programmes that were completed in 2020 can still be given the attention they deserve.

The most important real-estate issue in 2020 was the additional construction that is taking place in the Ypenburg district of The Hague. This will provide the last department still in Rijswijk with modern research facilities. That requires substantial investments in real estate and facilities, which must be able to last for many years. Careful consideration was needed in order to reach a decision. At the end of 2020, the CDR agreed on the required functionality and what budget would be available. In order to make the financing of the property plans future-proof, the system of earmarked property reserves was modified.

Further decision-making on real-estate files has been affected by the coronavirus pandemic. Whereas before the pandemic there was

pressure on the available space because of the growth, this turned into a surplus when employees started working from home. Plans to temporarily house part of the workforce in the mostly vacant complex in Rijswijk because of the aforementioned pressure were therefore dropped. The adjusted post-pandemic property needs will be determined in the course of 2021. Decisions on the modernisation of that part of the complex that is located on the Oude Waalsdorperweg in The Hague, which is currently still leased to the NATO Communications and Information Agency, have therefore been postponed until mid-2021.

On behalf of the Council for Defence Research,  
Maarten Tossings, Chair



The Council for Defence Research, clockwise from top left:

Maarten Tossings, Marja Eijkman, Harold Bousché, André Steur, Auke Venema, Marc Gazenbeek.



## 2020 GAME CHANGER

## INNOVATIVE AIR-MONITORING NETWORK IN BRABANT

Over the past eight years, Eindhoven city council has installed measuring units (Airboxes) in the city to measure concentrations of nitrogen dioxide and particulate matter. New insights emerged from this initiative that other municipalities in the region were interested in. Therefore, since 2020, the quality of the living environment in terms of air quality has been measured throughout the Zuidoost-Brabant region of the Province of North Brabant using a regional air measurement network. After all, there are no municipal boundaries when it comes to an approach to ensuring healthy air. By definition, a regional approach is needed here. TNO, AiREAS, the Municipality of Eindhoven, the Province of Noord-Brabant, the Municipal Health Service, RIVM, Utrecht University and the Zuidoost-Brabant local environment agency signed a cooperation agreement to this end. The 50 measuring units are equipped with sensors that display information 24/7. They measure, in real time, levels of nitrogen and particulate matter, including ultra-fine particles. In a subsequent phase, they will even measure noise levels. The focus is on the urban area, the airport, and outlying areas where there is a lot of intensive livestock farming. Providing insights into the levels of harmful substances present, their sources, and their health effects has been an important step towards ensuring a healthy living environment.

[You can read more here.](#)



CIRCULAR ECONOMY & THE ENVIRONMENT



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## REPORT OF THE SUPERVISORY BOARD

Made up of seven members, the Supervisory Board is tasked with overseeing the policy pursued by the Executive Board, and with offering it advice.

The Supervisory Board normally conducts its meetings at various TNO locations. In view of the coronavirus measures, almost all meetings of the Supervisory Board and its committees were held online in 2020.

### TOPICS

In a general sense, the Supervisory Board has overseen the policy pursued by TNO in 2020. A number of significant issues are examined in more detail below.

#### Coronavirus

Just as for all organisations, in 2020 the coronavirus crisis and the measures it occasioned had a major impact on work at TNO and on its operations. Starting in March, the Supervisory Board was regularly updated by the Executive Board on the measures the crisis required and on the short- and long-term impact that it was already having or was expected to have. The Supervisory Board greatly appreciates the flexibility and decisiveness with which TNO employees and management dealt with and proactively responded to this new situation.

#### The 2022–2025 Strategic Plan

In 2020 work was started on the TNO strategy for the coming period, 2022–2025. In addition to periodic updates on progress, the Supervisory and Executive Boards held a joint strategic session in September to discuss the outline of the new plan and what it would encompass.

#### Knowledge position

Once every four years, the technology portfolio of each unit goes through a Knowledge Position Audit (KPA) that is carried out by an outside committee. The Quality Committee discussed the results of five KPAs conducted in 2019 and 2020, and considered the recommendations these contained and what the next steps should be.

#### Thought leadership

In 2020 the visibility of TNO around key societal challenges has grown. A good example of this is the Brains4Corona programme, in which short-cycle innovations were developed in cooperation with external partners so that TNO could help combat the effects

of the coronavirus crisis. The Supervisory Board also discussed various white papers (novel points of view) that provide innovative insights into major social transitions. These papers were presented by, and discussed with, the relevant unit directors. The Supervisory Board was pleased to see various statements on social media, and in the media more generally, about the *Zie het voor je* ('Envision it') campaign, which also helped increase TNO's visibility.

#### Compliance and risk management

The Supervisory and Executive Boards regularly discuss TNO's compliance with various laws and regulations. In 2020, the focus of these meetings was specifically on the development of the Internal Control Framework (ICF). The risk of fraud was also specifically examined as part of the annual risk management report.

#### Finances

On 8 April 2020 the Supervisory Board approved the 2019 financial statements; on 9 December 2020, the budget for 2021. EY has audited TNO's financial statements since 2018.

#### Performance of the Supervisory Board and evaluation of the Executive Board

In 2020 the Supervisory Board appraised its own performance and that of its members. The results were discussed jointly.

To evaluate the Executive Board and its individual members, the Supervisory Board conducted the annual round of performance reviews with both the Chair and the members of the Executive Board.

In 2020 the Executive Board also commissioned a 360° evaluation, the results and conclusions of which were discussed with the Supervisory Board.

## COMPOSITION OF THE SUPERVISORY BOARD AND ITS COMMITTEES

There were no changes in the composition of the Supervisory Board in 2020.

The Supervisory Board's three committees were made up of the following members in 2020:

### Audit Committee

Ms J. D. Lamse-Minderhoud (Chair)  
Ms I. H. J. Vanden Berghe  
Ms L. Verheij van Wijk

### Quality Committee

Prof. P. P. C. C. Verbeek (Chair)  
Prof. H. Bijl

### Selection and Remuneration Committee

Mr P. J. M. van Laarhoven (Chair)  
Mr P. G. de Vries  
Ms L. Verheij van Wijk

## INDEPENDENCE

In the opinion of the Supervisory Board, the requirements related to independence of action, as specified in provisions 2.1.7 to 2.1.9 of the 2016 Dutch Corporate Governance Code, were satisfied.



*The Supervisory Board, from left to right:*

*Peter van Laarhoven, Louise Verheij van Wijk, Peter-Paul Verbeek, Jolanda Lamse-Minderhoud, Gijs de Vries, Hester Bijl, Ingrid Vanden Berghe.*

*This photo of the Board of Supervisors was taken in 2019.*

## MEETINGS

The Supervisory Board held six meetings in 2020. The Audit Committee and the Selection and Remuneration Committee each met three times in 2020, the Quality Committee, twice.

Where necessary, committee members liaised with each other outside meetings. Representatives from the Supervisory Board attended two Works Council meetings. There were also regular consultations with the Dutch Ministry of Economic Affairs and Climate Policy.

## ATTENDANCE

The attendance record of the individual members of the Supervisory Board at its own meetings and those of its committees in 2020 was as follows:

	<b>SB meetings</b>	<b>Committee meetings</b>
Mr De Vries	6 (of 6)	3 (of 3)
Mr Van Laarhoven	6 (of 6)	3 (of 3)
Ms Vanden Berghe	6 (of 6)	3 (of 3)
Ms Bijl	5 (of 6)	2 (of 2)
Ms Lamse-Minderhoud	6 (of 6)	3 (of 3)
Mr Verbeek	6 (of 6)	2 (of 2)
Ms Verheij van Wijk	6 (of 6)	6 (of 6)

## 2020 GAME CHANGER

## THERMOCHROMIC COATINGS

It takes a lot of energy to heat and cool homes and other buildings. That is not good for the climate. One way to save energy is to apply special coatings to the windows. These ensure that the sun's rays are used when they are needed, and blocked whenever it is warm enough. The switch is made automatically, thanks to the thermochromic coating. TNO has applied for a patent for this invention.

What is special about the coating, which TNO developed at the Brightlands Materials Center, is that it is affordable and does not discolour or darken the glass. This gives architects plenty of scope to use the technology in new apartment complexes. It is estimated that the total energy consumption of a home could be cut by more than twenty percent. On average, this will save more than EUR 600 per home per year. Nationally, it will cut the release of CO<sub>2</sub> emissions by 4.5 megatonnes.

[You can read more here.](#)



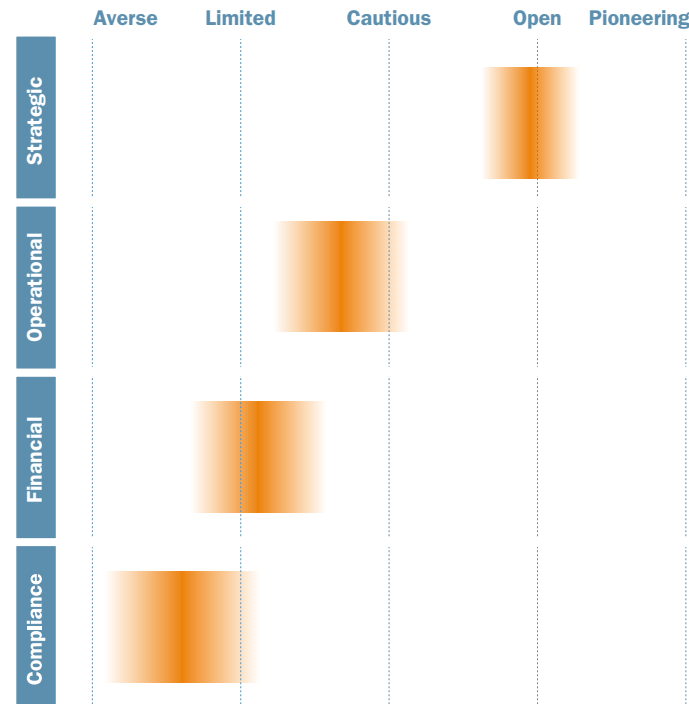
# RISK MANAGEMENT AND CONTROL SYSTEM

## RESPONSIBILITY

The Executive Board is responsible for developing, implementing, and monitoring TNO's risk management and control system, whose goal is to achieve operational, quality and financial objectives, among other things by managing the risks involved in pursuing them.

## RISK APPETITE

Risk appetite is closely related to TNO's objectives and the unique nature of TNO as a research and technology organisation (RTO). It is not so much about avoiding risk altogether, but rather about creating the right assessment framework for deciding which risks to take. So, TNO is prepared to take risks regarding the success or failure of its innovations – which is TNO's core business, after all – but has far lower risk acceptance in the areas of finance and compliance. The risk appetite of TNO is expressed and described as follows:



TNO wants to be a leading player in society in order to boost competitiveness and increase well-being across society. We are ready to take on challenges in developing unique, distinctive, multidisciplinary knowledge and using world-class facilities, as well as to generate impact by bringing knowledge to market.

Given its strategic objective, TNO wants to operate from an enterprising mindset. In projects, we are prepared to operate in an innovative way and want to be a reliable and efficient partner, albeit always on the condition that the integrity of our internal systems and processes and the safety of our employees are adequately safeguarded.

TNO's financial strategy is designed to provide a sufficient buffer to allow it to accept certain financial risks as well as to invest in new facilities and sustain existing facilities without jeopardising its continuity.

TNO operates in a playing field wedged between public and private interests that is governed by regulation and ethical standards. TNO embeds control measures in a way that is responsible and as efficient as possible. When it comes to compliance risks, TNO's risk appetite is minimal.

**NATURE AND SCOPE**

Embedded in TNO’s organisational, management, and governance model, and therefore an integrated part of this model, the risk management and control system is made up of a number of sub-systems that are each intended to reduce to an acceptable level the main risks involved in pursuing strategic objectives. This involves not only strategic but also operational risks, as well as compliance with laws and regulations and ethical standards. TNO takes the lines-of-defence model as a guiding principle in designing its risk management and control system:

- First line: controlled execution of the primary process by all TNO employees within the internally and externally defined frameworks in order to achieve the objectives concerned.
- Second line: support for, and monitoring of, the correct execution of these activities.
- Third line: internal audits of primary and secondary processes at TNO, focusing on quality, health and safety, the environment, compliance, internal financial and administrative control, and efficiency.
- Fourth line: audits by third parties, focusing on financial aspects (these to be done by the external auditor) but also on non-financial aspects. This includes quality audits of ISO certificate requirements, IT audits, Knowledge Position Audits, and inspections of compliance with laws and regulations (such as permits relating to health, safety, and the environment).

**SET-UP OF THE RISK MANAGEMENT AND CONTROL SYSTEM**

The following are the main elements of the risk management and control system:

- Culture and conduct
- Duties, responsibilities, and powers
- Planning and control cycle
- Risk management
- Audits

These elements are detailed in the appendices.

**CONCLUSION**

Based on the measures outlined in the appendix and on the audit outcomes, the Executive Board has concluded that internal-control mechanisms and risk management in the financial domain have been set up as they should be, and that they proved to be effective throughout the reporting year. There were no indications to the contrary. As far as the other aspects of operations are concerned, no evidence has emerged that these do not comply with current requirements. It should, however, be noted that risks may also occur that cannot be anticipated, and that not all inaccuracies, losses, fraud or non-compliance with laws and legislation can be ruled out.



## 2020 GAME CHANGER

## LIFESTYLE MEDICINE

Lifestyle diseases cause great suffering to patients and are financially costly for society. Preventing or curing these diseases enables many people to live a better life. And if they can do their work normally and make either little or no use of healthcare services, financial savings can also be achieved. In most cases physical activity and adjustments to diet are involved, but mental and cognitive factors also play a role.

Lifestyle4Health, an initiative of TNO and Leiden University Medical Centre, is an open national platform whose mission is to halve the lifestyle disease burden over the next 10 years. This requires a transformative shift towards self-care and control over one's own health. Through Lifestyle4Health, TNO focuses on scientific research, innovations and new business models in the context of lifestyle medicine.

[You can read more here.](#)



HEALTHY LIVING UNIT



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## A RESPONSIBLE IMPACT

Both in its operations and in terms of the substance of its research programmes, TNO is committed to operating responsibly, sustainably, and with integrity. Legal and ethical standards are embedded in codes and policies such as the TNO Code and the compliance, integrity, and CSR policies, which, taken together, constitute a clear framework for cultural and behavioural standards within TNO.

### COMPLIANCE AND INTEGRITY

#### Scientific integrity

TNO has committed itself to the Netherlands Code of Conduct for Research Integrity (NCCRI), which was implemented in 2019. In 2020, NCCRI principles and related case studies were discussed by all operational management teams at TNO. An implementation review was launched in the autumn of 2020; the results will be made known in the course of 2021.

#### General Data Protection Regulation

TNO ensures in its operations that the principles of data protection are observed. It does this through data protection impact assessments and by producing other documents that meet accountability requirements under the General Data Protection Regulation (GDPR). In addition, research involving human subjects is assessed by an ethics committee.

Data protection plays a prominent role in these assessments by the ethics committee. To raise awareness in this area, in 2020 TNO developed an e-learning tool on protecting data in research. The ongoing availability of training and workshops on compliance with the GDPR ensures that knowledge in this area is continually being enhanced and improved.

In addition, particular attention was paid in 2020 to the consequences of the Schrems II decision handed down by the European Court of Justice. In it, the Court declared the EU-US Privacy Shield invalid, and this has an impact on TNO, which uses American cloud service providers for the transfer of personal data. As a result, the agreements that TNO has with providers on data processing were amended in 2020.

TNO detected 7 data leaks in 2020, one of which it reported to the Dutch Data Protection Authority. In 2020, data subjects submitted six requests to TNO under the GDPR.

#### The Government Information (Public Access) Act

TNO's ambition is to respond in a timely fashion to all requests made under the Government Information (Public Access) Act (*Wet openbaarheid van bestuur, WOB*).

In 2020, 37 requests for access to information were made of TNO under this act, five of which were submitted to TNO directly. Thirty-two requests were for the opinion of another administrative body. All requests were addressed in accordance with statutory requirements.

In 2020, no objection was made to any primary decision by TNO, and no appeal was lodged against any TNO decision on a complaint. In 2020, three appeal cases were pending in relation to an appeal that had been lodged prior to the reporting period against a TNO decision on a complaint.

#### Export control and sanctions

TNO is determined to strictly comply with international and national legislation and regulations on the export of knowledge. Since December 2019 it has had an internal compliance programme in place on export controls. In 2020, further work was done on implementing an automated tool for use under the programme, and the programme was rolled out in six of the nine units involved. It will be rolled out in the remaining three units in the first quarter of 2021.

Cooperation with the export control departments in the Ministry of Defence was also intensified in 2020 through mutual process agreements on the application of US and other authorisations and of Dutch sanctions policy.

### Customer acceptance

In 2020 TNO adopted a customer acceptance policy. This policy covers the full range of criteria and processes for screening customers and partners with a view to ensuring that TNO cooperates with them only if doing so will not conflict with any legislation or regulations, or with any TNO or government policy. Implementing the customer acceptance policy is one of the priorities for 2021. The aim is to automate as fully as possible the processes governing the acceptance of customers.

### Research involving human subjects and animal testing

TNO's work also covers research involving human subjects, and research for which personal data is collected. Some of this research is subject to the Medical Research Involving Human Subjects Act (*Wet Medisch-wetenschappelijk Onderzoek met mensen*), and is reviewed by an external medical ethics review committee. All research that is not subject to this legislation is assessed by a TNO-wide internal-review committee, which evaluated over 130 proposals in 2020. The internal review is itself evaluated annually, and the results are reported to the Executive Board.

TNO conducts biomedical research with a view to improving human health. Its ambition is to keep animal testing to an absolute minimum. Wherever testing is unavoidable, TNO will do its utmost to carry out the research involved in a meaningful way, using as few animals and causing as little distress as possible.

### Nagoya Protocol

Some of the genetic material used by TNO for research counts as 'genetic resources' under the Nagoya Protocol<sup>1</sup>. This Protocol lays down rules for the use of genetic resources. The aim of these rules is the fair and equitable sharing of the benefits arising from use of the resources. In 2020, TNO adopted the Nagoya policy and procedure to ensure that it, TNO, takes due care in the use of genetic resources and that it complies with the conditions governing their use.

### Reports and complaints

TNO has a procedure for handling internal and external complaints and a system for addressing cases in which wrongdoing is suspected. In 2020 no complaints were submitted under the external or internal complaints procedure. Similarly, no formal reports were submitted in the context of TNO's system for addressing cases in which wrongdoing is suspected.

In a case regarding a whistle-blower statement made in 2016 under the whistle-blower regulation valid at the time, a court found in favour of TNO on all essential points. The complainant has since appealed. TNO is still awaiting a recommendation from the Dutch Whistle-blowers Authority.

### CORPORATE SOCIAL RESPONSIBILITY

In further articulating TNO's policy on corporate social responsibility (CSR) in 2020, the Executive Board took

<sup>1</sup> EU Regulation 511/2014 on compliance measures for users from the Nagoya Protocol on access to genetic resources and the fair and equitable sharing of benefits arising from their utilisation in the European Union.

a significant step in this area, and has committed itself to the national and international frameworks under the UN Global Compact (UNGC). TNO thus wants to make a concrete contribution to the United Nations Sustainable Development Goals (SDGs). A method for socially responsible procurement was also introduced in 2020.

In its operations, TNO prioritises the topics of energy and sustainability, integrity, diversity and working conditions. TNO uses an incremental improvement cycle (similar to the 'Plan-Do-Check-Act' principle) to decide on specific actions and have them carried out and adjusted by all parts of the organisation. Wherever possible, knowledge from within TNO is used. For instance, in the 'Applying Innovations' programme, TNO applies its own innovations in its operations, such as innovative solar panels at the TNO location in Petten.

TNO makes its CSR ambitions clear in the 'CSR Statement of Policy', which it updated in 2020. The results achieved in 2020 in terms of the CSR policy will be published in a separate report in June 2021, in accordance with the UNGC guidelines.

### PUBLICATION POLICY

The NCCRI prescribes that research data be made publicly available to the extent possible after the research in question has been completed. At the same time, it recognises that there are also valid reasons for not doing so, and it asks that these be recorded where that is the case.

This is in line with the 'open where possible, closed where necessary' principle. In 2020, TNO's publication policy was adjusted to ensure that information is made available in accordance with the requirements of the NCCRI. The publication policy, as adjusted, offers the greatest encouragement for the publication of scientific information, but also of underlying 'research artefacts'.

## COMPOSITION OF THE EXECUTIVE BOARD

### MEMBERS OF THE EXECUTIVE BOARD IN 2020

**Mr P. de Krom**, Chair and CEO (1963)

Since 1/3/2015

*Executive and supervisory roles:*

- Executive Board member, Federatie van Samenwerkende Organisaties in het Toegepast Onderzoek (TO2) (Federation of Organisations in Applied Research)
- Chair of the Supervisory Board, HTM Beheer B.V. until 13/10/2020
- Supervisory Board member, HTM Personenvervoer (public transport provider in the City of The Hague)
- Director, Koninklijke Hollandse Maatschappij der Wetenschappen (Royal Netherlands Society for the Sciences)
- Vice-Chair of the Supervisory Board, HU University of Applied Sciences, Utrecht
- Chair, Thorbecketafel, Sociëteit de Witte (until 17/8/2020)
- Member, Zuid-Holland Economic Board
- Chair, Holland International Distribution Council
- Supervisory Board member, PhotonDelta (until 10/6/2020)

**Mr M. G. L. H. Tossings**, COO, Rear Admiral (1962)

Since 15/3/2019

*Executive and supervisory roles:*

- Board member, The Netherlands Industries for Defence & Security (NIDV)
- Executive Committee member, Netherlands Maritime Cluster (NMC)
- Board member, *Stichting Maritiem Kenniscentrum* (MKC) (Centre for Maritime Expertise)
- Supervisory Board member, First Dutch Innovations B.V.
- Chair, Digital Task Force, Zuid-Holland Economic Board (EBZ)
- Member of the IT Advisory Council of the Judicial Institutions Department (DJI)

**Ms F. Marring**, CFO (1963)

Since 1/2/2014

*Executive and supervisory roles:*

- Board member, Stichting Pensioenfonds TNO (pension fund)
- Supervisory Director and Chair of the Audit Committee, Novec B.V.
- Board member, Nederlandse Vereniging van Financial Executives (Netherlands Society of Financial Executives)
- Supervisory Board member, Stichting Sint Antonius Ziekenhuis (hospital)
- Supervisory Board member, Stichting de Noordzee (The North Sea Foundation)

**Prof. P. J. Werkhoven**, CSO (1959)

Since 1/5/2019

*Executive and supervisory roles:*

- Professor, Utrecht University
- Board member, Top Consortium for Knowledge and Innovation, High Tech Systems and Materials
- Member, Technology and Innovation Committee, VNO-NCW (employers' organisation)
- Supervisory Board member, PhotonDelta (since 10/6/2020)
- Board member, Stichting Toekomstbeeld der Techniek (Foundation for the Future of Technology)

**Mr W. C. A. Maas**, Secretary (1967)

Since 1/1/2018

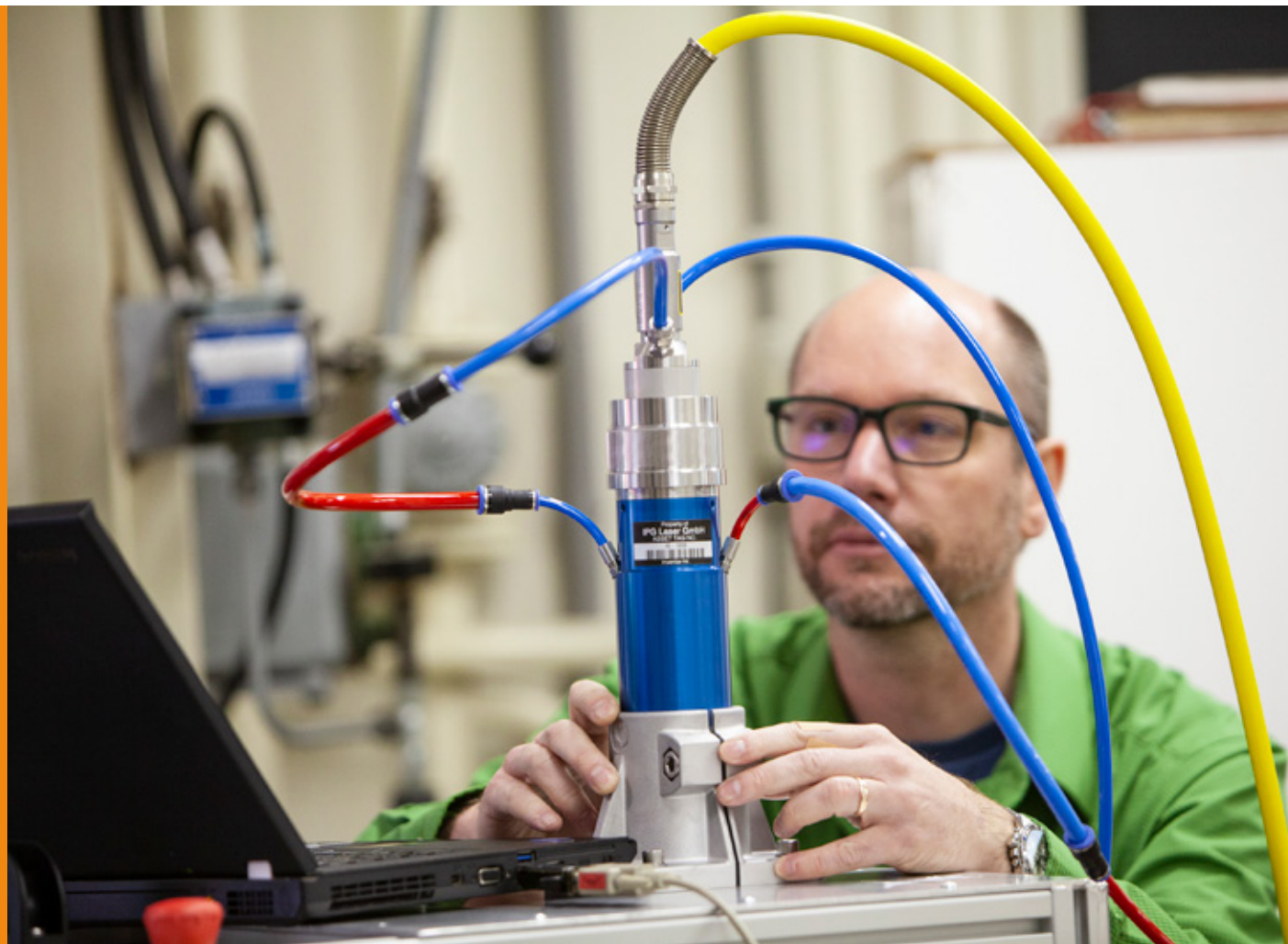
## 2020 GAME CHANGER

**LIGHT AS A DEFENCE**

Drones are everywhere these days. They are used to get awe-inspiring shots of the landscape from above for television, for example and in the future they will probably take on the job of package delivery. Still, malicious persons can cause a lot of damage with a drone, for example by mounting explosives on it. This actually happened in Saudi Arabia. But even when they're not armed, drones can cause problems. Interfering with aviation at Schiphol Airport is one example.

Several countries around the world, the Netherlands among them, are developing solutions to the drone problem. TNO is focusing on high-energy lasers that can shoot down unwanted drones at the speed of light. Researchers have already achieved promising test results in a laboratory setting. The laser can already pierce a thick steel plate in just a few seconds. With high-energy lasers, we will have a powerful weapon at our disposal in the near future that can be used on many fronts.

[You can read more here.](#)



**DEFENCE, SAFETY & SECURITY UNIT**



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## COMPOSITION OF THE SUPERVISORY BOARD

**Mr P. G. de Vries (1958)**, Chair as of 1 July  
Since 1/7/2019; first term runs up to 1/7/2024.

*Professional activities outside TNO:*

- Chair of the Supervisory Board, Erasmus University Medical Center Rotterdam
- Chair of the Supervisory Board, Arbo Unie (occupational-health service)
- Chair of the Supervisory Board, Netherlands Comprehensive Cancer Organisation (IKNL)
- Chair of the Board, Stichting Achmea Slachtoffer en Samenleving (Achmea victim and society association)
- Executive Coach, New Generation Leaders International
- Member of the Advisory Board, Erasmus Center for Leadership

**Mr P. J. M. van Laarhoven (1959)**, Vice-Chair  
Since 1/10/2016; first term runs until 1/10/2021.

*Professional activities outside TNO:*

- Chair of the Supervisory Board, CQM
- Chair of the Supervisory Board, Port of Moerdijk
- Chair of the Supervisory Board, Arnhem and Nijmegen University of Applied Sciences Foundation
- Supervisory Board member, CB Logistics
- Supervisory Board member, H&S GROUP
- Vice-Chair, the Netherlands National Commission for UNESCO

**Ms I. H. J. Vanden Berghe (1962)**  
Since 1/2/2011; second term runs until 1/2/2021.

*Professional activities outside TNO:*

- Administrator-General, National Geographic Institute
- Member, Council of Administrators-General of State-Owned Organisations
- Chair, the Belgian federal government's G-Cloud Strategic Board
- Visiting Professor, Catholic University of Leuven
- Chair of the Executive Board, Flemish institute for Technological Research (VITO)
- Member of the Management Committee, Royal Museum for Central Africa and Royal Belgian Institute of Natural Sciences
- Member of the Management Committee, Royal Meteorological Institute, Royal Institute for Space Aeronomy, and Royal Observatory of Belgium
- Co-Chair, United Nations Global Geospatial Information Management Committee of Experts

**Prof. H. Bijl (1970)**  
Since 1/9/2018; first term runs up to 1/9/2023.

*Professional activities outside TNO:*

- Vice-Rector Magnificus and Member of the Executive Board, Leiden University
- Professor of Numerical Mathematics, Mathematical Institute, Leiden University
- Executive Board member, Leiden BiosciencePark Foundation
- Chair of the Advisory Board, Airbus Defence and Space, Netherlands

**Ms J. D. Lamse-Minderhoud (1969)**

Since 1/11/2014; second term runs until 1/11/2024.

*Professional activities outside TNO:*

- Executive Board member, PricewaterhouseCoopers Netherlands (PwC)
- Member of the Executive Team, PwC Europe (until 1 July 2020)
- Supervisory Board member, Wildlife Justice Commission (as from November 2020)

**Prof. P. P. C. C. Verbeek (1970)**

Since 1/5/2012; second term runs until 1/5/2022.

*Professional activities outside TNO:*

- Professor of the Philosophy of Human-Technology Relations, University of Twente
- Co-Director, DesignLab, University of Twente
- Honorary Adjunct Professor, Aalborg University
- Chair, UNESCO World Commission on the Ethics of Science and Technology (COMEST)
- Vice-Chair of the Board, Rathenau Institute
- Member of the Board, NWO Domain Social Sciences and Humanities
- Member of the Commission, Social Sciences and Humanities Sector Plans
- Member of the Programme Board, Maatschappelijk Verantwoord Innoveren (MVI) (Socially Responsibly Innovation)
- Member, the Netherlands National Commission for UNESCO
- Member of the Committee on Freedom of Science and Technology of the Royal Netherlands Academy of Arts and Sciences
- Member, Royal Netherlands Academy of Arts and Sciences

**Ms L. Verheij van Wijk (1964)**

Since 1/10/2019; first term runs up to 1/10/2024.

*Professional activities outside TNO:*

- Member, IT & Innovation Think Tank of the Netherlands Comprehensive Cancer Organisation

**Mr W. C. A. Maas (1967), Secretary**

Since 1/1/2018

Ms Vanden Berghe is a Belgian national. The other members are Dutch nationals.

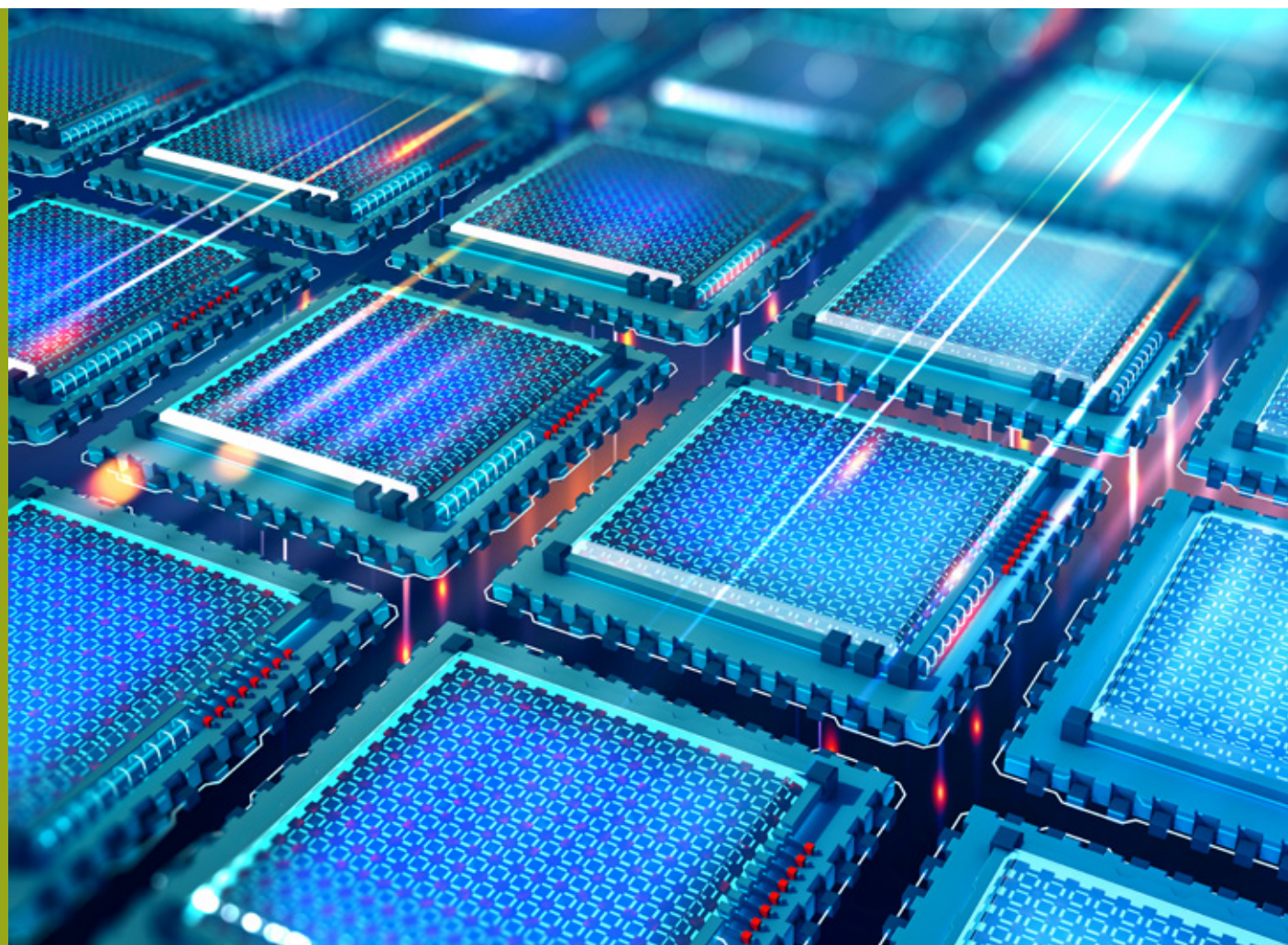
## 2020 GAME CHANGER

## QUANTUM INSPIRE

In 2020, Minister Ingrid van Engelshoven and European Commissioner Mariya Gabriel launched the first European quantum-computing platform, Quantum Inspire. It was developed in Delft by QuTech, a partnership between Delft University of Technology and TNO. A quantum computer has the potential to solve problems much faster than ordinary computers. One example is the unravelling of the complex behaviour of molecules in the development of medicines.

Quantum Inspire calculates with a quantum processor made of spin qubits. These are made the same way classic transistors are and can therefore be scaled up well. This is how TNO will make quantum technology accessible to everyone, and in the process will be building a smarter, more sustainable and safer European Union.

[You can read more here.](#)



## COMPOSITION OF THE COUNCIL FOR DEFENCE RESEARCH

**Mr M. G. L. H. Tossings**, Chair

*Outside activities*

- Board member, The Netherlands Industries for Defence & Security (NIDV)
- Executive Committee member, Netherlands Maritime Cluster (NMC)
- Board member, *Stichting Maritiem Kenniscentrum* (MKC) (Centre for Maritime Expertise)
- Supervisory Board member, First Dutch Innovations B.V.
- Chair, Digital Task Force, Zuid-Holland Economic Board (EBZ)
- Member of the IT Advisory Council of the Judicial Institutions Department (DJI)

**Mr M. Gazenbeek**, Vice-Chair

*Outside activities*

- Member of the Advisory Board, InterCoach
- Member of the Board of Directors, International Society for Military Law
- Chair, *Militaire Rechterlijke Vereniging* (Military Law Society)
- Member of the Advisory Board, Netherlands War Graves Foundation

**Ms M. J. Eijkman**, member since 16/4/2020

*Outside activity:*

- Member of the Board, Royal Institute of Engineers

**Mr H. A. H. C. van Veen**, interim member, until 16 April 2020

**Mr Major-General A. Steur**

**Mr A. P. Venema**

**Mr H. F. Bousché**, Secretary



2020 GAME CHANGER

**DEEDS**

The European Green Deal is one of the priorities of the European Commission. Its objective is to achieve a climate-neutral Europe by 2050 in a fair and equitable way. In order for this to happen, the behaviour of industry, farms, agricultural businesses, the transport sector and the energy system will have to change significantly. But that also applies to the role of government and the behaviour of citizens. Research and innovation are crucial to guiding and facilitating these technological and social changes.

That is why the international consortium DialoguE on European Decarbonisation Strategies (DEEDS) was established. Under the leadership TNO, it decides on directions for research and opportunities innovation in order to achieve a climate-neutral Europe. Businesses, governments, scientists, NGOs and other stakeholders sit down together to address the 'decarbonisation of the EU economy'. DEEDS has played a significant role in shaping Horizon Europe, the EU's new research and innovation framework programme.



 STRATEGIC ANALYSIS & POLICY UNIT



## COMPOSITION OF THE STRATEGIC ADVISORY COUNCILS

Each TNO unit has a Strategic Advisory Council (SAC) made up of representatives from business and industry, the public sector and knowledge institutions. Each council supports its units with advice on priorities, and draws attention to new developments, thus fulfilling a key role in TNO's innovation strategy. SAC members are appointed for a period that runs concurrently with the Strategic Planning period.

### BUILDINGS, INFRASTRUCTURE & MARITIME UNIT

Mr J. H. Dronkers, Ministry of Infrastructure and Water Management, Secretary-General.  
 Ms M. H. W. van Buren, Rochdale, Chair of the Executive Board  
 Mr C. F. Eggink  
 Ms T. Muusse  
 Ms C. Reiner, Uneto-VNI, Vice-Chair  
 Mr J. Roodenburg, Huisman, President  
 Mr M. R. Schurink, Ministry of the Interior and Kingdom Relations, Secretary-General  
 Mr F. Vermeulen, Delegate of the Province of South Holland  
 Prof. L. Volker, University of Twente, Faculty of Engineering Technology, Professor of Integrated Project Delivery  
 Mr R. P. van Wingerden, Executive Advisor to the National Coordinator for Groningen (NCG)

### DEFENCE, SAFETY & SECURITY UNIT

Mr Major-General A. C. J. Besselink (retired)  
 Mr R. Berkvens, Damen Shipyards, Advisor to the Executive Board  
 Mr J. C. Dicke, Ministry of Economic Affairs and Climate Policy, Commissioner for Military Production  
 Prof. P. H. A. J. M. van Gelder, Delft University of Technology, Professor of Safety Science  
 Mr C. Haarmeijer, Re-LiON, CEO  
 Ms E. G. M. Huyzer, Member, National Police Board  
 Major-General R. J. Jeulink, Ministry of Defence, Defence Staff, Deputy Commander of the Armed Forces  
 Mr G. van Klaveren  
 Mr H. J. J. Lenferink, Municipality of Leiden, Mayor  
 Mr R. Nulkes, Netherlands Industries for Defence & Security (NIDV), Director  
 Prof. P. J. Oonincx, Netherlands Defence Academy, Dean of the Faculty of Military Science

### CIRCULAR ECONOMY & ENVIRONMENT UNIT

Mr T. J. A. Wagenaar  
 Prof. L. M. C. Buydens, Radboud University Nijmegen, Institute for Molecules and Materials, Analytical Chemistry  
 Prof. S. R. A. Kersten, University of Twente, Faculty of Science and Technology  
 Mr R. P. Lapperre, Ministry of Infrastructure and Water Management, Directorate-General Environment & International Affairs  
 Ms M. Rietbergen, Design Innovation Group  
 Mr B. Rüter, Rabobank  
 Ms J. C. M. Sap  
 Mr M. Waas, Nouryon

**ENERGY TRANSITION UNIT**

Mr G. J. Lankhorst, VEMW  
 Mr J. Atema, NAM, General Director  
 Mr H. Fennema, Gasunie, CEO  
 Mr A. F. Gaastra, Ministry of Economic Affairs and Climate Policy, Director-General  
 Mr M. E. Galjee, Nouryon, Director, Energy  
 Prof. M. P. Hekkert, Utrecht University, Professor  
 Prof. P. M. Herder, Delft University of Technology, Professor  
 Prof. M. W. Hofkes, VU Amsterdam, Professor  
 Mr J. W. van Hoogstraten, EBN, CEO  
 Prof. N. J. Lopes Cardozo, Eindhoven University of Technology / Dutch Research Council (NWO) - Domain Science  
 Mr R. Miesen, NWE Generation SE, CEO  
 Ms M. Minnesma, Urgenda, General Director  
 Prof. A. Polman, Amolf/UvA, Scientific Group Leader  
 Mr Y. Sebregts, Shell Global Solutions International B.V., EVP Technology and CTO

**HEALTHY LIVING UNIT**

Prof H. A. P. Pols  
 Ms L. T. Bouwmeester  
 Ms G. M. Fijneman, Zilveren Kruis (health insurer), Chair of the Board  
 Prof A. J. van Gool, Radboud UMC, Professor of Personalized Healthcare  
 Ms A. W. M. de Groot, FNV, Director of Policy, Strategy & Lobbying  
 Ms M. E. Y. Koster, Janssen-Cilag B.V., Lead, Strategic Alliances Netherlands  
 Mr T. A. J. Oostrom, Dutch Kidney Foundation, Director  
 Mr H. Smid, ZonMW, Advisor

**INDUSTRY UNIT**

Prof E. M. Meijer, 'Standard Bearer' for the Dutch chemical industry  
 Mr P. M. T. M. van Attekum, Synovac BV  
 Prof. F. P. T. Baaijens, TU Eindhoven, Rector Magnificus  
 Prof. S. C. M. Bentvelsen, Nikhef, Director  
 Mr J. ter Harmsel, Zeton BV, Managing Director  
 Mr H. van Houten, Royal Philips, CTO  
 Prof. P. F. Levelt, Royal Netherlands Meteorological Institute, Head of R&D, Department of Satellite Observations  
 Mr P. J. Nieuwenhuizen, Enerkem, VP Strategy & Development  
 Mr P. M. Smeets, Ministry of Economic Affairs and Climate Policy, Directorate-General for Business and Innovation  
 Mr H. Tappel, Bronkhorst High-Tech B.V., General Director  
 Mr M. Wubboldts, Corbion, CTO

**INFORMATION & COMMUNICATION TECHNOLOGY UNIT**

Mr R. Penning de Vries  
 Ms S. Heukelom-Verhage, Pels Rijcken, lawyer and partner  
 Mr S. B. Luitjens  
 Mr T. D. Poelheken, Royal KPN B.V., CTO  
 Prof. M. R. van Steen, University of Twente, Scientific Director, Digital Society Institute

**STRATEGIC ANALYSIS & POLICY UNIT**

Prof. K. M. Becking, Nyenrode Business University, Chair of the Board and Rector Magnificus  
 Prof. N. M. P. Bocken, Maastricht University, Maastricht Sustainability Institute  
 Ms M. Demmers, Natuur & Milieu, Managing Director  
 Prof. J. F. T. M. van Dijk, Utrecht University, Professor of Media and Digital Society  
 Mr P. A. J. Geluk, The Boston Consulting Group  
 Prof. M. L. P. Groenleer, Tilburg University, Scientific Director, Tilburg Center for Regional Law and Governance  
 Mr R. de Jong, Retired Member, Executive Committee, Royal Philips  
 Mr R. Zonneveld, InnovationQuarter, Director

**TRAFFIC & TRANSPORT UNIT**

Mr M. B. Unck, RET NV, CEO  
 Mr F. van Bruggen, ANWB, Managing Director  
 Ms S. M. Dekker, Minister of State  
 Prof. G. Odekerken-Schröder, Maastricht University, Professor of Customer-Centric Services Science  
 Mr R. Paul, Chair, Board of Supervisors, Portbase  
 Mr B. Schultze, Royal IHC, Managing Director  
 Mr A. Toet, Sequel Work, strategic advisor  
 Mr G. Veenstra, Keolis Nederland, Head of Corporate Affairs

2020 GAME CHANGER

CARE FOR DATA

In recent years, eHealth – using IT to facilitate remote healthcare – has been on the rise. In theory, this has major advantages for doctor and patient alike: it saves time, it gives the patient insights into their own health, and it costs less. Yet the effectiveness of eHealth solutions is usually difficult to demonstrate. This is primarily because of privacy laws. In principle, patient data may not be shared by parties in the healthcare sector, and that makes it difficult to measure effects.

The TNO CareForData project originates from the idea of value-based care: delivering the right healthcare in the right place. In order for that to be delivered, personal and medical information is required. Using Secure Multi-Party Computation (SMPC) data-encryption technology allows parties to share data securely and anonymously. This way, innovations will reach the market faster, thus bringing personalised care one step closer.



 INFORMATION & COMMUNICATION TECHNOLOGY UNIT



REPORT OF THE EXECUTIVE BOARD

STRATEGY

REPORT OF THE COUNCIL FOR DEFENCE RESEARCH

REPORT OF THE SUPERVISORY BOARD

RISK MANAGEMENT AND CONTROL SYSTEM

A RESPONSIBLE IMPACT

FINANCES

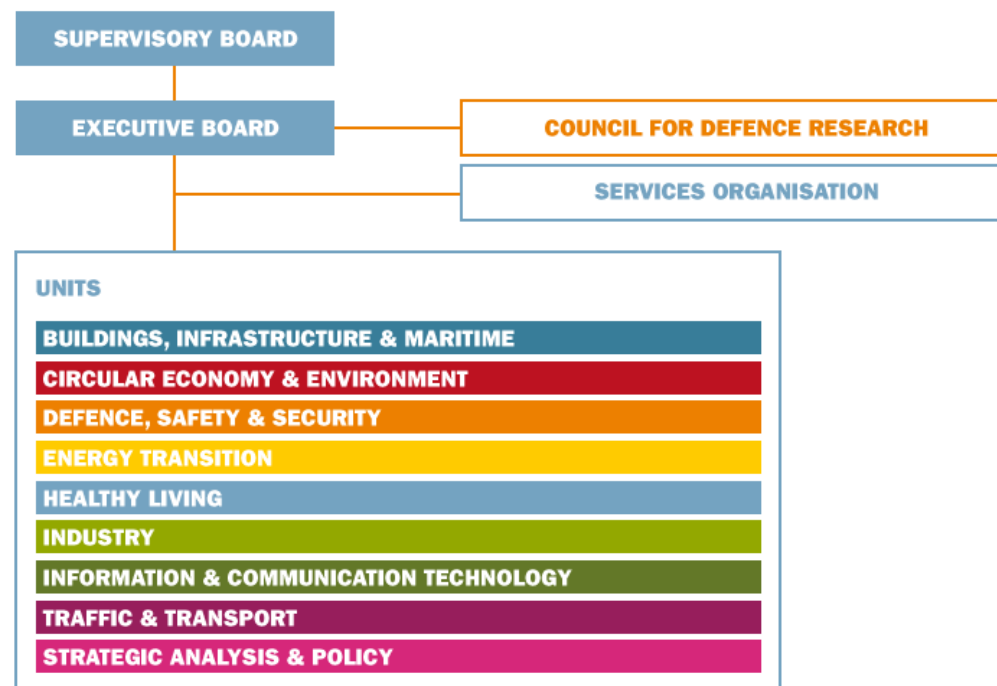
APPENDICES

## TNO ORGANISATION

As this chart shows, the core of TNO comprises nine units.

The Managing Directors of these units report to the Executive Board. The Executive Board and the units are supported by the Services Organisation. The Executive Board reports to the Supervisory Board.

The Defence Research Council has specific legally defined powers with respect to the Defence & Security unit.



# TNO: KEY FIGURES

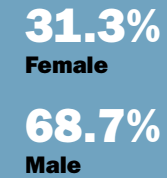
## NUMBER OF EMPLOYEES AS AT 31 DECEMBER



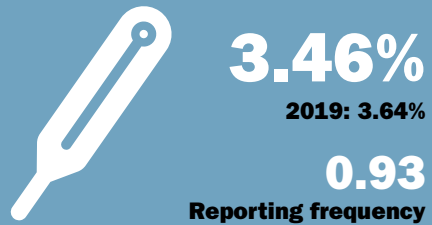
## NATIONALITY



## GENDER RATIO ALL OF TNO



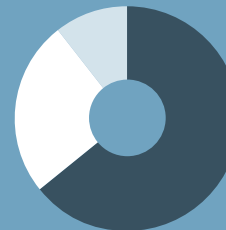
## SICK LEAVE



## FULL TIME/PART TIME

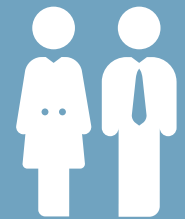
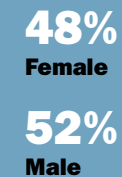
**11.06%** Part time 90% - 100%

**20.89%**  
Part time  
< 90%



**68.05%**  
Full time

## GENDER RATIO TNO SENIOR MANAGEMENT (EB, SB AND 1<sup>ST</sup> ECHELON)



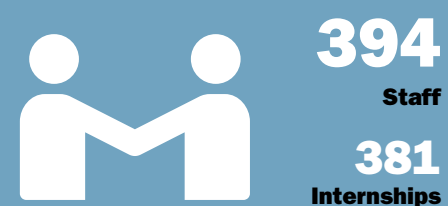
## EMPLOYEE ENGAGEMENT



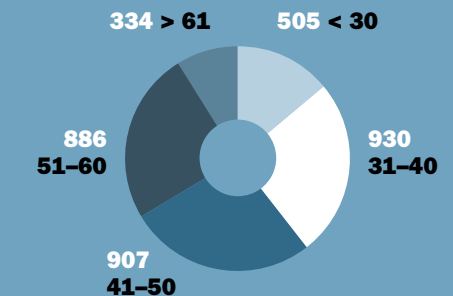
## CONTRACT



## RECRUITMENT NEW HIRES IN 2020



## BREAKDOWN BY AGE



# TNO: KEY FIGURES



	2020	2019	
STATE FUNDING	258.8	242.6	+ 6.7% ↑
MARKET REVENUE	281.3	291.9	- 3.6% ↓
TOTAL	540.1	534.5	+ 1.0% ↑

## PATENTS

### Active patents



**880** -2.5% ↓  
2019: 903

### First filing\*

\*First filing of a patent application on a specific date.



**91** +7.1% ↑  
2019: 85

## PROFESSORS AND LECTURERS



**65** +12.1% ↑  
2019: 58



## FINANCIAL INDICATORS

(in millions of EUR)	2020	2019	2018
<b>TNO consolidated result</b>			
<b>Operating income</b>	553.5	553.9	504.9
revenue	541.0	534.7	483.0
other operating income	12.5	19.2	21.9
<b>Revenue breakdown</b>			
Market revenue	282.2	292.1	266.7
State funding	258.8	242.6	216.3
<b>Costs</b>			
<b>Operating expenses</b>	540.7	537.7	497.9
personnel costs	356.5	340.2	313.2
impairments	4.7	1.7	-
<b>Net income</b>			
<b>Net income</b>	<b>65.6</b>	<b>15.4</b>	<b>1.0</b>
result from participating interests	52.0	3.6	-3.9
<b>Cash flow for the financial year</b>			
	105.3	5.8	55.6
<b>Capital</b>			
Operating capital invested <sup>1</sup>	361.3	297.9	284.7
Equity	328.9	263.3	247.9
Solvency ratio <sup>2</sup>	54%	53%	51%
<b>Assets</b>			
Tangible fixed assets	204.7	192.5	181.2
Investments in tangible fixed assets	46.3	42.3	37.5

<sup>1</sup> Invested operating capital = total balance sheet – current liabilities

<sup>2</sup> Solvency ratio = equity divided by total capital

	2020	2019	2018
<b>Employees</b>			
Number of TNO employees (average FTEs)	3,243	3,079	2,860
Number of FTEs at year's end	3,263	3,173	2,900
Number of group company employees (average effective)	3	2	5
Number of group company employees (effective as at year's end)	3	2	5
Number of FTEs at year's end	3,266	3,175	2,905
Average number of FTEs	3,246	3,081	2,865



## FINANCES AT A GLANCE

### NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS

#### Result

TNO achieved a positive result of EUR 14.4 million (excluding participating interests).

TNO was largely able to continue its work during the coronavirus crisis because of a healthy level of work in progress at the start of the crisis, and because of a virtually problem-free switch to remote working. Losses were incurred because of projects that had to be abandoned or postponed because of the need for the physical presence of project staff and for project-related provisions. Another factor was the possibility that was offered to employees to take special leave when their home situation required it.

However, these losses were offset by a number of gains. For example, there was a higher attendance rate among staff, with lower levels of sickness and less leave. Travel and accommodation costs were also significantly lower than usual. In addition, at the end of 2019 and the beginning of 2020, TNO's workforce grew by approximately 100 FTEs because of the large workload and favourable developments in order intake. It thus became possible to generate more revenue. This combination of factors led to a positive result, not counting participating interests, of EUR 14.4 million.

Operating expenses include one-off costs related to an addition to other provisions (including an onerous lease contract), downward value adjustments to assets (including those under construction, and an impairment) and other items totalling approximately EUR 12 million. In addition, in 2020, the opening balance sheet for corporate income tax determined by the Tax Authorities as of 1 January 2016 (in respect of the returns for the period from 2016 to 2019) yielded a positive result of approximately EUR 5 million.

[Click here for the 2020 financial statements.](#)

A gain of EUR 51.1 million was realised on participating interests. This includes an exceptional one-off result of EUR 51.4 million from the sale of some businesses by the joint-venture company First Dutch Innovations B.V.

In accordance with instructions from the Ministry of Economic Affairs and Climate Policy, these funds will be used within TNO in the coming years for such purposes as strategic partnerships, investments in innovative facilities and the Technology Transfer Programme.

There is no room for necessary investments of this kind in TNO's regular funding instruments.

### NOTES TO THE FINANCIAL STATEMENTS

#### Revenue

Revenue rose from EUR 534.6 million in 2019 to EUR 540.1 million in 2020. The increase in revenue from state funding of EUR 16.1 million in 2020 – as a result of the final tranche of additional investments by the Cabinet in applied research – was offset by a decrease in market revenue of EUR 10.6 million. Within the market revenue, assignments for businesses in the Netherlands and assignments from businesses in other countries decreased by more than EUR 20 million. This was partly a result of the coronavirus, and was partially offset by a EUR 10 million increase in revenue from government contracts. Revenue from international organisations in 2020 remained virtually unchanged from 2019.

The ratio of public funding to market sales in 2020 was EUR 1.00 to EUR 1.09 (2019: EUR 1.00 to EUR 1.20).

EUR 0.04 of this movement is due to the decrease in market revenue, while EUR 0.07 is due to the increase in state funding.

### Work in progress

The total value of work in progress at the end of the reporting year amounted to EUR 371 million, as against EUR 436 million at the end of 2019. As a result of market conditions, one unit was partly reorganised in 2020.

### Other operating income

Other operating income fell by EUR 6.1 million to EUR 12.4 million in 2020. In 2019, other operating income included incidental revenue of EUR 6 million, of which EUR 3 million was from licences and patents, and EUR 3 million was from property sales, neither of which took place in 2020.

### Operating expenses

The change in operating expenses was affected in part by the increase in staffing levels on the one hand and the coronavirus crisis on the other.

Staff costs increased by EUR 16.3 million over the 2019 figure, to EUR 356.1 million. In 2020, EUR 20.5 million more than the year before went to higher wages and salaries, including for pension and social insurance contributions, as well as for changes in staff provisions. This rise is related, on the one hand, to the increase in staffing levels in 2020 and, on the other, to the organic salary increase of 2.7% as of 1 January 2020. Other staff costs fell by EUR 4.2 million, of which EUR 1.8 million was attributable to lower temporary staffing costs, and EUR 1 million in lower costs for canteens and vending machines.

At EUR 94.8 million, other operating expenses are, broadly speaking, similar to those for 2019. That said, taken together, accommodation and energy costs, materials, technical equipment, outsourced work and other expenses went up by EUR 8.3 million, of which EUR 2.1 million was related to a provision for an onerous lease. This was offset by a decrease

of EUR 6.6 million in general operating expenses, within which – partly as a result of the coronavirus crisis – travel and accommodation costs and costs for symposia and congresses in particular were EUR 4.6 million lower than in 2019.

Direct project costs dropped from EUR 80.2 million in 2019 to EUR 60.7 million in 2020, thanks mainly to EUR 8.4 million less in project costs for outsourced work, a EUR 5.1 million drop in project costs for materials, and EUR 5.1 million less in project-related travel and accommodation costs as a result of the coronavirus crisis.

In 2020, depreciation charges increased by EUR 3.9 million to EUR 27.7 million. The depreciation charges include impairment losses amounting to EUR 4.7 million (as against EUR 1.7 million in 2019). Of this, EUR 2.2 million is the result of an impairment test carried out at one of the cash-generating units.

### Taxation

In 2020, an agreement was reached with the Tax Authorities regarding the fiscal opening balance sheet as of 1 January 2016 for the purposes of corporate income tax. Subsequently, corporate income tax returns for 2016 to 2018 were filed and have now been finalised. The corporate income tax return for 2019 return has not yet been finalised. The taxes in the profit-and-loss account are EUR 3 million positive and consist of the following items:

- The subsequent settlements amount to EUR 5.1 million positive over the period from 2016 to 2019 as a result of the final determination of the fiscal opening balance sheet;
- The current tax liability of EUR 1.7 million for 2020;
- the movement in the deferred tax receivable of EUR 0.4 million.

### Equity

TNO's equity totals EUR 328.9 million, EUR 132.9 million of which is related to its projects for the Ministry of Defence.

The reserve earmarked for defence-related projects came to EUR 28.8 million at the end of 2020, an increase of EUR 10.8 million over the year-end figure for 2019 of EUR 18 million. This movement concerns the balance from defence-related investments of EUR 2.4 million, and allocations to the earmarked reserve of EUR 13.2 million.

The statutory reserve rose by EUR 15.4 million in 2020 to EUR 18.0 million by year's end. The statutory reserve represents the non-distributable profits relating to investments in group companies.

Taken together, the above movements and the positive result of EUR 65.6 million lead to a EUR 52.2 million increase in the amount of the general reserve.

In the general reserve, EUR 107 million was earmarked for strategic alliances, technology transfer, and innovative investments in facilities that are considered necessary to carry out TNO's innovative research but for which the payback potential is limited, given the experimental nature of the facilities.

### Liquid assets

The balance of liquid assets at the end of 2020 was EUR 226.0 million (as against EUR 168.1 million at the end of 2019). The increase in cash and cash equivalents in 2020 was EUR 57.9 million – the sum of various items that are explained in more detail below, particularly improvements in the working capital position.

Tangible fixed assets were up EUR 12.5 million. Investments exceeded depreciation by EUR 16.5 million. Of the increase, EUR 17 million is from the investment in new construction in Petten. This is offset by divestments of EUR 4 million.

The working capital position improved by EUR 55.9 million. Of this, EUR 21.7 million was related to an increase in the amount of advance payments that were received related projects in progress, while EUR 31.7 million was related to increases in other amounts received in advance, and to other liabilities.

The positive result for 2020 of EUR 14.4 million and other balance sheet movements totalling EUR 0.1 million contributed EUR 14.5 million to the increase in liquid assets.

An amount of EUR 83.2 million in liquid assets was reserved for the settlement of funds received in advance in the context of the coordinated partnerships on the one hand and, on the other, for government funding yet to be spent. An amount of EUR 28.8 million in liquid assets was also set aside for future investments in defence-related real estate.

The investment budgets released for 2021 come to about EUR 68 million. Taking into account the funds from depreciation, this is expected to result in an additional outgoing cash flow of EUR 44 million in 2021.

Shortly after the start of the coronavirus crisis, TNO shifted the payment terms for purchase invoices from '30 days' to 'immediately after approval of the invoice'.

### Solvency ratio

The solvency ratio was, as expected, up on the previous year, rising from 53% at the end of 2019 to 54% a year later.

### Number of employees

In 2020, the average number of FTEs went up by 164, from 3,079 in 2019 to 3,243.

# APPENDICES

**TNO** innovation  
for life



REPORT OF THE  
EXECUTIVE BOARD

STRATEGY

REPORT OF THE COUNCIL  
FOR DEFENCE RESEARCH

REPORT OF THE  
SUPERVISORY BOARD

RISK MANAGEMENT  
AND CONTROL SYSTEM

A RESPONSIBLE  
IMPACT

FINANCES

APPENDICES

## APPENDIX: CORPORATE GOVERNANCE

### STANDARDS FOR GOVERNANCE AND OVERSIGHT

TNO, the Netherlands Organisation for Applied Scientific Research, was founded by law in 1932. For close on 90 years, TNO has been connecting people and knowledge to create innovations that boost companies' competitiveness and increase wellbeing across society in a sustainable way.

Corporate governance is a set of rules, standards and institutions for the administrative set-up of the organisation, intended to ensure adequately supervised ethical, responsible and transparent operations.

The corporate governance set-up is based on the TNO Act. TNO is also governed by the Code of Conduct for Applied Research Organisations (*Gedragsregels voor TO2-organisaties*), which are included in the Dutch government's 'Vision for Applied Research' (*Visie op toegepast onderzoek*), and by the 'Common System of Standards for Financial Management and Oversight of Semi-Public Institutions' (*Gemeenschappelijk normenkader voor financieel beheer en het toezicht semipublieke instellingen*).

TNO is an organisation under public law. TNO is committed to adhering to the governance code for companies (2016 Corporate Governance Code) and governance code for public sector organisations (2015 Governance Code for Public Service Providers (*2015 Code Goed Bestuur Publieke Dienstverleners*)), even if TNO is not legally required to adhere to these codes.

The rules of procedure for TNO, the Executive Board, the Supervisory Board, the CDR, the SABs, and the Works Council comprise TNO's organisational regulations along with the Mandate Regulation. These regulations stipulate mutual responsibilities as well as powers and obligations. The Mandate Regulation gives a precise indication of the powers granted

within the organisation. A system of internal mechanisms for advice and approvals ensures adequate checks and balances as part of careful preparations for decision-making.

### EXECUTIVE BOARD

The Chair and members of the Executive Board are appointed by the Crown. They are remunerated in compliance with the Senior Executives in the Public and Semi-Public Sector (Standards for Remuneration) Act (*Wet normering bezoldiging topfunctionarissen publieke en semipublieke sector, WNT*).

The Executive Board is responsible for governing TNO: for defining objectives, policy and strategy, for implementing these, and for the ensuing results. As required under the TNO Act, the Executive Board applies a peer management system.

### THE SUPERVISORY BOARD

The Chair and the members of the Supervisory Board are appointed by the Crown for a term of five years. Members can be reappointed for one further term. They are remunerated in line with the Senior Executives in the Public and Semi-Public Sector (Standards for Remuneration) Act.

The Supervisory Board is responsible for overseeing the Executive Board's policy and its implementation, and for supporting it in an advisory capacity. Its supervisory role primarily covers risk management and compliance, but it also monitors performance against objectives and Key Performance Indicators (KPIs); the strategy; the annual plan, including a plan for investments; financial reporting, and compliance with laws and regulations. The TNO Act specifies the decisions for which the Executive Board needs the Supervisory Board's approval or consent.

### COUNCIL FOR DEFENCE RESEARCH

The policy pursued with respect to TNO's research for the Dutch Ministry of Defence is, under the TNO Act, the responsibility of the Council for Defence Research (CDR). The Chair of the CDR is appointed by the Crown at the recommendation of the Minister of Defence, and is also a member of the Executive Board.

To be effective, the Dutch armed forces must continually innovate their military capabilities to stay ahead of actual or potential adversaries. That calls for scientific support in a large number of knowledge and technology domains. Part of the knowledge required is so specific to defence matters that the Ministry of Defence has to develop it itself, and this is where its strategic partnership with TNO comes in. Since as far back as 1947, TNO has handled the majority of applied scientific defence research in the Netherlands, working in close cooperation with the Ministry of Defence, with business and with other knowledge institutions. In this regard, defence and a safe and secure society comprise a closely interconnected ecosystem. The fact that TNO also works for other clients in the defence, safety and security domain broadens and deepens the defence knowledge base and keeps it affordable for the Ministry of Defence.

### EMPLOYEE PARTICIPATION

Employee participation at TNO takes the form of the Works Council and Unit Committees. Members of the Works Council are elected by the employees of TNO. The Works Council debates all matters relevant to employees in general and to TNO as an organisation, and submits recommendations, both solicited and otherwise, to the Executive Board.

There are also Unit Committees for each unit. The unit's Managing Director has regular meetings with the Unit Committee for their unit to discuss matters related to it. There is also a Unit Committee for the Services Organisation.

### STRATEGIC ADVISORY COUNCILS

A SAC is made up of leading individuals from across business and industry, the public sector, and knowledge organisations. These members are appointed by the Executive Board for a term that runs concurrently with that of the Strategic Plan.

The SACs have an advisory role to play with regard to setting priorities generally and to selecting research priorities and programmes in the field the unit in question covers. They identify external developments in the field the unit covers, and share these with the board of the unit.

Each SAC meets at least twice a year, and their meetings are attended by a member of the Executive Board. The Chairs of the SACs are invited at least once a year for strategic deliberations by the Executive Board.

### DIRECT TNO SUBSIDIARIES

TNO has transferred its participating interests to three holding companies: TNO Tech Transfer Holding B.V., TNO Affiliates Holding B.V. and TNO International Holding B.V.

TNO Tech Transfer Holding B.V. is a venture capital company that administers shares – often minority stakes – in spin-off companies. This includes the participating interests of First

Dutch Innovations B.V. Creating a spin-off is a business transaction in which TNO pursues equality and transparency. TNO is not involved in the day-to-day operations of the interests it has transferred to TNO Tech Transfer Holding B.V. Aside from that, TNO enters into agreements with these spin-offs on market terms, such as the leasing of TNO facilities or the provision of a licence to intellectual-property rights owned by TNO, such as patents and know-how. An exit policy also applies to these participating interests, focused on the divestiture by TNO of its remaining shareholdings in the medium term.

TNO Affiliates Holding B.V. holds shares in other Dutch entities that are not TNO spin-offs. For reasons related to transparency, taxation, or cooperation with third parties, these entities are kept at arm's length from TNO. TNO is generally more actively involved in these entities than it is in participating interests that are held by TNO Tech Transfer Holding B.V. Moreover, no exit policy applies to these entities.

TNO International Holding B.V. holds shares and similar stakes in TNO's branch offices outside the Netherlands. These branch offices were set up for reasons related to transparency, taxation and risk management.

## APPENDIX: RISK MANAGEMENT AND CONTROL SYSTEM

### CULTURE AND CONDUCT

In TNO's Strategic Plan, the organisational culture and conduct hinge on four core values: integrity, independence, professionalism, and social commitment. Various tools are used to actively encourage the target behaviour, including the TNO Code, the system for addressing cases in which wrongdoing is suspected, the integrity policy and the integrity officer, the central compliance function, the complaints handling scheme, the policy on outside activities, the Netherlands Code of Conduct for Scientific Integrity (*Nederlandse gedragscode wetenschappelijke integriteit*), the data protection policy, and the agency policy. The TNO Code puts into operation a number of important core values for ethical behaviour. Every TNO employee confirms that they will comply with the TNO Code upon commencement of employment, and will be asked to take regular note of it and of any changes to it.

### DUTIES, RESPONSIBILITIES AND POWERS

The Executive Board's management practice consists of defining strategic, policy and organisational frameworks and decision-making (Strategy & Policy). These include financial frameworks and budget allocations, the formulation and implementation of the annual plan and budget, the setting of policy and frameworks, the TNO strategy, and the development of knowledge across TNO.

Together with their respective teams, which bring together a focus on markets, implementation and knowledge, the Managing Director of each unit is responsible for implementing the TNO strategy and for carrying out its annual plan and budget. The units have operational responsibility for developing and managing knowledge, as well as for market development, order intake, commercialisation of intellectual property, and operational efficiency.

The Managing Directors of the Services Organisation are responsible for the functioning of TNO-wide processes and systems. The Services Organisation supports the Executive Board and the management of the various units.

### PLANNING AND CONTROL CYCLE

Every year, TNO makes an annual plan and sets a budget for the year, in keeping with the Strategic Plan. Progress is monitored partly on the basis of KPIs. Each month, a unit's results for the preceding month are discussed by its Managing Director and the Controller, as well as by the COO and the CFO. Three times a year, each unit's management team and the Executive Board hold a business review on the basis of milestones and KPIs, during which progress is assessed and any necessary adjustments are made. This review includes a progress report that covers the key risks and measures, which are linked to the strategic and other objectives of both the unit and the Services Organisation.

### RISK MANAGEMENT

TNO's risk management policy covers both the identification of the main financial and other risks regarding the achievement of TNO's objectives, and the controlled execution of operations across all layers of the TNO organisation.

### IMPROVEMENTS IN 2020: INTERNAL CONTROL FRAMEWORK

In 2020, work continued on implementing and strengthening the Internal Control Framework (ICF), which was started in 2019, and which is intended to provide comprehensive insights into the main risks, the controls associated with them, and to how these are documented. In this context, 'comprehensive' means that all kinds of key risks – strategic, operational, compliance-related, and financial – are assessed in their interrelationships across the entire TNO organisation. This also brings into focus any potential issues that may have escaped attention. The ICF also, and for the first time, establishes a link between the risks assessed and the risk appetite that the Executive Board articulated in 2020. Finally, the ICF is intended as a verifiable substantiation of risk-control efforts, so that an in-control statement can be issued.

In 2020, the focus was once again on risks and controls related to finance.

The compliance programme is an integrated part of the ICF. In 2020, an action plan was adopted for this programme. It also provides a good overall view of compliance-related risks, other than those related to finance, that might affect the licence to operate. The action plan assigns duties and responsibilities in the second line of defence, while also ensuring compliance with

laws, regulations, and ethical standards by setting up a centralised compliance function. This function is intended to identify and raise any concerns with compliance, suggest frameworks for compliance and monitor progress in implementing policy.

In 2020, six of the nine TNO units were brought under the Internal Compliance Programme for Export Control with regard to compliance with international sanctions and export control laws and regulations. This means that in these units, the screening of external parties and the classification of products and services take place via an automated tool. Quality assurance around these laws and regulations improved, and included a full *audit trail*. This will help ensure that decisions are well-founded and verifiable when it comes to applying for the required permits. The remaining units will follow suit in 2021.

In the area of IT, risks were differentiated in terms of the availability, reliability, and integrity of systems and data. Control measures that are deemed necessary are detailed in various security guidelines, and include data and document classification and compartmentalisation, the separation of functions with layered roles and rights, and the monitoring of compliance with agreed procedures. TNO has organised the security of its systems and data in line with the principles of ISO 27001. These security measures include data-processing agreements with providers of externally procured IT solutions. These agreements are audited by an external party, which, among other things, carries out an ISAE 3402 audit. In addition, TNO's external auditor audits relevant systems for information security as part of the overall audit of the financial statements. This includes general application controls, such as the automated separation of functions and access to systems.

## Finances

Target	Key risks	Key controls
Reliable and healthy finances	Unreliable control information	<ol style="list-style-type: none"> <li>1. Planning and control cycle: budget instructions (kaderbrief) bottom-up budget process, adoption of budget, adoption of annual plan, monthly reporting, monthly review, and forecasting</li> <li>2. Description of the financial model, definition of target values, translation of target values for the various units, follow-up on improvement plans, and inclusion of these in the budget</li> </ol>
	Inadequate financial accountability	Process-based and data-driven checks to guarantee accuracy, timeliness and completeness of financial data reported
	Inappropriate use of public funds	<ol style="list-style-type: none"> <li>1. Predefined process within the Knowledge Procedure</li> <li>2. Formulating Knowledge Plans for projects paid for entirely through state funding</li> <li>3. The use of state funding in mixed funding is scrutinised by an internal committee (Interne Beoordelingscommissie)</li> <li>4. The monitoring of projects with regard to time, content, and money</li> <li>5. End-of-year review by Corporate Control of the use of state funding in mixed funding</li> </ol>
	Non-compliance with tax legislation	Tax Control Framework
	Insufficient insurance coverage	Risks are identified and insured in consultation with the insurer
	Non-compliance with European tendering rules	<ol style="list-style-type: none"> <li>1. Capacity planning for the procurement department</li> <li>2. Spend analysis</li> <li>3. Tender reporting</li> </ol>



An Information Security Management System (ISMS) was implemented in 2020. A number of pilot controls with assessment workflows were activated in the fourth quarter of 2020. The ISMS is used to monitor IT risks and to gain insights into the effectiveness of control measures.

**POINTS OF EMPHASIS FOR 2021**

The emphasis for 2021 is on strengthening TNO's ICF and the resulting risk management policy among other things by implementing the concept of risk appetite on a larger scale within the organisation. In 2021, the focus will be put more fully on those elements of the ICF that have received less attention so far, such as other business support functions and topics that are pertinent to the primary process from operational and other standpoints.

To complement the ICF, a more top-down and strategic approach will be taken for the TNO-wide risk analysis as it existed until 2020. The implementation of the compliance organisation – as set out in the above-mentioned plan of action – will take further shape in 2021, thus enabling an in-control statement on this aspect.

In 2021, the ISMS will be expanded, and controls and management measures relevant to IT operations will be put into operation. This will then make it possible to have an in-control statement on this aspect.

**AUDITS**

The Operational Excellence & Auditing department conducts internal operational and financial audits. The Supervisory Board signed off on a three-year cycle for implementation of the auditing plan, which is based on the risk analysis and process descriptions across TNO in the TNO management system. Audit reports are discussed with the Executive Board and fed back to the Supervisory Board's Audit Committee. The outcomes and recommendations serve as input for various improvement processes. In addition, within the expertise groups, Knowledge Position Audits take place periodically in each of TNO's areas of expertise. These are conducted by committees made up of certified experts, who assess the quality and societal relevance of TNO's knowledge base.

TNO is audited annually by various external bodies. The most important are the following:

- TNO's management system, under ISO 9001, is audited by Det Norkse Veritas GL.
- The financial statements and approximately 150 grant projects are audited by an external auditor.
- Compliance with security legislation and regulations is audited by the Dutch Military Intelligence Service (MIDV) and the Dutch General Intelligence and Security Service (AIVD).
- Compliance with working conditions and environmental legislation and regulations is audited by Dutch Customs and the competent authority within one and another permit-issuing authority.
- Quality audits of laboratories in the context of Good Laboratory Practice and ISO standardisation. The results of these external audits do not relate to any material findings.

Any recommendations made based on audit outcomes are implemented.



## › PUBLICATION DETAILS

› If you want to find out more about TNO or have questions after reading this report or any ideas you would like to share, please contact us:  
[info@tno.nl](mailto:info@tno.nl).

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