Connecting Science and Society

NWO strategy 2019-2022

Netherlands Organisation for Scientific Research

Connecting Science and Society

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Foreword

Connecting science and society is one of the focal points in the vision of NWO. Knowledge from scientific research forms the breeding ground for the societal and economic innovation that is necessary for the well-being of Dutch society. NWO facilitates scientific research on the basis of competition for the best proposals as a supplement to the basic funding for universities and universities of applied sciences. As such, NWO contributes to Dutch science belonging to the world top, being closely connected with society and industry, and being a breeding ground for talent.

On 1 January 2017, a new NWO came into being. The internal organisation of NWO has been considerably simplified to facilitate research programming and multidisciplinary collaboration that overarch the NWO organisational units ('domains'). As such, NWO is optimally equipped to respond more flexibly to scientific and societal developments, and to strengthen the impact of scientific research. A new executive board has been appointed and new managers are heading up the NWO domains and the institutes organisation.

This new NWO presents the strategic plan for the period 2019-2022.
This plan was realised following consultations with many external parties.
I would therefore like to thank everybody for their contribution.

This strategic plan describes NWO's ambitions. It forms the basis for each NWO domain and institute to elaborate and deepen its own programming. That will allow each domain and institute to optimally focus on the specific needs and wishes of the scientific field it represents so that a maximum impact can be realised for science and society.

NWO will focus more than ever before on connecting. We do not merely facilitate science with funding for the best researchers and for the most challenging scientific infrastructure, but we also connect researchers in the Dutch science landscape with societal partners. Besides curiosity-driven research, NWO wants to facilitate research into the themes that are important for Dutch society. We will do that together with all other parties in the knowledge chain of fundamental, applied and practice-oriented research and across all disciplines. Hence the title of the strategic plan: connecting science and society.

Stan Gielen, on behalf of the NWO executive board

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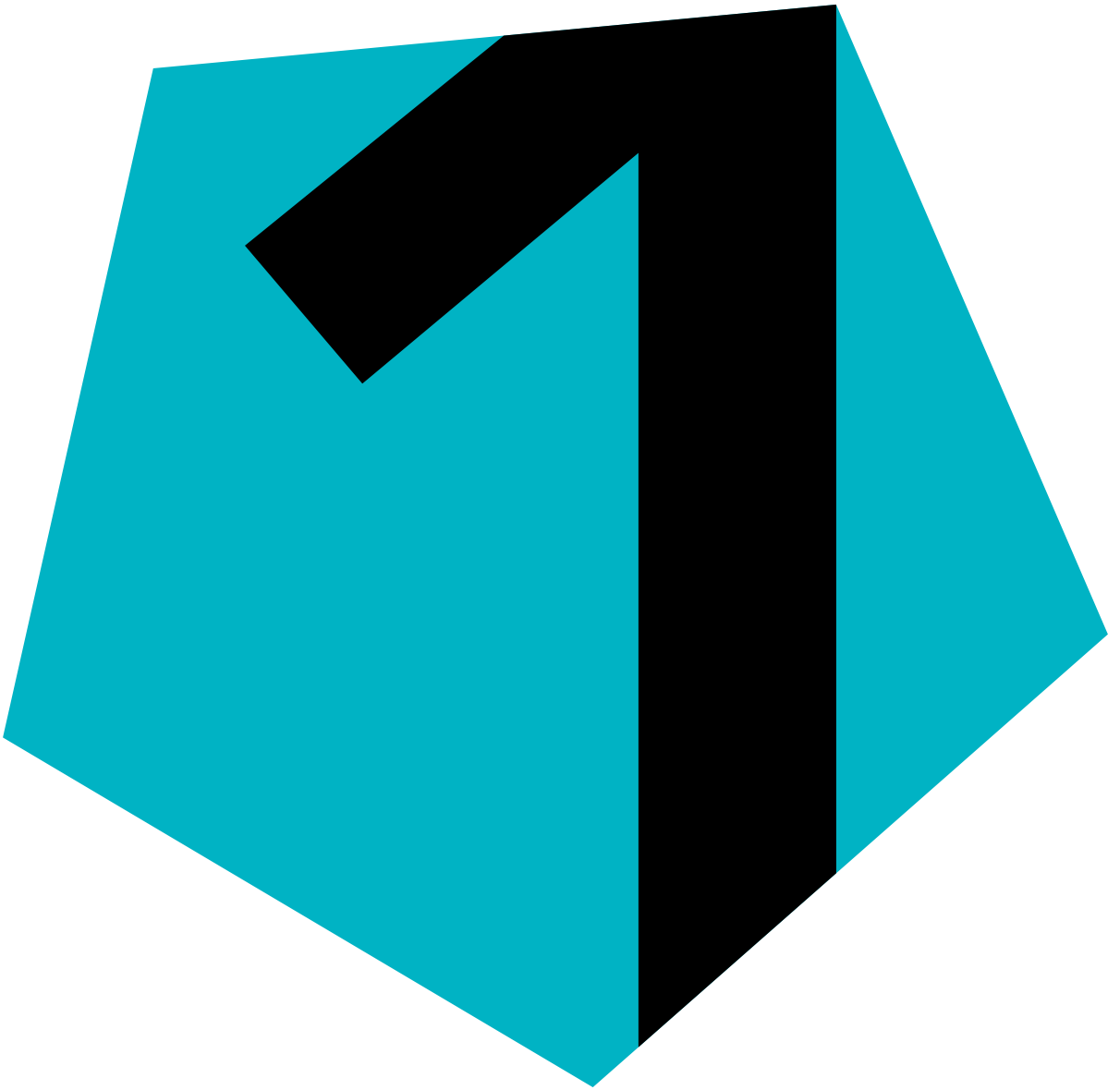


1 Introduction Dutch Research and NWO

Dutch research is highly regarded and effective. The Netherlands wishes to maintain and strengthen this leading position. In 2017, NWO started a transition towards a single coherent organisation, which ensures a coherent programming and approach to tackling societal challenges. To achieve this, NWO works as single organisation in which research domains, initiatives and institutes give shape to one and the same strategy. The NWO organisation is therefore optimally equipped to realise this strategic plan.

Knowledge and skills are valuable

Scientific research increases our understanding of the world. Science inspires, innovates and can offer solutions for problems. Scientific research generates new, reliable knowledge and contributes to the quality of society. Science also forms the basis for education and ensures that skills such as a problem-solving ability and creative thinking can be developed. Carrying out research, training and cherishing talent, and developing and maintaining research facilities give the Netherlands the ability to absorb and apply knowledge developed in the Netherlands and beyond. Knowledge from scientific research and newly developed skills can be regarded as the breeding ground for the societal and economic innovation needed for the well-being of Dutch society.

Dutch research is highly regarded

Dutch research enjoys a considerable reputation worldwide. That is apparent from the scientific impact of publications from Dutch researchers, the position of Dutch universities in international rankings, and the success in acquiring European funding for scientific research. Dutch science is well embedded internationally and succeeds in training and attracting talented researchers. The contribution of Dutch research to tackling societal challenges is also significant. That is clear from, amongst other things, the public-private partnerships in research programmes of the top sectors and from the substantial contribution

of Dutch researchers to Horizon2020, the European programmes focused on major societal challenges. In addition, for many years, the Netherlands has scored high on the European Innovation Scoreboard of the European Commission.

Effective science system

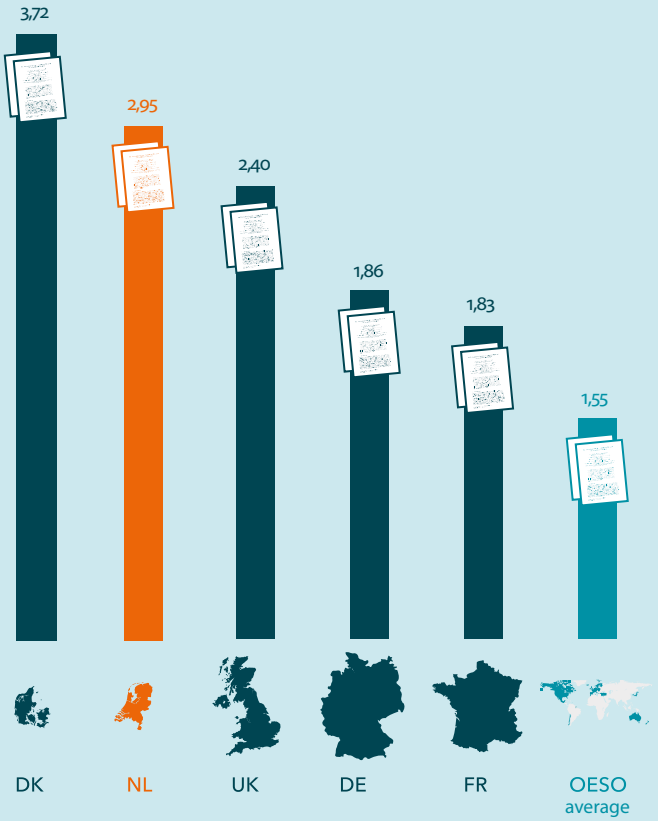
The Dutch science system is effective due to a smart combination of collaboration, competition, quality assurance, good infrastructure and making choices. In the recent essay *Science in the Netherlands* by the Royal Netherlands Academy of Arts and Sciences, it is argued that the strength of Dutch science largely lies in what is often referred to as "poldering": ‘consulting, seeking consensus, collaborating and innovating from the bottom up are part of a unique scientific culture’. Another aspect is the complimentary relationship of the various forms of funding. Dutch universities partly receive direct funding from the government. In addition, indirect government funding is allocated to research projects in competition based on international assessments. Consequently it serves to support excellence and innovation across the full range of Dutch research. It is partly thanks to this competition and international assessments that Dutch science belongs to the world top. Research funding from third parties to universities and research institutes includes funds from the European Union, private organisations, government bodies, non-governmental organisations and charities.

1 José van Dijck and Wim van Saarloos, The Dutch Polder Model in science and research. (2017) 28-37.

A small powerhouse in science

Large production of scientific articles

The Netherlands is a major producer of peer-reviewed scientific articles, especially if the production is corrected for the number of inhabitants per country. In that case, the Netherlands produced double the OECD country average for the period 1996 -2015 and far more than major science nations such as France and Germany.

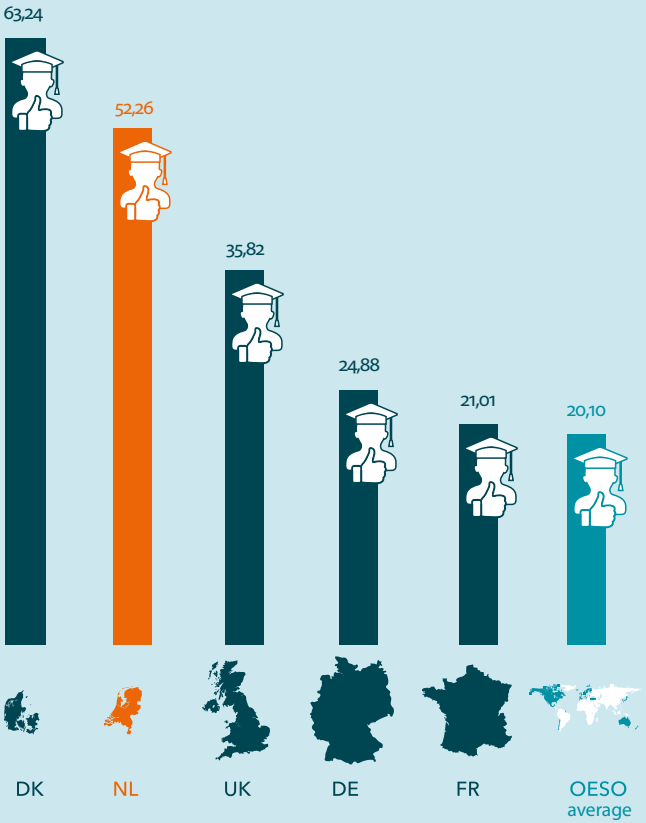


Source data: Dialogic, SCImago Journal & Country Rank (www.scimagojr.com) based on Elsevier's Scopus database; UN World Population Prospects: The 2015 Revision.

Research with exceptional impact

Many scientific citations

Dutch research has considerable impact in science: we score a high number of citations, especially if the figures are corrected for the number of inhabitants. Calculated in this way, the Netherlands has considerably more citations than the average OECD country or large science nations such as the United Kingdom, Germany and France.



Source data: Dialogic, SCImago Journal & Country Rank (www.scimagojr.com) based on Elsevier's Scopus database; UN World Population Prospects: The 2015 Revision.

Dutch research policy: excellence and impact

The Netherlands wants to retain its leading position in science and improve it where possible. In the *2025 - Vision for Science choices for the future*[2], the Dutch government formulated three ambitions for the future:

1. Dutch science is of worldwide significance;
2. Dutch science has even closer ties with society and the private sector; it has maximum impact;
3. Dutch science continues to be a breeding ground for top talent.

In other words – Dutch research policy is about both excellence in science and societal impact.[3] In a letter to the Dutch House of Representatives dated 30 November 2017, the Minister of Education, Culture and Science stated that NWO must give priority to fundamental research in the context of the Dutch National Research Agenda and the top sectors with the new focus, whilst ensuring ample room for curiosity-driven research.[4]

From ZWO via NWO...

NWO was created in 1988 when the Netherlands Organisation for Fundamental Scientific Research (ZWO) was also given the responsibility for strategic and practice-oriented research. NWO is an Independent Administrative Body and therefore has public authority. The Minister of Education, Culture and Science is responsible for the NWO policy and for its monitoring. NWO now has an

2 *2025 - Vision for Science choices for the future* (2014).

3 NWO defines the societal impact of research as societal (cultural, economic, industrial, ecological or social) changes that are entirely of in part the consequence of knowledge and expertise generated by research. Therefore, in this strategic plan, 'societal impact' is also understood to include 'economic impact'.

4 www.rijksoverheid.nl/documenten/kamerstukken/2017/11/30/kamerbrief-over-investeringen-in-onderwijs-en-wetenschap

annual budget of about one billion euros. In accordance with the *Netherlands Organisation for Scientific Research Act*, NWO has the task of advancing the quality of scientific research and initiating and encouraging new developments in scientific research.
NWO carries out its tasks by allocating funding in competition and by facilitating the transfer and exchange of knowledge resulting from research it has initiated and encouraged so that this research benefits society. In realising its task, NWO's main focus is on university research. NWO provides the necessary coordination and ensures a national research strategy.[5]

...towards an integrated NWO

In recent years, the NWO organisation has been adjusted so that it can optimally fulfil its tasks. The previous organisational units ('domains') that were mainly organised along disciplinary lines and were quite independent have now been integrated into a single coherent NWO organisation that can carry out its tasks more effectively and efficiently and can ensure a more coherent programming for and approach to tackling societal challenges. Also, the governance and management of the nine NWO institutes has been brought together in the foundation NWO-I, which has enhanced the role of the NWO institutes in realising NWO's strategic plan. In addition, NWO has knowledge of and experience with supporting applied and practice-oriented research. Consequently, the organisation is well-equipped to connect partners from the entire knowledge chain, across the boundaries of disciplines and sectors. NWO can optimally respond to developments in science and society by further developing and implementing knowledge, interventions, methods and instruments.

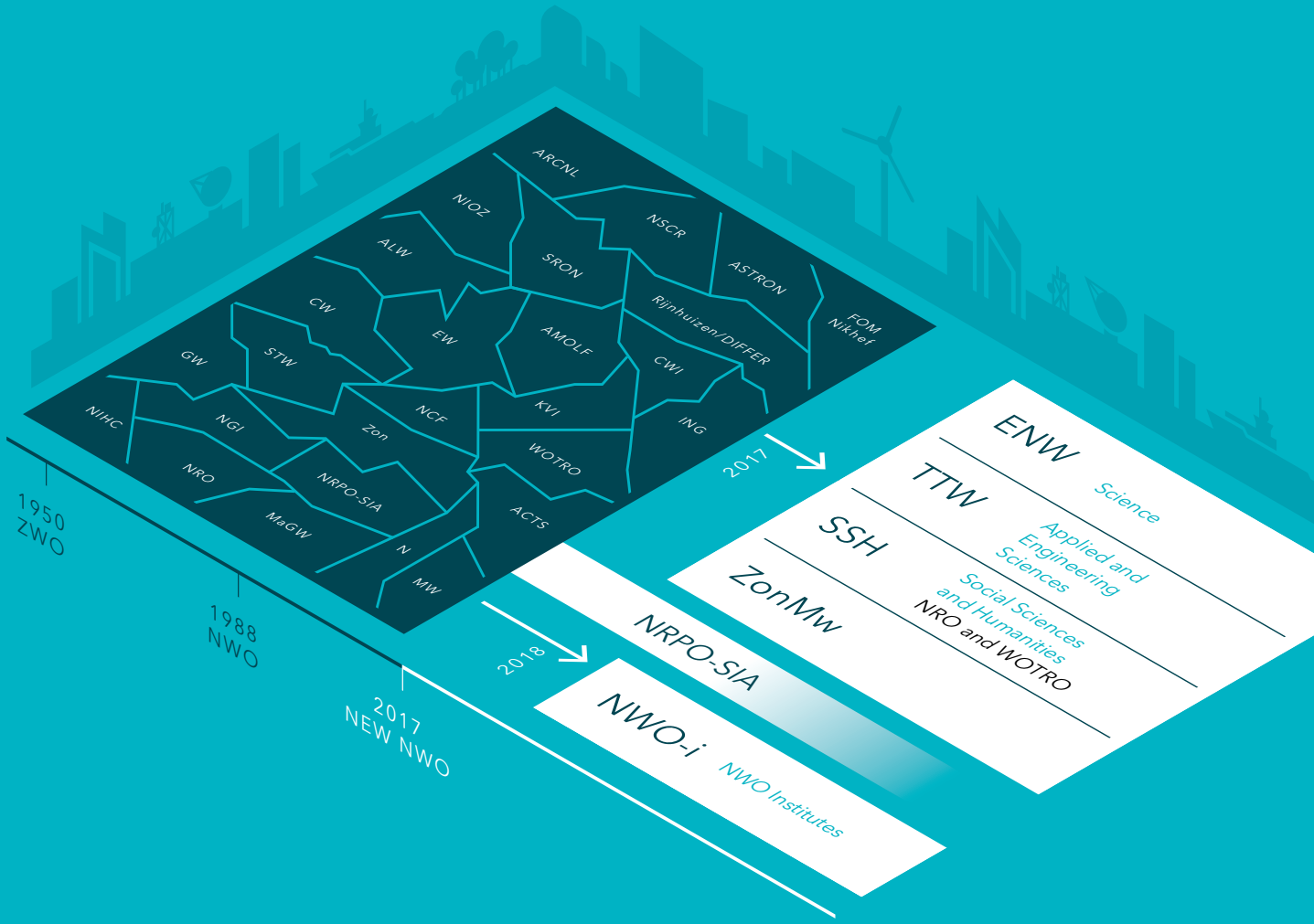
5 See Article 3 of the Netherlands Organisation for Scientific Research Act.

Institutes of strategic importance

In its institutes, NWO carries out research of strategic importance for Dutch science. Many institutes play an important role in big science, the fundamental and groundbreaking research that is carried out in large international collaborations. NWO institutes provide an inspiring environment for researchers from the Netherlands and abroad and ensure access to national and international research facilities. The research programmes frequently have a duration of many years. NWO periodically sets the missions of the institutes as part of a coherent national research policy.

Impression historical development of NWO

See Annex 2 for a description of the NWO institutes



2 Mission, Vision, Ambitions and Core Values

NWO's mission is to advance scientific research with scientific and societal impact. NWO approaches that from its vision of being a connector and is guided by its core values: groundbreaking, committed, reliable, and connecting. For the coming strategic period, NWO has established five ambitions along which the mission will be shaped. The ambitions are: connecting agendas, science and society; providing perspective to researchers; collaboration for excellence and innovation; ensuring an accessible and sustainable scientific infrastructure; and effective use of knowledge through co-design and co-creation.

Mission: world-class science with impact

NWO advances world-class scientific research. This research has scientific and societal impact.

Vision: connecting role

NWO facilitates excellent, curiosity-driven disciplinary, interdisciplinary and multidisciplinary research. In this role, NWO focuses on all scientific disciplines and on the entire knowledge chain with an emphasis on fundamental research. NWO connects researchers from various disciplines and across the entire knowledge chain and brings researchers and societal partners together. NWO funds the personnel and material cost for scientific research and knowledge exchange and impact activities of Dutch universities and public research institutes. NWO invites partners from industry, the government and societal organisations to contribute with their own knowledge agendas and questions to the programming, realisation and co-funding of research.

Institutes have a national and international role

Each of the NWO institutes has a mission that is of national and international strategic importance. Institutes frequently work together with researchers and other knowledge centres and are incubators for scientific innovation. In doing

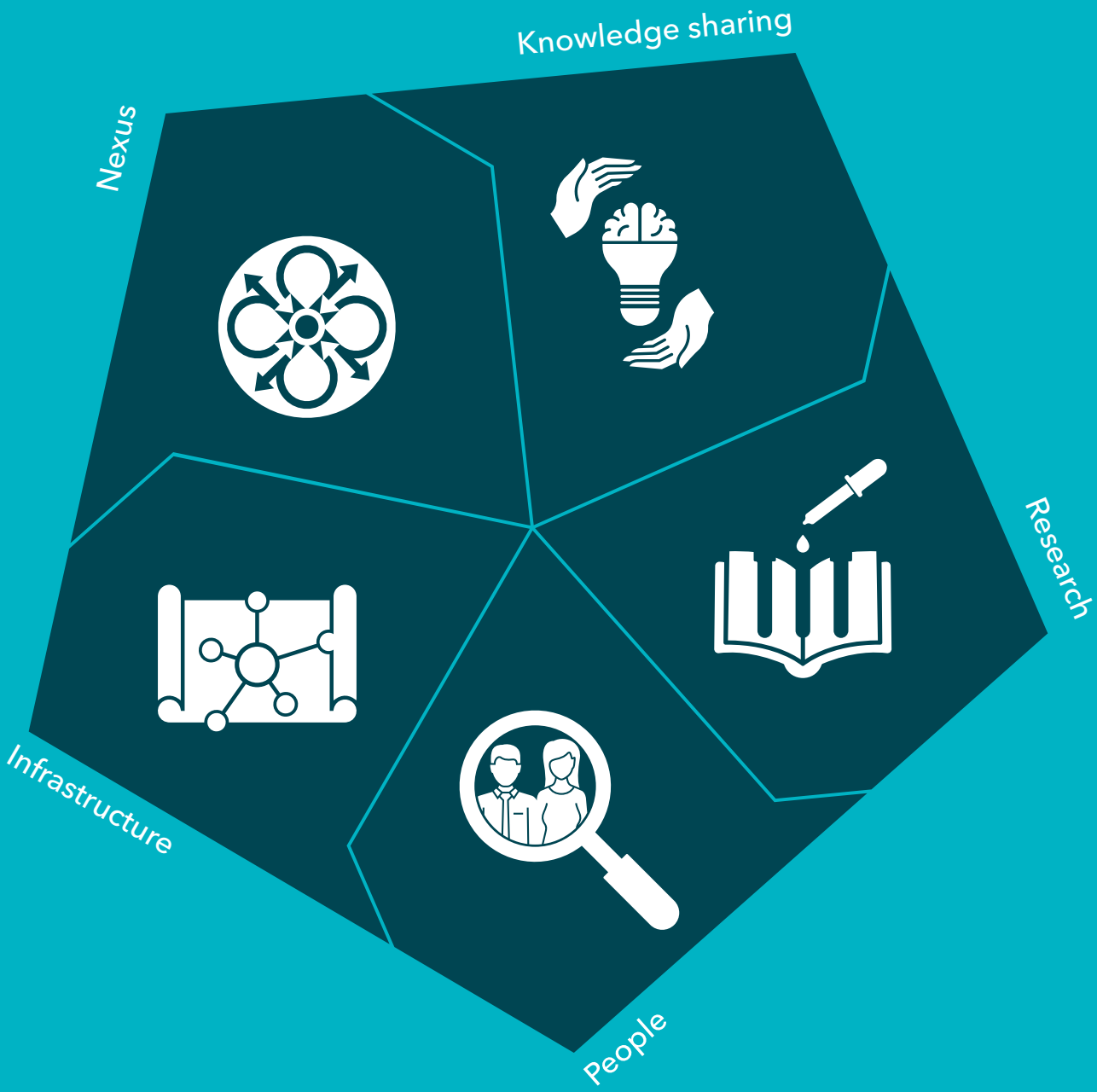
this, they play a connecting role within their specific research areas. From a national and international perspective and in consultation with the board of the Royal Netherlands Academy of Arts and Sciences, NWO strives to align the research its institutes carry out with that of the research carried out in the institutes of the Royal Netherlands Academy of Arts and Sciences, which mainly focus on the humanities and life sciences.

Five ambitions: nexus, people, research, infrastructure, knowledge sharing

There are five key ambitions for the period 2019-2022. The individual organisational units of NWO will contribute to their realisation. They will do this from the perspective of their own individual (connecting, funding and/or realising) roles and will match their activities to the needs, expertise and knowledge of Dutch science and society.

These five ambitions are:

1. **Nexus:**
   connecting agendas, science and society
2. **People:**
   perspective for researchers
3. **Research:**
   collaboration for excellence and innovation
4. **Infrastructure:**
   accessible and sustainable scientific infrastructure
5. **Knowledge sharing:**
   effective use of knowledge through co-design and co-creation


Knowledge sharing
Nexus
Research
Infrastructure
People

Core values: groundbreaking, committed, reliable, connecting

NWO operates with the following core values that are vital for realising its ambitions:

- **Groundbreaking:**
  NWO pioneers and explores the boundaries of existing knowledge, applications and processes.
- **Committed:**
  NWO anticipates developments in science and in society.
- **Reliable:**
  NWO keeps its promises, is honest, transparent and meticulous.
- **Connecting:**
  NWO has an open attitude and connects actors, expertise and agendas.

3 Societal and Scientific Developments

It is a challenging time for Dutch science. Science is increasingly being called upon to contribute to solutions for complex and often global societal issues. And science itself is becoming increasingly complex. Both the Netherlands and Europe have compiled various agendas to tackle societal and scientific challenges. Big science has now become a necessary precondition for many issues. In addition, the importance of open science is growing. Furthermore, the role of Europe is becoming more significant, international competition is increasing and some groups in society are calling science into question.

Complex societal issues

The Netherlands, as the rest of the world, faces major interrelated challenges. Demographic developments in the world are associated with conflicts, migration flows, the depletion of natural resources and climate change, for example. There are limits to what the Earth can provide. This requires, amongst other things, a new interpretation of the term growth, the development of new energy sources, new ways of feeding the world's population, and new methods to settle conflicts and facilitate collaboration. Many of the societal challenges are global in nature and are described in the United Nations' Sustainable Development Goals (SDGs).[6] Cooperating with countries and regions where the majority of the world's population live is essential for finding solutions. At the same time, the Netherlands faces specific challenges such as preparing for the fourth industrial revolution, tackling the contradictions in society, keeping healthcare affordable and dealing with the consequences of an ageing population. Science is increasingly being called upon to contribute to solving these and other complex societal issues.

Science is becoming increasingly complex

It is not just society that is presenting science with a number of large and complex challenges. Science itself is becoming increasingly complex in nature. In the traditional scientific approach, the emphasis is on a reductionist analysis of separate components of a problem, from the rationale that a better understanding of the components will lead to a better understanding of the

6 https://sustainabledevelopment.un.org/sdgs

overall problem. Modern-day science, however, increasingly views reality from the perspective of the dynamics within and between complex systems. Diversity in experimental and conceptual approaches is now seen as a source of strength. This requires a greater interconnectedness between different disciplines, as has happened in biotechnology, nanotechnology and brain research, for example. More interdisciplinary and multidisciplinary collaboration without losing sight of the importance of disciplinary research is needed.

Big science encourages innovation

For some scientific problems, big science has become a necessary precondition. International collaboration and large-scale advanced research facilities are needed to answer major questions. The discovery of new knowledge and the development of groundbreaking skills to acquire this knowledge go hand-in-hand. Connecting Dutch researchers with other researchers and large infrastructures, wherever these might be located, helps Dutch science to advance. Superbly equipped institutional workplaces and collaboration with high-tech companies are vital for the production of extremely advanced equipment. Therefore big science also encourages innovation and the development of existing and new key technologies.[7]

7 A key technology is a technology that is characterised by a broad application area or scope in innovations and/or sectors. Key technologies are essential for solving societal challenges and provide a large potential contribution to the economy through the development of new commercial activities and markets, increasing the competitive strength and strengthening the growth in jobs. Key technologies make groundbreaking innovations possible and are relevant for science, society and market.

Open Science strengthens innovative capability

Open Science is defined as the scientific practice where research data, research methodologies and other information (methods, publications, data, workflows, software, standards, et cetera) are made available for use and reuse across disciplinary, social and national boundaries at the earliest possible stage.[8] Open Science implies a change in the approach of carrying out and evaluating scientific research: a shift from an emphasis on publications of mainly positive results in scientific journals to the sharing of all available knowledge, such as research hypotheses, methods and techniques, and research data in various stages of the research process.

Open Science requires a new infrastructure with data repositories for the storage of research data in a secure and reliable manner. It also requires the training of data stewards to make data available according to the internationally established FAIR principles.[9] Here, research software and its support play a vital role. Research software provides an essential connection between hardware, databases and the scientific results. Digitisation and the modern ICT infrastructure provide unprecedented opportunities for Open Science. Open Science is vital for the progress of science and contributes to the societal impact of research because it not only provides researchers but the entire of society (for example citizens, patients, companies) access to research and its results. This way, Open Science strengthens the innovative capability of the Netherlands.

8 The six principles of Open Science are: Open Methodology, Open Source, Open Data, Open Access, Open Peer Review and Open Educational Resources. See: http://openscienceasap.org/open-science/

9 FAIR principles: Findable, Accessible, Interpretable, Reusable.

A multitude of agendas

The demand from government bodies, companies and other societal organisations for innovative and reliable knowledge is growing. This is resulting in a multitude of knowledge agendas. An example is the knowledge agenda of the Ministry for Economic Affairs and Climate Policy that has implemented the top sector policy since 2010. This policy is aimed at collaboration between industry, knowledge institutions and the government. For this cabinet period, the top sector agenda focuses on economic opportunities with respect to the energy transition, sustainability, agriculture, water, food, quantum, high-tech, nano and photonics.[10] Another example is the knowledge agenda of the Ministry of Health, Welfare and Sport, which commissions The Netherlands Organisation for Health Research and Development (ZonMw) to encourage research and innovation in the area of health and healthcare. A third example is the knowledge agenda of the Ministry of Foreign Affairs that encourages and facilitates knowledge platforms which identify the knowledge questions for the most important policy dossiers and, when necessary, commissions the carrying out of research. The Ministry of Agriculture, Nature and Food Quality, the Ministry of Infrastructure and Water Management, the Ministry of Social Affairs and Employment, the Ministry of Justice and Security, and the Ministry of Defence also have their own knowledge agendas. In addition, there is the government-wide knowledge agenda aimed at achieving the United Nation's Sustainable Development Goals.[11]

In 2015 the Dutch National Research Agenda was realised as a consequence of the *2025 - Vision for Science choices for the future* report and on the basis of a public consultation, as well as a dialogue between the parties involved, scientists and interested citizens. The Dutch National Research Agenda ensures that through cross-fertilisation and smart collaboration between universities, research institutes and other knowledge organisations, companies and societal

10 *Confidence in the future. Coalition agreement 2017 – 2021, VVD, CDA, D66 and ChristenUnie, 33.*

11 Nederland ontwikkelt duurzaam. Plan van aanpak inzake implementatie SDGs, Tweede Kamer, vergaderjaar 2016–2017, 26 485, nr. 232.

organisations, the whole is greater than the sum of the parts. With this approach, science can excel and fundamental research together with applied and practice-oriented research can make a more significant contribution to the quality of life, the resilience of society and the healthy development of the economy. The Dutch National Research Agenda focuses on an improved matching of research with societal and economic opportunities and challenges. It also reveals the subjects in which Dutch research excels and can make a difference. Finally, it provides an overview of the opportunities for scientific breakthroughs and the finding answers to societal challenges and economic opportunities.[12]

Europe's role is becoming more significant

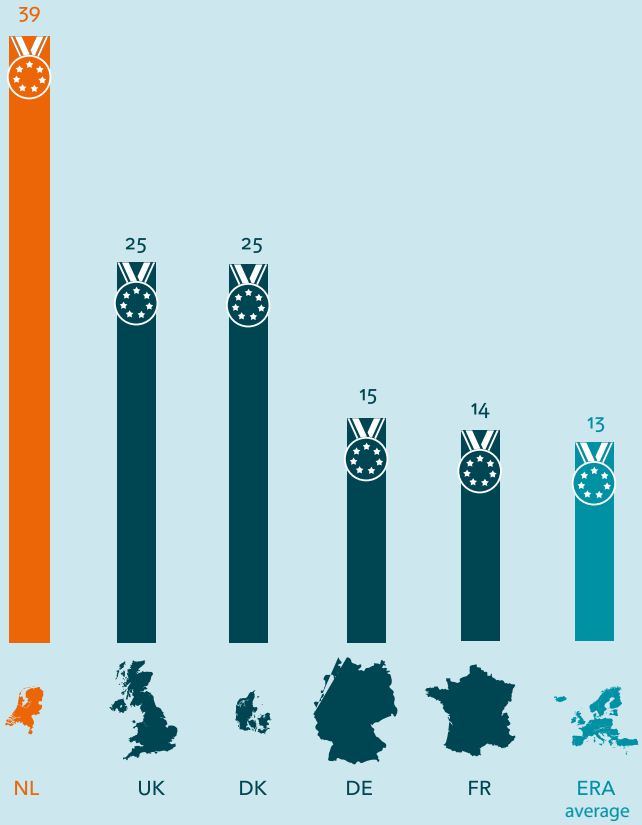
Dutch research is part of the European Research Area, where the EU has set itself the objective of ensuring the free movement of researchers, knowledge and technology. In the European Research Area, the EU strengthens international collaboration and the development of a shared policy for research infrastructure. The policies are set, for example, via the European Strategy Forum on Research Infrastructures (ESFRI) and implemented by the European Research Infrastructure Consortiums (ERICs). Collaborating with European partners benefits the quality and impact of Dutch research. It allows Dutch researchers to absorb new knowledge from abroad, which in turn strengthens the Dutch knowledge base. It increases scientific impact because publications that involve international collaboration have higher citation indexes.[13] The importance of European Union policies for Dutch research and innovation policy has strongly increased in recent years. The contribution of the ERC to Dutch science is even bigger than that of NWO's Talent Scheme.

12 *From Vision for Science to Dutch National Research Agenda in 365 days* (2016).

13 www.rathenau.nl/nl/page/citatie-impact-van-alle-publicaties-en-internationale-co-publicaties-wos

Tokens of European appreciation

Between 2007 and 2016, the Netherlands acquired 663 grants from the European Research Council. This is 39 grants per million inhabitants. That was three times as many as the average country in the European Research Area, but also considerably more than major science nations such as the United Kingdom, Germany and France.



Source data: ERC, ERC Funded Projects (https://erc.europa.eu/projects-figures/erc-funded-projects, spring 2017); UN World Population Prospects: The 2015 Revision.

New Framework Programme offers opportunities

With its framework programmes, the EU challenges Dutch science with an additional research agenda. A recent report[14] by the independent High Level Group calls for the retention of curiosity-driven scientific research in the forthcoming Ninth Framework Programme. At the same time, it calls for a greater interconnectedness between science and society. The report has been accepted as the basis for designing the Ninth Framework Programme. The European Commission will probably establish mission-driven programmes based on the United Nations' Sustainable Development Goals.

International competition is increasing

The Netherlands is one of the countries in the world where world-class science is practised. However, a growing number of countries seek to acquire a position as a competitive knowledge economy. The competition between researchers and between countries and institutions to attract the best scientific talent is therefore increasing. Furthermore, some countries invest more in science and technology than the Netherlands. Investments in science elsewhere provide Dutch scientists with opportunities for international collaboration. However, the Netherlands must face the challenge to keep up its own investment by ensuring that by 2020 the objective of spending 2.5% of the gross national product on research and development will be achieved.

14 *LAB – FAB – APP. Investing in the European future we want* (2017).

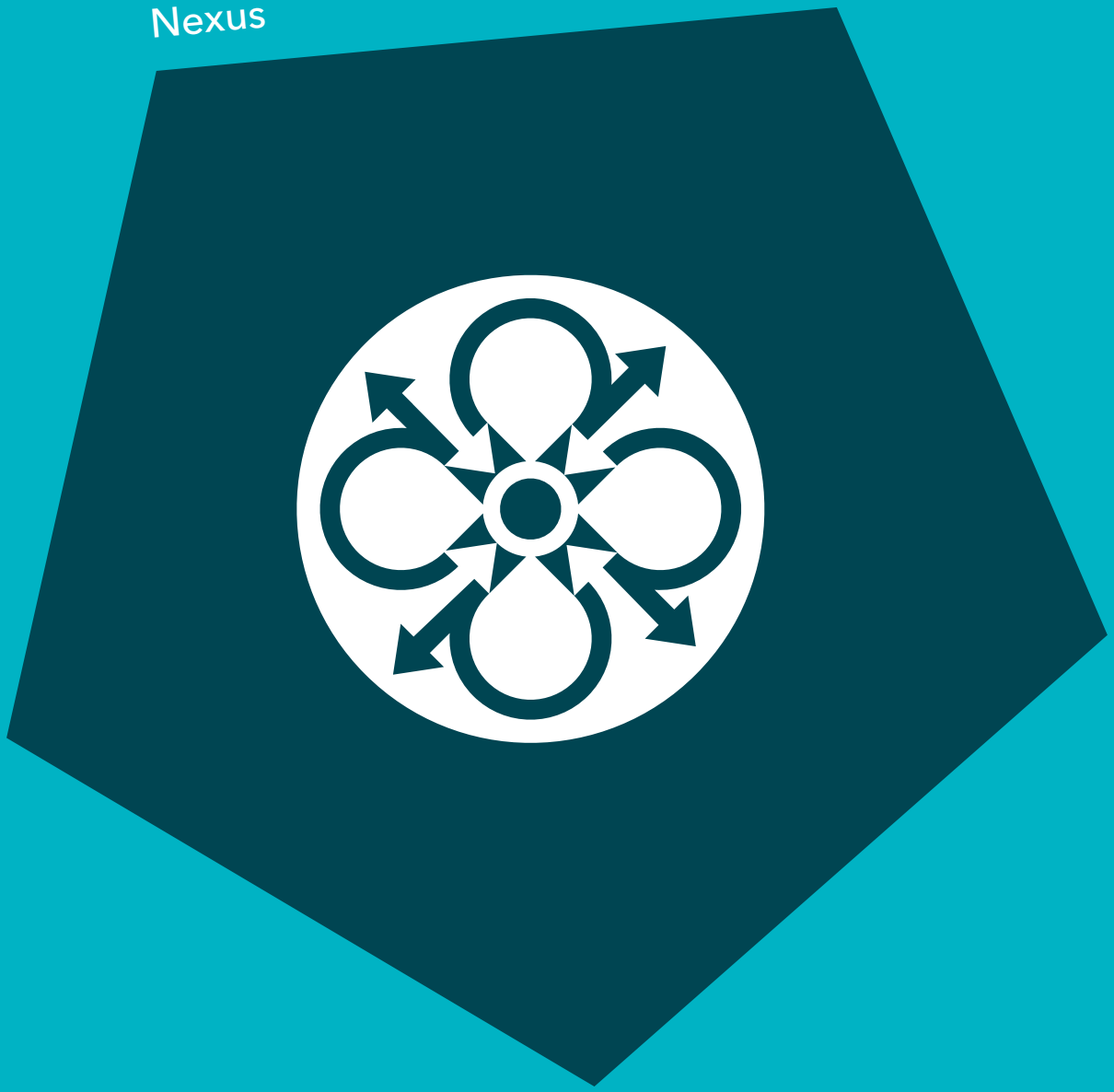
Science and society are interwoven

Since the scientific revolution, there has been considerable trust in scientific and societal progress based on independent and empirically testable knowledge. In other words, the role of science is to establish facts through observations and measurements. In the 21st century, however, some parts of society are calling the independence and reliability of science into question. This could have severe consequences. For example, if governments deny the anthropogenic nature of climate change and consequently fail to implement urgent measures. Therefore now is the time for science to emphasise the importance of scientific knowledge even though that knowledge is complex and can be incomplete. Furthermore, science will need to maintain its relationship with citizens in various ways and must enter more into dialogue with society. And surely, science must maintain the highest standards of scientific integrity.

4 Ambitions NWO 2019-2022

NWO has set itself five ambitions for the years to come. The ambitions relate to the nexus role, people, research, infrastructure, and knowledge exchange and impact.

Nexus



4.1

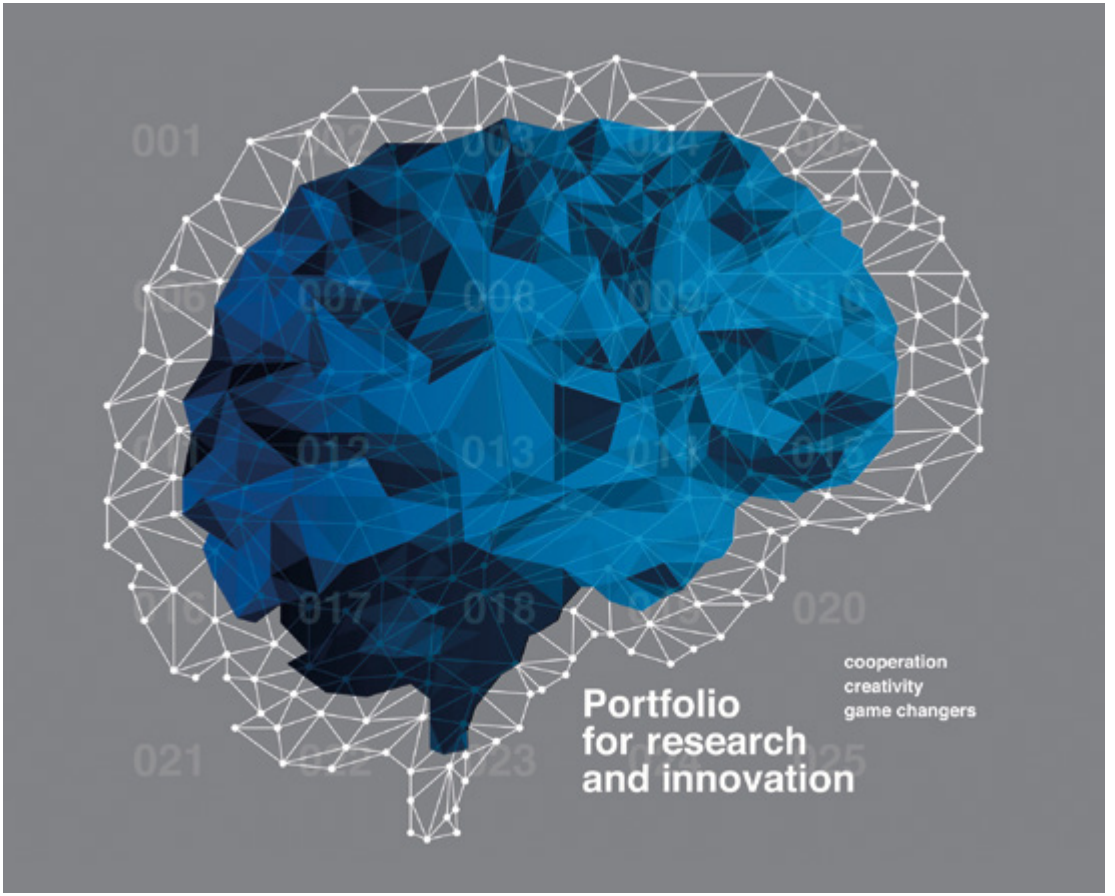
Nexus: connecting agendas, science and society

In the Dutch science system, NWO is a central, independent, transparent and reliable partner. NWO is therefore uniquely positioned to operate as an intermediary within science and between science and society. In consultation with the Knowledge Coalition and with knowledge institutions, NWO is in an unrivalled position to optimally match the balance between direct and indirect government funding to strengthen the basis for education and research. NWO aims to ensure improved coordination in Dutch science so that a national research strategy can be developed, including a regularly updated Dutch National Research Agenda.

Coherent programming in the Netherlands

NWO's budget is largely tied to the conditions set by the bodies that fund it. Consequently, parallel policy frameworks have arisen, which sometimes lead to a lack of clarity as well as the fragmentation of brainpower and resources. In the coming strategy period, NWO will assume a strong role in connecting the various agendas. For this, a long-term perspective for research related to scientific breakthroughs and broad societal questions and challenges will be formulated in a transparent process. Through such programming, the distinction between the thematic NWO programmes, the knowledge agendas of various government ministries, the top sectors and the Dutch National Research Agenda will disappear. In organisational terms, this means a simplification of the complex landscape of research funding. NWO intends to focus on a limited number of research themes that provide guidance for (part

NWO aims to ensure improved coordination in Dutch science and will do this on the basis of government policy, the Dutch National Research Agenda and other knowledge agendas. This will be realised in consultation with individual researchers, knowledge institutions, TO2 institutes, companies, citizens, government bodies, the Royal Netherlands Academy of Arts and Sciences, and representatives from organisations such as the Association of Universities in the Netherlands, the Netherlands Association of Universities of Applied Sciences, the Netherlands Federation of University Medical Centres, Royal Association SME-Netherlands and the Confederation of Netherlands Industry and Employers.



of) the research. These will be based on the Dutch National Research Agenda, the objectives of the top sectors and the knowledge agendas of government ministries.

At the same time NWO respects the autonomy of Dutch science. After all, innovation will not be possible unless there is a strong basis on which researchers can make their own specific choices. NWO will therefore safeguard the balance between thematically driven and curiosity-driven research in the coming years. In addition, NWO aims to create opportunities for both individual researchers and research consortia. We will also allow talent to flourish and will facilitate disciplinary and interdisciplinary research.

Encouraging self-organisation

NWO wants to encourage the self-organising capability that is already strongly present in Dutch science. Examples of self-organisation are the knowledge agendas of the Association of Universities in the Netherlands, the Netherlands Federation of University Medical Centres, and the sector plans with respect to physics and chemistry and with respect to the humanities. Through an integral approach, sector plans seek to strengthen the knowledge base and the further profiling of the research at Dutch knowledge institutions, whereby education, research and societal objectives are closely interrelated. The sectors draw up their own plans with clearly testable objectives.

NWO supports the Lorentz Center.[15] The Lorentz Center is a unique place where researchers from around the world organise workshops within and between all discipline in the natural sciences, social sciences and humanities.

15 https://www.nwo.nl/en/funding/our-funding-instruments/enw/lorentz-center/lorentz-center.htm

The dialogue with society

NWO wants to explicitly involve societal parties and citizens in the programming and realisation of research. NWO brings scientists and societal stakeholders (including companies) in contact with each other via events, (knowledge) platforms and user committees, for example. NWO also expects researchers to inform a wider public in an understandable and accessible manner as to how their research contributes to society. Finally, NWO will ensure that research is brought into contact with policy and politics, so that policies become more evidence based.

The international dialogue

NWO will continue to proactively participate in important international networks such as Science Europe and the Global Research Council. The aim of this is to exert influence on international developments in science both within and beyond Europe. NWO is active in various committees at the European level and partly aligns its policy with that of the European Commission. NWO participates in intergovernmental organisations that focus on big science and large international research infrastructure. NWO also continues to promote research in European and global programming and agendas via channels such as the Belmont Forum, for example. In addition, NWO encourages collaboration between various Dutch parties that are active in European policy making.

Science diplomacy

The Netherlands wants to strengthen its international profile as a knowledge economy where world-class science is conducted. In this regard, recent reports from the Dutch Trade and Investment Board[16] and the Advisory council for science, technology and innovation[17] have already made important suggestions. NWO will play a proactive role in harmonising the international knowledge policy of the Dutch government, Nuffic and the knowledge institutions. With a joint effort, Dutch research can be better presented abroad.[18] For this, NWO will make strategic use of visitor grants and other instruments. Furthermore, NWO will request Dutch diplomats to facilitate international scientific collaboration, for example through collaboration on valuable research infrastructure or by representing the Dutch knowledge sector abroad like the *Innovatie Attaché Netwerk* (diplomacy for science) does. In addition, NWO wants to highlight the importance of research for providing an evidence-informed basis to foreign policy (science in diplomacy). NWO is also open to the idea of using science for achieving policy related, political and/or diplomatic objectives (science for diplomacy), as long as this aligns with the mission of NWO.

16 Team Nederland: *Samen sterker in de wereld:* www.vno-ncw.nl/sites/default/files/102393_rapport_DIO-BE_WEB.pdf

17 AWTI-Diplomatie - *Offensief voor internationalisering van wetenschap, technologie en innovatie:* www.awti.nl/documenten/adviezen/2017/05/16/advies-wti-diplomatie---offensief-voor-internationalisering-van-wetenschap-technologie-en-innovatie

18 A good example is: Research in Germany: https://www.research-in-germany.org/en

People

4.2

People: prospects for researchers

Good research requires good researchers. NWO ensures that researchers in the Netherlands can continue to develop in all phases of their career by doing research of their own choice. To this end, NWO offers the possibility of enabling talent to flourish and of enabling researchers with small and large research projects to realise their ambitious research objectives. With the structural increase in the funds for fundamental research that has been announced in the coalition agreement, NWO will offer the best researchers betters prospects for realising their own curiosity-driven fundamental research.

Matthew effect

The more grants a researcher receives, the greater his or her chance of receiving grants in the future. This effect, called the Matthew effect, has both benefits and drawbacks. The benefits are that the research funding ends up in the hands of outstanding researchers. They deploy it in a superb manner for research in which young researchers are also given the opportunity to develop further. This opportunity for exceptional researchers to build up a large research programme by being successful in various funding competitions is one of the distinctive characteristics of the Dutch research system. Accordingly, it is one of the trump cards in the competition for international talent.

A drawback is that because success in the past increases the chances of obtaining grants in the future, the chances for emerging talent are reduced. Another undesirable effect is that established researchers link their name to the research programme without making a substantial contribution to its realisation. Furthermore, the efficacy and return on investments for research decrease if the number of grants awarded to a person is too large.

NWO is aware of the Matthew effect. We are investigating its influence in the Netherlands and are taking measures to safeguard the balance. For example, we place more emphasis on research-related criteria when assessing proposals, and not merely on past performance. We also register how many projects and programmes an applicant is participating in.

Development of talent: from the Innovational Research Incentive Scheme to the NWO Talent Programme

Possibilities for talent to develop are vital for Dutch science. NWO continues to provide individual researchers the opportunity to prove themselves and to develop their own line of research via the Rubicon, Veni, Vidi and Vici programmes. In addition to this, NWO wants to offer talented researchers the opportunity to develop further, either alone or with a team, by contributing to an existing research programme with a longer duration. This is in line with developments in the medical, physical and technical sciences, amongst others. To this end, the Innovational Research Incentives Scheme, which has been NWO's most important talent programme since 2000 and is highly valued by both universities and individual researchers, will be modernised into the 'Talent programme'. Talent is a broad term and can be expressed in many ways.

For example, in new scientific directions, new technology, the development of new schools of thought, leadership, and the ability to connect different scientific fields as well as science and society. NWO embraces the different ideas that prevail about this in the various disciplines. Of course, the quality of the research and potential of the candidate will continue to be the most important factors.

NWO also has an eye for special target groups. For example, with PhD programmes for teachers, NWO wants to improve the professional practice and quality in schools. NWO also will continue to offer employees from industry the possibility to acquire specialised knowledge by carrying out doctoral research. As an Industrial Doctorate, they can use that experience for a career within or outside of science.

Application pressure

The competition for funding for research proposals continues to increase. At the same time, the percentage of proposals that can actually be awarded is decreasing. Funding bodies must reject high-quality proposals due to a lack of funds. This is a problem for both researchers and funding bodies in the Netherlands and abroad. NWO consulted Dutch scientists, knowledge institutions and sister organisations in the Netherlands and abroad about their experiences as well as possible solutions. This process resulted in a number of broadly supported proposals that will reduce the application pressure for researchers. NWO is investigating the suggestions and will take measures where possible.[19]

19 https://www.nwo.nl/en/documents/nwo/strategy/measures-to-reduce-application-pressure

NWO Open Competition

Each NWO domain will make a substantial contribution to the NWO Open Competition: the programme for curiosity-driven research. Individual researchers can continue and develop their line of research via the programme. NWO recognises that different scientific domains have different needs with respect to the size of the projects and the deployment of equipment and personnel. Via a modular structure of the funding instrument, NWO will meet the specific requirements of researchers in different disciplines. Where necessary, we will reduce the application pressure, by setting a maximum for the number of applications and grants awarded per researcher per year, for example.

Prizes for top researchers

Spinoza Prize
Researchers in the Netherlands who, according to international standards, belong to the absolute top of science are eligible for the Spinoza Prize. Spinoza laureates are a source of inspiration for younger researchers.

Stevin Prize
NWO annually awards the Stevin Prize to recognise and encourage knowledge exchange and impact. The prize awarded to a talented researcher or a team of two or three people. The researcher or team must have achieved an exceptional success in the area of knowledge exchange and impact for society.

International circulation of talent

Free circulation in an open, international science system inspires researchers, contributes to new skills and knowledge, ensures the embedding of Dutch researchers in international networks, and increases the impact of research.[20] Under certain conditions, researchers from the Netherlands can already take the remainder of their funding if they accept an appointment at foreign knowledge institution thanks to the 'Money Follows Researcher' scheme agreed by the European science organisations. NWO will drop the principle of reciprocity in the scheme. As a result of that, researchers will truly be able to continue and complete a research project anywhere in the world.

In addition, NWO will follow the example of the Alexander von Humboldt Professorship in Germany by establishing a new individual grant to bring excellent senior scientists to the Netherlands: the Huygens Professorship.

Diversity

NWO strives to achieve an inclusive culture where there is no place for intentional or unintentional barriers due to cultural, ethnic or religious background, gender, sexual orientation, health, or age. Where necessary, NWO will adapt its funding instruments, procedures and approaches to guarantee this.

20 Caroline S. Wagner and Koen Jonkers, 'Open countries have strong science', *Nature* 550 (2017) 32-33.

NWO will make efforts to attract more researchers with a migrant background and women via incentive measures in the financial possibilities as well as in the appointment policy of its institutes. NWO also considers the issue of diversity in the design and realisation of projects and programmes.

Institutes

The NWO institutes are an inspiring place for researchers. One of their roles is to operate as a breeding ground for talent that subsequently moves on to other knowledge institutions, companies and societal organisations. The tenured staff of NWO institutes often hold an appointment at a university as well. And the NWO institutes frequently provide places to researchers from other knowledge institutions, for example via fellowships or temporary part-time appointments. In the next strategy period, the NWO institutes will strengthen their relationships with other knowledge institutions and offer bigger opportunities to researchers from these institutions. NWO will make an effort to facilitate such exchanges, guest researchers and shared appointments.

Research

4.3

Research: collaboration for excellence and innovation

A strong basis...

Fundamental scientific research is the basis for understanding the world around us, for understanding the natural and human past, and for important new discoveries. In 2016, the Advisory council for science, technology and innovation recommended that for the development of the Netherlands as a knowledge society and the realisation of (more radical) innovations, it is advisable to give a strong boost to curiosity-driven fundamental research with a long funding period. This would also help to maintain the basis.[21] Curiosity-driven fundamental research is eventually translated into innovations that increase the resilience and economic success of society. And conversely, questions from society can give rise to new fundamental questions. NWO explicitly wants to provide space for fundamental scientific research as well as ensuring that the various scientific disciplines in the Netherlands can continue to develop and innovate.

For a balanced national research portfolio, NWO continues to have an eye for excellent research within sometimes vulnerable scientific disciplines that do not appear to flourish sufficiently or find it harder to connect with large-scale multidisciplinary or interdisciplinary research agendas but are nevertheless vitally important.

21 AWTI report *Maintain the basics - Priorities for extra investments in research and innovation* (2016).

Tailored approach for pioneering research

Although pioneering research is important for exploring new directions in research and creating opportunities for radical innovation, its high-risk and high-gain nature can be a disadvantage in competitive funding. In the next strategy period, NWO will create more room within various programmes for this type of high-risk, high-gain research. We will do that via staged funding with various go/no-go moments. Small grants in particular will be used to encourage risky research proposals. With this approach, we will explicitly provide space for innovation in research. Because the pioneering research of today generates the thematic programmes and societal impact of tomorrow.

… with a high focus on collaboration

The capacity to realise multidisciplinary and interdisciplinary collaboration between researchers, disciplines and institutions is already a major strength of the Netherlands. This ‘polder-strength’ of the Dutch system places the emphasis on strengths such as connecting, collaborating, self-organisation, and the role of various organisations. This strength is deployed to innovate, inspire and find surprising solutions to scientific problems. In this respect, multidisciplinary and interdisciplinary collaboration can only be successful if the disciplinary basis is both strong and healthy. The focus subsequently lies on using the strengths of the humanities, social sciences and natural sciences to make connections so that scientific problems that cross the boundaries of scientific disciplines can be jointly tackled.

Collaboration with the best international researchers also increases the scientific quality of both the researcher and the research. The same applies to access to facilities that are not available in the Netherlands.

The contribution of science to societal challenges, including economic challenges, also requires collaboration. Besides the collaboration of disciplines and between disciplines and between the various types of research in the knowledge chain, collaboration with societal stakeholders, including companies, is also vital in this regard. Where the research intends to make a contribution to societal challenges from the global perspective, collaboration with scientists and societal actors across national boundaries is necessary (for knowledge and a better understanding of the context).

Space for team science

The developments in science described earlier, require broader and more intensive forms of collaboration: multidisciplinary and interdisciplinary collaboration, cross-sectoral collaboration and collaboration between fundamental, applied and practice-oriented research. The interaction between fundamental, applied and practice-oriented research determines the dynamic interaction in the knowledge chain. For such types of collaboration, inspiring leaders are needed who can establish the contours and who often form the face of large consortia. Besides attention for these talented, excellent researchers via the Talent Programme, the Spinoza Prize and the Stevin Prize, NWO recognises that these researchers can often only excel thanks to the collaboration with fellow researchers and support staff who form a close-knit team. NWO will therefore provide room for team science in its funding instruments.

Gravitation

NWO will continue the Gravitation programme. The programme encourages research into new subjects with potential breakthroughs, carried out by consortia consisting of the best researchers in the Netherlands. Researchers must carry out innovative and influential research in their discipline. The consortia belong to the world top in the research field or have the potential.

Netherlands Polar Programme

The Netherlands Polar Programme funds scientific research in and into the polar regions. With this programme, the Netherlands makes an important and high-quality scientific contribution to international polar research. This research, which is interdisciplinary in nature and connects researchers from several NWO domains, is highly relevant for the climate issue, for example.

Caribbean research: a multidisciplinary approach

This programme focuses on scientific research that is specifically associated with the island area in the Caribbean region. The six islands within the Kingdom of the Netherlands take centre stage. Via thematic orientation, the programme brings together researchers from different disciplines.

A solid basis for innovation

The Knowledge and Innovation Agendas of the top sectors focus more than the Dutch National Research Agenda on economic valorisation in collaboration with companies. Here, the joint articulation of knowledge questions plays a pivotal role and the use and development of key technologies is vital. The Knowledge and Innovation Agendas of the top sectors therefore complement the Dutch National Research Agenda.
NWO wants to provide innovation in the Netherlands with a solid scientific basis by selecting and funding the best research projects within the Knowledge and Innovation Agendas of the top sectors. In doing this, NWO will encourage public-private partnerships. Furthermore, the involvement of small and medium-sized enterprises in the research needs to be strengthened. NWO will therefore involve small and medium-sized enterprises more in the formulation of research questions and in monitoring the progress of research, for example through user committees. In this regard, NWO will continue to mainly concentrate on the low Technology Readiness Levels.

New type of programming

Broad scientific and societal questions and challenges will be approached with a new type of programme. Here, the focus will be more on what must be achieved with the research and why this is important than on how the research is carried out. There will always be a concise and powerfully formulated raison d'être of the intended research and the research consortium carrying it out that will provide answers to questions such as what does a consortium stand for, what will it achieve and what is the role of various members of the consortium in achieving the societal or scientific breakthroughs? The intended societal scientific breakthroughs (the 'what') give direction, capture the imagination,

are inspiring and elicit involvement, action and collaboration across the boundaries of disciplines, institutions and sectors. This approach will initially be applied to programmes in the context of the Dutch National Research Agenda.

NWO and the Dutch National Research Agenda

The realisation of the Dutch National Research Agenda in 2015 was the answer to a need for greater connection and coherency within the Dutch system of research and innovation and a closer relationship between that system and society. The basis of the Dutch National Research Agenda is formed by questions from Dutch citizens to science. The Dutch National Research Agenda intends to build bridges between various scientific, innovation and policy agendas and to facilitate collaboration between the various actors across the entire chain of research and innovation. At the request of the Ministry of Education, Culture and Science, NWO will assume responsibility for the funding, quality assessment and quality monitoring of the research that emerges from the Dutch National Research Agenda.

The Dutch National Research Agenda

NWO will set up a programme that builds further upon the dynamics and process of self-organisation that has developed around the routes of the Dutch National Research Agenda. However, this does not mean that only parties that have been involved in the shaping of the routes so far can form consortia and develop proposals. Some routes are so broad and ambitious that they cannot be funded with the available resources. Therefore, proposals that are related to a part of the route can also be submitted and new combinations of underlying questions are possible. To guarantee optimal flexibility, the only condition will be that research proposals must be aimed at (parts of) one or more routes of the Dutch National Research Agenda.

Complimentary to the realisation of the Dutch National Research Agenda described above, NWO will form programmes around a limited number of societal themes that are important for the Netherlands and that establish the connection between the different agendas: Dutch National Research Agenda, Knowledge and Innovation Agendas of the top sectors, and policy agendas of government ministries. These research programmes will have a size comparable to that of the Gravitation programmes.

Programmes for the Dutch National Research Agenda must be established from across the full breadth of science. In addition, these programmes will provide space for a broad chain approach in which, where relevant, fundamental, strategic, practice-oriented, and applied research are connected. Non-scientific parties can also be involved in the realisation of research within the Dutch National Research Agenda programmes. This means the involvement of various sciences, sectors and parts of the knowledge chain that are relevant to the theme. In the funding of these programmes, NWO will mainly focus on the fundamental science. A financial contribution is expected from non-scientific parties that participate in the programmes.

Cyclical knowledge chain

A traditional knowledge chain has been conceived to go from fundamental research to translational research to applied research and practice-oriented research. Nowadays, the converse is also possible, namely the problem-driven direction (from practice-oriented research to fundamental research), and the cyclical character of research and innovation processes is also of interest. Accordingly, the distinction between fundamental and applied research is becoming vaguer. NWO embraces the cyclical character of the knowledge chain in which fundamental research has an important and connecting role.

Projects of longer duration for consortia

Carrying out research in consortia requires time. Time to build up or expand trust, time to learn to understand each other, time to exchange knowledge and time to coordinate the research. NWO will therefore extend the standard duration of four-year projects in which the collaboration takes place in new consortia. Examples of this are projects in the context of realising the Dutch National Research Agenda.

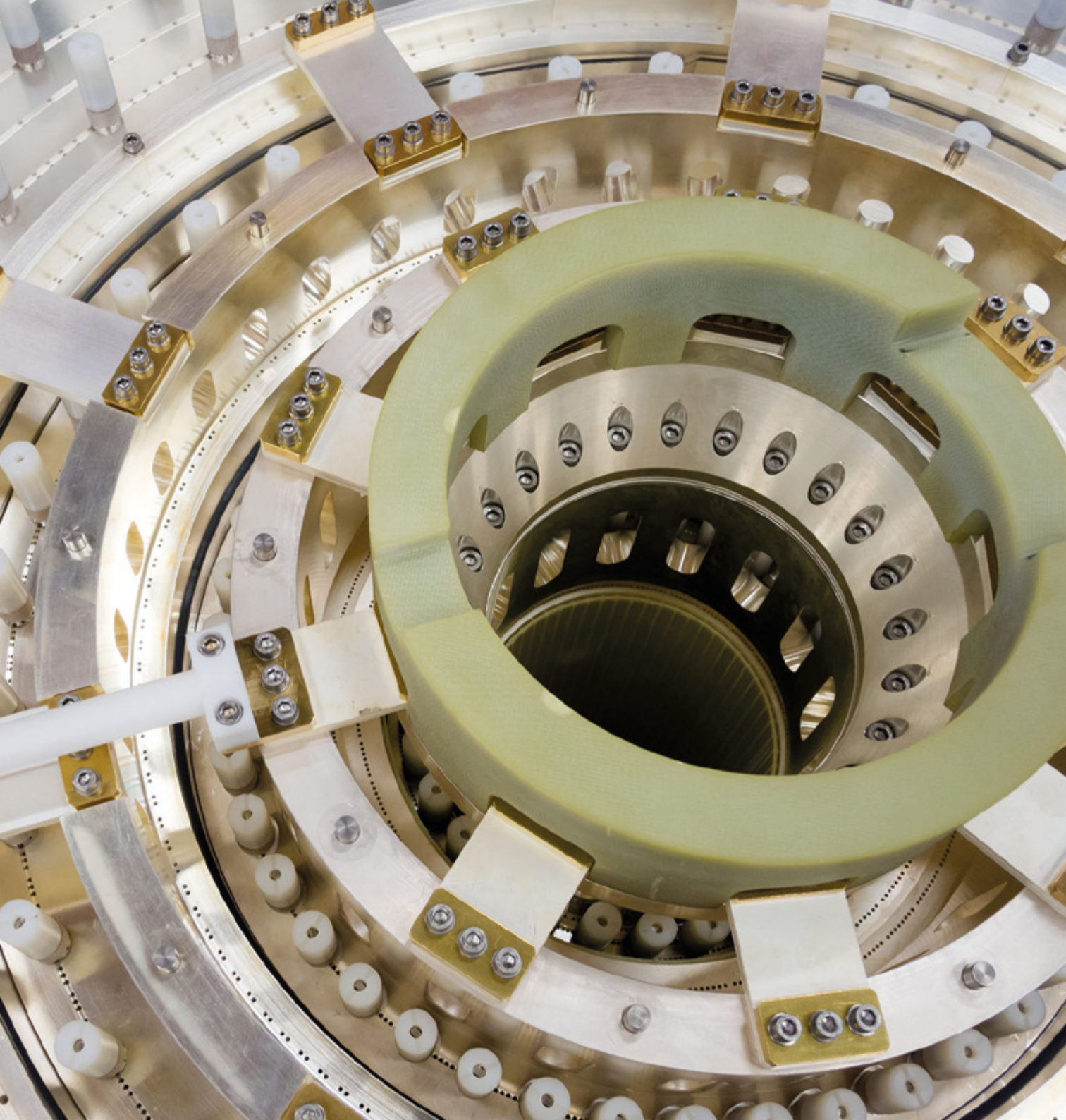
Institutes: nexus for national and international collaboration

NWO institutes have a national function and collaborate with research groups from universities and other knowledge institutions. They provide a breeding ground for talent and different institutes function as portal with respect to large research infrastructure, either because they accommodate, develop and exploit it, or because they act as the access point to international facilities.

NWO can give an institute a partially or entirely new mission to support the NWO strategy. Accordingly, the institutes are one of the most direct resources with which NWO can implement research policy.

NWO is capable of playing a connecting role in Dutch science because on the one hand, it carries out research in its institutes and on the other hand, it enables other research organisations to do research through the funding of projects and programmes by the NWO domains. An effective performance is facilitated by a good alignment of the programmatic and policy choices of the NWO institutes with the policy of the NWO domains and leading research groups in the Netherlands. In the Nikhef partnership, for example, besides Nikhef - the university departments for subatomic physics of the University of Amsterdam, VU Amsterdam, Utrecht University, Radboud University and the University of Groningen participate. The same applies to the National Committee for Astronomy that is formed by ASTRON, SRON, top research school NOVA and the NWO Domain Science.

In the missions of the institutes, NWO makes choices for subjects that are important in a long-term perspective. In 2018, a portfolio evaluation will take place in which the position of all institutes of NWO and the Royal Netherlands Academy of Arts and Sciences in the Dutch knowledge landscape will be evaluated in relation to each other. NWO will use this evaluation in the further decisions it takes about the missions of the institutes.
NWO will attempt, also with the Royal Netherlands Academy of Arts and Sciences institutes, to realise a good alignment of the institutes' missions and the research policy of the NWO domains.



Practice-oriented research

Since 2013, the Taskforce for Applied Research (NPRO-SIA) has been a part of the NWO organisation. The taskforce encourages demand-driven, practice-oriented research at the universities of applied sciences. Through this research, the application of knowledge in companies, institutions and education is encouraged. Thanks to the taskforce, NWO can facilitate the coherency across the entire chain of fundamental, applied and practice-oriented research. NWO will make efforts to further expand the quality and quantity of practice-oriented research. With this in mind, NWO will strengthen the platform and advisory function of the taskforce for the universities of applied sciences and the broader network function of the taskforce in the entire Dutch knowledge chain, for example.

International collaboration: Money Follows Cooperation

Although science transcends national boundaries, funding frequently is bound to national borders. Via the principle of Money Follows Cooperation, NWO will remove the boundaries and facilitate bottom-up international collaboration in all the research it funds. Money Follows Cooperation offers the possibility of creating added value for research projects by using expertise from abroad that is not available in the Netherlands or not present at the desired level.

Joint programmes with European sister organisations

NWO is in favour of a good alignment between the research programme of the European Union and the national research programmes within Europe. We support the efforts to realise a simpler research landscape in Europe. NWO will investigate the possibilities to set up research programmes together with

European research funding bodies that are aimed at societal missions. In these, NWO or a European sister organisation will act as the lead agency.

Collaboration with developing countries

Many societal challenges are unhindered by national borders and mainly affect vulnerable societies worldwide. Knowledge of the local context is vital for research to be able to make contributions to the United Nations' Sustainable Development Goals and for the contextual application of knowledge. NWO wants to strengthen the collaboration with local researchers and societal stakeholders in the developing parts of the world. NWO will do this in close collaboration with Nuffic, the Ministry of Foreign Affairs and the *Innovatie Attaché Netwerk*. This concerns, amongst other things, alumni policy, branding, capacity building and representation abroad.

Merian Fund

NWO will establish the Merian Fund to increase the visibility and profiling of Dutch science abroad. It will be a fund in which international collaboration with emerging science nations and developing countries will play an important role. In addition, the programme will improve the coordination between the Ministry of Education, Culture and Science, the Ministry of Economic Affairs and Climate Policy and the Ministry of Foreign Affairs and organisations such as Nuffic and the Netherlands Enterprise Agency. Flexibility in themes and partner countries will be the key factors in organising bilateral and multilateral funding rounds. The common thread will be research that supports the worldwide achievement of the United Nations' Sustainable

Development Goals. Partner countries will be invited to make a financial or in-kind contribution to the Merian Fund. In addition, the collaboration with China, India and Brazil will be supplemented with collaborations with other partner countries. Domains and institutes of NWO and of the Taskforce for Applied Research (NPRO-SIA) will contribute from their own expertise, instruments and networks.

The Merian Fund is inspired by the Newton Fund in the United Kingdom and is named after Maria Sibylla Merian (1647-1717). Merian was the daughter of a Swiss father and a Dutch mother. She lived in Frankfurt, Nürnberg, Wieuwerd, Amsterdam, Suriname and then Amsterdam again. Merian laid the foundation for entomology and was one of the first botanical artists. In 1699, she travelled to Suriname to investigate exotic butterflies. Upon her return, she produced a book using the drawings she had made in Suriname and the prepared insects.

Open Science

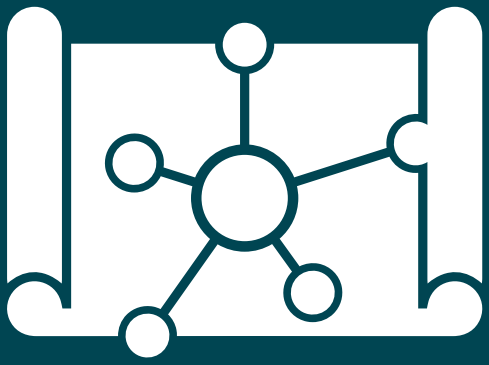
NWO is taking the lead in promoting Open Science. All projects funded by NWO must make both the publications and research data available for general use via trusted repositories.[22] Furthermore, NWO has received the support of all European sister organisations and from the EU and the ERC to establish uniform guidelines within Europe for the management of research data. All researchers in Europe will follow these guidelines. This will give rise to a uniform and transparent setup that will contribute to a greater acceptance by researchers. It will also ensure the efficient use of funds for implementing Open Science in practice.

Citizen science

NWO will make a funding module available for research carried out in collaboration with citizens. The 'open' realisation of research in collaboration with citizens is already taking place successfully in several scientific disciplines, whereas in other areas of science this aspect of Open Science is still in its infancy. Involving citizens in carrying out research has added value for the development and application of knowledge but also contributes to the public support for research.

22 National plan Open Science (2017). See: https://www.openscience.nl/binaries/content/assets/subsites-evenementen/open-science/nationaalplanopenscience_nl.pdf

Infrastructure



4.4

Infrastructure: accessible and sustainable scientific infrastructure

Research infrastructure plays a role in all scientific disciplines, from the social science and humanities to astronomy. It is often a necessary precondition for prominent international research. In this respect, not just the 'hard' equipment and facilities are important but also the technical support and a professional environment where brainpower is concentrated and people meet. Exceptional and advanced research infrastructure, in-house or at international centres, are the reason why many NWO institutes exist. Large infrastructure brings together researchers from different disciplines, countries and cultures.

Science and technology

NWO continues to focus on the development of technology for the realisation of large research infrastructure. This is because research infrastructure encourages innovation at technology companies that are involved in its development. The development and exploitation of research infrastructure also contributes meaningfully to the training of specialised personnel. Consequently, research infrastructure ensures cross-fertilisation with positive scientific and societal results.

A national investment agenda for large-scale infrastructure

NWO believes it has an important task in supporting large-scale research facilities that are accessible to all Dutch researchers. This also includes the possible participation in new, large international research facilities. However, the demand for infrastructure is, significantly greater than the financial possibilities available. Besides, investments are often needed over a period of many years. This requires agreements with the various stakeholders concerning sustainability, collaboration in the Netherlands and abroad, and priorities.

Therefore, together with universities and the Royal Netherlands Academy of Arts and Sciences, NWO wants to draw up a national investment agenda to which all parties involved contribute. In this context, NWO has appointed the Permanent Committee for Large-Scale Scientific Infrastructure, which advises about strategic policy for encouraging the development of and participation in infrastructure initiatives on a national and international scale. The National Roadmap for Large-Scale Research Facilities from the Permanent Committee for Large-Scale Scientific Infrastructure provides the basis for a national investment agenda. NWO will design an assessment framework to ensure that all disciplines will benefit from the limited funds available for large-scale research infrastructure in accordance with the allocation key proposed by the committee.[23] In addition, NWO will pay attention to the initial process of developing new large-scale research facilities.

23 *National Roadmap Large-Scale Scientific Infrastructure (2016) 7-8: "A total amount of approximately € 200 million will be available for the coming five years. Of this amount € 20 million is available for the humanities/social sciences, € 90 million for science/technology and € 90 for the life sciences, or 10%, 45% and 45% of the available resources respectively. The committee recommends using this ratio for upcoming National Roadmap calls. Recently, incidental and structural funds have been added to this in the context of the coalition agreement."*

Phased investments and seeking partners

Investments in and access to facilities are necessary but also costly. The investments required could exhaust the available funds for a long period of time so that future needs can no longer be met. In order to prevent this, NWO is investigating the possibility of realising part of the investment with societal partners. We also want to phase the costs over a large number of years. NWO will also require a business plan from each infrastructural facility, which guarantees the infrastructure's long-term sustainability.

High-grade ICT infrastructure

Science has an increasing need for the rapid analysis of research data, its storage and access to it. A strong ICT infrastructure provides the foundation for large-scale scientific infrastructure. NWO wants to make additional investments possible in high-performance computing, in networks, data facilities and in cyber security. NWO also acknowledges the need for extra investments in large computing facilities and the development of research software and support of its use.

Organisation of the national digital infrastructure is in the Netherlands

SURF

National digital infrastructures are largely organised within the SURF cooperation. Within this cooperation, universities, universities of applied sciences, university medical centres, research institutions and a growing number of further education colleges work together at the administrative, policy and operational levels on ICT innovation and digital infrastructures.

Netherlands eScience Center
The Netherlands eScience Center was established in 2011 by SURF and NWO. It bridges the gap between the ambitions of researchers and the increasingly complex digital infrastructure and ICT, including knowledge and expertise from computer sciences and data science. The eScience Center supports researchers in such aspects as the development of high-grade research software and it does this in close collaboration with the research groups concerned.

DANS
DANS is an initiative of KNAW and NWO. It is the national data archive and knowledge centre for access to research data and scientific information. DANS facilitates sustainable access to digital research data and encourages researchers to sustainability archive and use data. DANS also provides access to thousands of scientific datasets, publications and other research information in the Netherlands and does research into sustainable access to digital information and sustainability of software.

International collaboration

The Netherlands participates in a number of international treaty organisations, other organisations and ERICs that frequently play an important role in the development and management of large-scale scientific infrastructure. In the strategy period, NWO will start a discussion with the knowledge institutions concerning the importance of these participations and how to decide about new ones. Choices concerning participation are required. Moreover,

collaboration with foreign research funding bodies offers opportunities to jointly realise facilities. NWO will actively investigate the possibilities to realise or jointly use facilities in collaboration with foreign research funding bodies.

NWO institutes

The NWO institutes play a major role as the host or entry point to large national and international research infrastructure. The infrastructure is closely related to the missions of individual institutes: without infrastructure, an institute cannot realise its mission.

Smaller-scale infrastructure

NWO believes it has the duty to make a contribution to providing access to infrastructure that is broadly accessible. With this, NWO recognises that universities have increasingly less room for research and infrastructure due to limited research funding. For this reason, within funding proposals for programmes such as the NWO Open Competition, funding can also be requested for the use of infrastructure to carry out the research. NWO will draw up clear guidelines on this subject.

In addition, NWO will continue the programme Investment Grant NWO Large. With this programme, research facilities of national importance can be established that make use of highly advanced equipment or innovative data collections. As a result of this, innovative developments in scientific research are facilitated that are valuable for science, society and companies.

Knowledge sharing

4.5

Knowledge sharing: effective use of knowledge through co-design and co-creation

Besides scientific impact, research preferably has societal impact as well and contributes to unravelling societal questions. Whereas research in the context of the Knowledge and Innovation Agendas of the top sectors and research related to major societal challenges is primarily aimed at achieving societal impact, fundamental curiosity-driven research often has unexpected results that can have a societal impact as well. NWO therefore ensures in various ways that research has societal impact.

Knowledge sharing

Knowledge sharing is a precondition for facilitating societal impact. Knowledge sharing between fundamental and applied science and between public and private parties (companies, government bodies and societal organisations) contributes to reflecting on the opportunities and risks of the research concerned. It offers researchers the possibility to anticipate these consequences, as a result of which the chances of responsible and desirable innovations are increased and the possibilities for utilising these increase as well. In this regard, knowledge sharing is an iterative, reciprocal and dynamic process in which implementation can also lead to new research questions and insights. Knowledge sharing starts with the joint formulation of research questions and is continued in the design of research (co-design). The joint realisation of research (co-creation) through various scientific disciplines and approaches and through various links in the knowledge chain and (societal) stakeholders also facilitates knowledge sharing.

NWO wants to facilitate knowledge sharing by increasing the collaboration with users. In doing this, NWO further builds upon the experience of various organisational units of NWO with research programming, funding modules for participation of (intermediary) end users and activities to make knowledge sharing, knowledge exchange and impact or implementation with and by end-users possible during and after the conclusion of research projects. NWO will also create possibilities for sustainable infrastructural (knowledge sharing) facilities, such as innovation and implementation networks, knowledge roundtables and academic workplaces.

NWO sees an added role in utilising knowledge developed from research (valorisation) to create societal impact. A combination of excellent knowledge, entrepreneurial education and accelerator programmes encourages the establishment of start-ups, which can convert this knowledge into marketable innovations. Where possible, NWO aims to contribute to professionalising the ecosystem of start-ups and the knowledge economy.

Co-funding

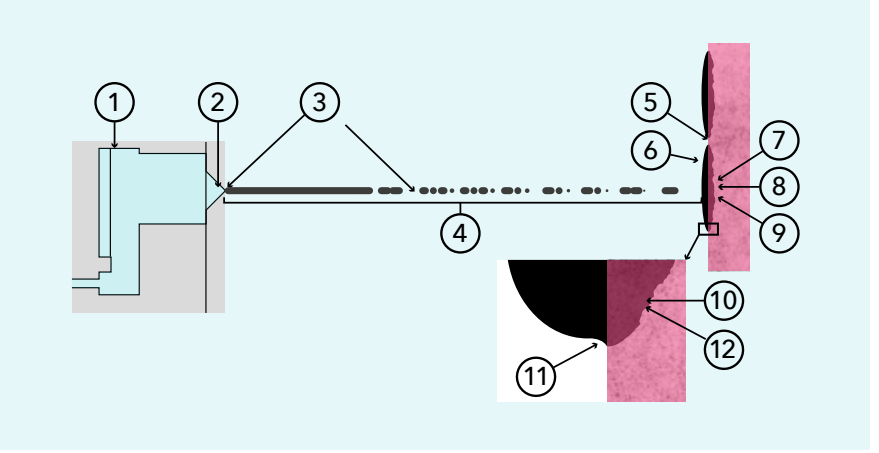
Involving societal stakeholders in the formulation and realisation of research programmes and research projects can also ensure greater commitment from the stakeholders.[24] NWO will continue to make public-private and public-public partnerships in research possible. Various possibilities will be made available to participate with money, expertise or knowledge. NWO will, of course, give due consideration to intellectual property rights. In recent years, several institutional forms of collaboration have been started in which NWO collaborates with other parties over a period of many years. In the next strategy period, NWO will evaluate these relatively new forms of collaboration so that the experiences acquired can be used to further improve the concepts.

24 *Kiezen voor duurzame groei. Report Studiegroep Duurzame Groei* (2016).
See: https://www.rijksoverheid.nl/documenten/rapporten/2016/07/06/advies-studiegroep-duurzame-groei

Four examples of public-private partnerships

Inkjetprinting: Océ, UT, TU/e

NWO is involved in a 12-year collaborative programme with the University of Twente, Eindhoven University of Technology and Océ to improve the fundamental understanding of inkjet printing. In the NWO Industrial Partnership Programme (IPP), the entire inkjet process is analysed: from the design of the actuator and the development of droplets to the ink-paper interaction.



The fluid dynamics of ink jetting takes centre stage in the twelve PhD projects of the IPP with Océ. Each of the projects explores a specific aspect of the process in detail.

The collaboration is characterised by the long-term perspective and the embedding of the research in the company. Océ accommodates of part of the research group, which is led by two scientific group leaders who are also funded by the programme. This setup guarantees an optimal transfer of knowledge.

Center for Nanolithography: ASML, NWO, University of Amsterdam, VU Amsterdam
The Advanced Research Center for Nanolithography was founded from a collaboration between ASML, NWO, University of Amsterdam and VU Amsterdam. The centre focuses on the fundamental science underlining current and future lithography techniques, the most important technology for producing computer chips and processors for PCs, smartphones and tablets. The scientific programme of the centre is closely connected with the interest areas of ASML. The private and public parties each contribute fifty percent to the basic funding of the centre.

Chemical Building Blocks Consortium: Shell, AkzoNobel, BASF, NWO, Utrecht University, University of Groningen, Eindhoven University of Technology, government ministries
If the world population increases to about 9 billion people towards 2050, then this will place a heavy demand on the supply of raw materials, which will form a challenge for sustainability and for the liveability in urban areas. ARC CBBC focuses on complex chemical and energy issues that contribute to the transition towards a circular economy, sustainable chemical processes and clean energy in the case of a finite supply of raw materials. It is a public-private research centre founded from a collaboration between Shell, AkzoNobel, BASF, NWO, Utrecht University, University of Groningen, Eindhoven University of Technology, the Top Sector Chemistry, the Ministry of Economic Affairs and Climate Policy and the Ministry of Education, Culture and Science. The centre collaborates with most Dutch universities. The private and public parties each contribute fifty percent to the basic funding of the centre.

QuTech: TU Delft, TNO, NWO, ministeries
The Advanced Research Center for Quantum Computing and Quantum Internet is a public-private partnership between Delft University of Technology, TNO, the Ministry of Economic Affairs and Climate Policy, the Ministry of Education, Culture and Science, NWO and the top sector HTSM. The aim of QuTech is to develop quantum technology, such as inherently secure quantum network connections and quantum computers. QuTech intensively collaborates with Microsoft and Intel. With the awarding of a Gravitation programme to QuSoft (the Research Center for Quantum Software) in 2017, the Netherlands is strongly positioned to help realise a quantum computer in collaboration with other countries.

Impact ex ante assessment

NWO assesses funding proposals for research into societal breakthroughs beforehand on the basis of a clearly substantiated projection of the intended scientific and societal impact, for example by demanding a theory of change with impact pathways that have been made explicit.

Theory of change

A theory of change is a schematic representation or illustration that clarifies how a programme/project is expected to bring about changes for the target group concerned in a specific context. It shows the intermediate steps with which the activities to be undertaken contribute to the ultimate goal. To this end, the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goals and the assumptions underlying these goals are first formulated. Next, the boundary conditions and the causality between boundary conditions and objectives are identified. Subsequently, information is derived from this, such as when specific stakeholders should be involved and which type of activities should be undertaken at which point. With this approach, a better understanding can be obtained of how the change can take place and a better grip can be obtained on the planning, monitoring and evaluation.

An example of this is the Global Food Challenges programme of WOTRO. Within this programme, the theory of change outlines the intervention logic that must be followed to realise the intended change, which is global food security. The starting point (1) is a description of the various problem fields to be solved. Subsequently, the assumptions and causes underlying the problems are analysed (2). Within this, knowledge-related causes and the associated knowledge needs are identified (3). These needs are translated (4) one for one into research outputs that should be strived for. These outputs are subsequently used (5) by different groups of users who apply the knowledge and insights and adjust these to tackle the causes of the problems described. The outcomes of the research lie in removing these causes. As a result of this, the desired change is realised (6), and that is where the impact of the research lies. The route from outputs via outcomes to impact is specified in several specific impact pathways, along which the use, adaption and impact of knowledge over time is projected.

Industrial Doctorates and Societal Doctorates

NWO wants to continue the Industrial Doctorates programme and expand it to Societal Doctorates. The programme Industrial Doctorates focuses on facilitating collaboration between knowledge institutions and companies, especially small and medium-sized enterprises. The programme Societal Doctorates facilitates collaboration with public partners. Within the programmes, a PhD candidate works at both the knowledge institution and the participating company or participating public organisation. Bringing scientific knowledge closer to companies and public organisations increases the chances of research results being applied in practice and eventually having societal impact.

Proof-of-concept grant

Fundamental and curiosity-driven research often has unexpected results that can also have societal impact. NWO will try to strengthen the societal impact of curiosity-driven research with the introduction of the proof-of-concept grant. This grant will enable researchers to explore the societal (including economic) potential of research previously funded by NWO.

5 Organisation

NWO wants to be a more flexible, effective and collaborative organisation that can respond better to developments in science and society. Realising this ambition is the most important organisational challenge for this strategy period. Furthermore, NWO wants to operate in a more sustainable manner, harmonise the funding instruments and invest in personnel policy.

Sustainability

NWO is an organisation that gives high priority to a sustainable environment. NWO contributes to such an environment by aiming for a paperless office, avoiding unnecessary use of plastic, making its buildings as climate neutral as possible and encouraging employees to use public transport.

Domains formulate specific strategies

NWO's role as a connector and funding body lies with four organisational units or research domains. They represent the various scientific disciplinary clusters. The domains will translate the NWO strategy into their own domain-specific strategies. The strategies will express the connecting role of the domains through multidisciplinary, domain-overarching activities, for example. In consultation with their field, the domains facilitate bottom-up programming and encourage collaboration between disciplines, with societal parties and within the knowledge chain.

Domains: unity in diversity

The four domains focus on different areas of science and aspects of the research and innovation system. They take into account fundamental and historical differences in research culture and allow for different expectations and institutional interests. Consequently, the working methods of the four domains cannot be entirely uniform. However, from the rationale that NWO operates as

a single entity and to make funding of domain-overarching research projects and programmes possible, the domains have a similar organisation structure. As such, NWO strives for unity in diversity.

Inclusive, sustainable development

WOTRO Science for Global Development coordinates an intersection and connection of the four domains for the funding of innovative scientific research into inclusive sustainable development and development cooperation issues in particular. The rationale behind this type of research is that inclusive development is a crucial condition for increased global equality, social justice and sustainability.

Harmonisation of funding instruments

NWO will harmonise the current funding instruments as much as possible to facilitate collaboration. As a result, researchers, irrespective of the research domain, will be subject to the same conditions as much as possible. Harmonisation will facilitate both applicants and NWO to work more across the boundaries of disciplines and domains. NWO will provide a limited palette of funding instruments with a clear number of modules. These modules can be combined in accordance with the objectives of the programme or call concerned. This approach will provide the flexibility needed to meet the needs of the various disciplines.

Funding lines

The harmonisation of instruments will provide the following palette of funding lines and each line will have a distinct objective:

1. **Talent Programme**: curiosity-driven, responsive-mode research aimed at research talent.
2. **Open Competition**: curiosity-driven research.
3. **Programmes for scientific or societal breakthroughs:** large-scale programmes based on the Dutch National Research Agenda, Knowledge and Innovation Agendas and the knowledge agendas of government ministries, where relevant in collaboration with public and/or private stakeholders.
4. **PPP**: projects or programmes in partnership with external public and/or private parties.
5. **Specific programmes**: projects or programmes in the context of, for example, the Merian Fund with third countries, the Netherlands Polar Programme, the User Support for Space Research programme, the Caribbean Research: a Multidisciplinary Approach programme, and the long-term strategic programmes of the NWO institutes.
6. **Infrastructure**: realising large-scale infrastructure.

In the majority of cases, the programmes and projects from the aforementioned funding lines will be built up from the following modules:

a. **Personnel**: researcher in training/PhD, postdoc, researcher, non-scientific personnel.
b. **Materials**
c. **Investments**: infrastructure and data files.
d. **Knowledge exchange**
e. **Internationalisation**
f. **Citizen Science**

Investing in personnel

The greater emphasis on collaboration and knowledge sharing in this strategy period requires a proactive role from NWO policy officers in connecting researchers with various disciplinary backgrounds, in connecting researchers with societal parties and citizens, and in advising on knowledge sharing. It also requires collaboration between NWO policy officers in influencing policy at both the national and European levels. In the personnel policy, explicit attention is given to identifying and developing the competencies required for this. Clear investments will therefore be made in NWO's personnel.

Institutes and domains

The relationship between NWO institutes and NWO domains is complex and can give rise to questions about the mutual dependency. In accordance with the *2025 - Vision for Science choices for the future* report, the two branches have therefore been administratively separated. By doing this, NWO is seeking to achieve a level playing field for the NWO institutes and the other knowledge institutions in the Netherlands. Additionally, NWO is working on a code of conduct that must prevent actual or apparent conflicts of interest. The independent supervisory board is monitoring this.

Result-focussed work

During this strategy period, NWO will develop into an organisation where all units will work in a result-focused manner on the basis of a coherent strategy. The five ambitions of the strategic plan provide the framework for the annual planning and control cycle (framework letter, annual plans, annual reporting), including financial planning, budget allocation and accountability.

Reflection on own performance

Each year, NWO will reflect on its own performance and, if necessary, make adjustments to the services it provides. NWO will also carefully evaluate its funding instruments and realises that it will take some time before the effects of many measures and research programmes become visible. During the evaluation of its funding instruments, NWO will consider the experiences of sister organisations in other countries. In 2020, the statutory evaluation of NWO will take place. Then it will become clear how successful NWO has been in realising its mission, achieving its ambitions and operating as a coherent, effective organisation. The evaluation can also be used as an opportunity to adjust the strategic course.

What does the strategy mean for the researcher?

Fewer front offices, more contact, monodisciplinary and multidisciplinary research

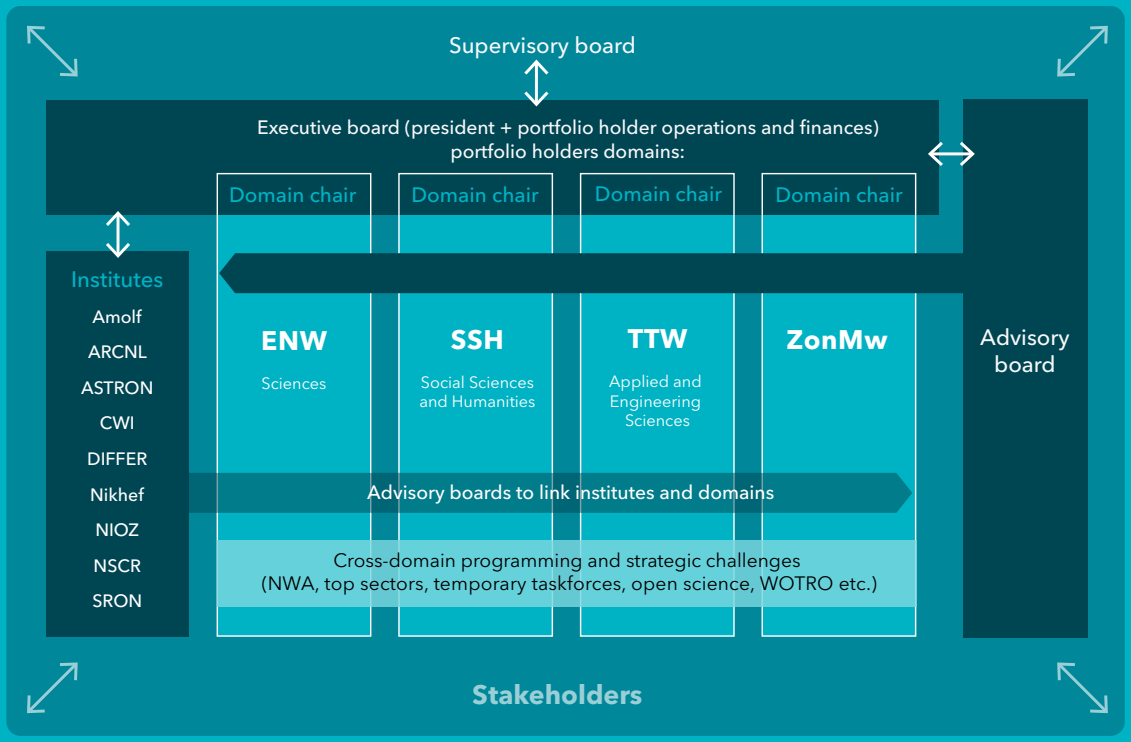
As a result of the new strategy, there will be fewer funding instruments, the grant conditions will become more uniform and the compartmentalisation of research resources will be reduced. The number of front offices will also drastically decrease. This will not in any way curtail the possibility to submit monodisciplinary research proposals. Direct contact with subject-specific policy officers will remain or, if necessary, be strengthened.

From small short projects to long-term large consortia
It will be possible to submit research proposals that range from small projects and high-risk projects to longer term, thematic or strategic research in larger consortia, whether or not in collaboration with private or public partners. There will be a new and separate budget for research set up in the context of the Dutch National Research Agenda and there will be more structural funding for infrastructure, including ICT facilities.

Platform for consultation
In the new system for funding research, consultation between researchers and other parties during the preparation of research proposals will be essential. NWO will assume responsibility for facilitating this consultation and will provide a platform for this.

Annexes

Organogram NWO per January 2018



I

Description domains and taskforces

Domains

Domain Science (ENW)

The NWO Domain Science encourages excellent research through research funding and agenda setting. It acts as coordinator of natural sciences research in the Netherlands. The domain connects researchers with each other and with societal organisations and companies. The domain's actions include the organisation of meetings and maintaining close contact with its stakeholders, for example.

Domain Social Sciences and Humanities (SSH)

Research in the social sciences and humanities focuses on important questions into who we are and what is needed to shape and maintain happy, healthy and resilient societies. Social sciences and humanities increase the ability to understand and respond to complex individual, social, cultural and economic issues. Knowledge and insights from the social sciences and humanities are a source of creativity, contribute to effective innovation, and provide a new view of culture and society both current and past. The NWO Domain Social Sciences and Humanities funds research, supervises current projects and programmes, and brings science, practice and policy together to facilitate the transfer of knowledge.

Domain Applied and Engineering Sciences (TTW)

The NWO Domain Applied and Engineering Sciences connects people and resources to develop technology with an added economic value that contributes to solving societal issues. This is done through funding excellent technical-scientific research, by bringing

together users and researchers, and by supervising projects towards optimal opportunities for knowledge exchange and impact. Various funding instruments are available.

Domain ZonMw

Progress requires the development and application of knowledge. With a view to this, ZonMw encourages healthcare research and innovation. With dozens of programmes, ZonMw serves the entire care innovation cycle, which ranges from fundamental research through to the implementation of new treatments, preventive interventions and improvements in the structure of healthcare. When selecting grant proposals, ZonMw always looks for innovation, with an assessment of societal relevance and scientific quality. ZonMw therefore does justice to the complexity of societal and health-specific challenges, and citizens receive affordable care and high-quality support.

WOTRO Science for Global Development

As a domain-overarching initiative within NWO, WOTRO programmes, funds and facilitates research for inclusive global development. WOTRO's programmes are aimed at providing knowledge and expertise that contribute to sustainable solutions for societal and ecological problems in low- and middle-income countries. Together with partners, WOTRO develops research programmes that encourage innovative forms of research with and within these countries. To increase the impact of the research, WOTRO makes considerable efforts to realise the sharing of knowledge and the use of research results in policy and practice. For this, it is vital that local knowledge institutions and societal actors participate from the developmental phase of the research onwards.

Taskforces

Netherlands Initiative for Education Research (NRO)

The Netherlands Initiative for Education Research contributes to improvements and innovation in education by coordinating and funding educational research and by improving the connection between research and practice. NRO has three main tasks. The first is to encourage the coherency of educational research through coordination at the national level. The second is to award funding to high-quality research. The third is to encourage knowledge exchange and impact through a better connection between science and practice and between science and policy.

Taskforce for Applied Research (NRPO-SIA)

The Taskforce for Applied Research (NRPO-SIA) funds and encourages practice-oriented research by universities of applied sciences. It provides the basis for a fully-fledged source of indirect government funding for practice-oriented research for the universities of applied sciences. The research is carried out in collaboration with companies and the public sector and is vital for generating and disseminating new knowledge for education and professional practice. The taskforce also initiates activities aimed at developing research conducted at universities of applied sciences and translating this to education and professional practice. The taskforce strengthens NWO in covering the knowledge chain that ranges from fundamental research to innovation in professional practice.

II

Description institutes

AMOLF

AMOLF carries out preeminent research on the fundamental physics and design principles of complex matter. This research leads to fundamental insights on topics such as the nanoscale interaction of light and matter, the programmable properties of metamaterials, and the molecular mechanisms underlying cellular functions. AMOLF uses this knowledge to create novel functional materials, and to find solutions in the fields of renewable energy and materials, green ICT, and healthcare. AMOLF initiates and develops new lines of research in the Netherlands in the field of functional complex matter and materials and does this in close collaboration with universities, companies and other institutes.

ARCNL

ARCNL is a public-private partnership between NWO, the University of Amsterdam, VU Amsterdam and the semiconductor equipment manufacturer ASML. ARCNL performs fundamental research, focusing on the physics and chemistry involved in current and future key technologies in nanolithography, primarily for the semi-conductor industry. While the academic setting and research style are aimed at scientific excellence, the subjects in ARCNL's research programme are closely connected with the interests of ASML.

ASTRON

ASTRON does fundamental astronomy research and designs and manages some of the world's leading radio telescopes. The Westerbork Synthesis Radio Telescope is still one of the best telescopes in the world. ASTRON also designed, developed and now operates LOFAR, which is measuring the earliest phases of the universe,

transient flashes in the sky, rotating neutron stars and colliding black holes. Furthermore, ASTRON is a partner of the Square Kilometre Array, which will be the world's largest and most sensitive radio telescope. The knowledge gained by building Westerbork and LOFAR is immensely valuable for the design and construction of SKA.

CWI

Centrum Wiskunde & Informatica (CWI) is the national research institute for mathematics and computer science. CWI conducts fundamental research in mathematics and computer science and conveys knowledge from these fields to society. Excellence is CWI's highest priority. CWI is a birthplace of new research areas and the institute is a breeding ground for talent. CWI has a unique identity and is a place where fundamental and applied research as well as mathematicians and computer scientists come together in virtually every single research group.
CWI is the founder of QuSoft (with University of Amsterdam and VU Amsterdam), which is carrying out research into software for the quantum computer and plays a leading role in national and international networks.

DIFFER

DIFFER carries out fundamental research into materials, processes and systems for a global sustainable energy infrastructure. As the national expertise centre for nuclear fusion and solar fuels, the institute closely collaborates with national and international research institutions and companies. With this, it is building an active national community for energy research. DIFFER manages the leading international research facility Magnum-PSI for nuclear fusion research. As the national partner in the European consortium EUROfusion, DIFFER coordinates the Dutch contribution to the worldwide nuclear fusion project ITER.

Nikhef

The National institute for subatomic physics Nikhef researches the elementary building blocks of our universe, their mutual forces and the structure of space and time. Within the institute, the development of theories and the

analysis of measurement data as well as the design and construction of instruments are brought together. To this end, Nikhef develops innovative technologies together with companies and facilitates knowledge and technology transfer.
As a partnership between NWO and five Dutch universities, Nikhef coordinates and leads Dutch experimental activities in the area of particle physics (especially at CERN) and astroparticle physics.

NIOZ

NWO-NIOZ Royal Netherlands Institute for Sea Research is the national oceanographic institute and principally performs academically excellent multidisciplinary fundamental and frontier applied marine research addressing important scientific and societal questions pertinent to the functioning of oceans and seas. Secondly, with its research vessels and seagoing equipment, NIOZ serves as the national marine research facilitator (NMF) for the Dutch scientific community. Thirdly, NIOZ stimulates and supports multidisciplinary fundamental and frontier applied marine research, education and marine policy development in the national and international context.

NSCR

The NSCR conducts independent, fundamental and multidisciplinary research into crime and law enforcement, to achieve scientific progress and evidence-based knowledge for society in general and for the criminal justice system in particular. The NSCR aims to collect and maintain unique longitudinal datasets that facilitate and renew national and international high-quality research on crime and law enforcement. The institute develops and maintains a national and international network of research partners, trains early-career researchers, and provides evidence-based knowledge that informs criminal justice policy-making and analysis.

SRON

SRON makes breakthroughs possible in scientific research from space. The institute carries out astrophysical, earth-oriented and exoplanetary research, with the

Earth-atmospheric research giving specific attention to air pollution and climate development. For this, SRON develops groundbreaking technology and advanced space instruments. As a national expertise institute, SRON advises the government and coordinates national contributions from science to the international space missions of ESA, NASA and JAXA, among others. In that role, the institute also encourages collaboration between the scientific community, technological institutes and industry. In addition, SRON facilitates societal applications of space technology.

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