The
Federal Government

HIGH-TECH STRATEGY 2025
Talents. Skills. Innovations.

The High-Tech Strategy 2025 Progress Report

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Foreword

Education, research and innovation are of central importance for safeguarding our future. They form the basis for economic, social and technological progress. Through research and innovation, we want to transform our lifestyles and economy in such a way that competitiveness, the preservation of the natural life-support systems and social equity become compatible.

To achieve these goals, we adopted the High-Tech Strategy 2025 in September 2018. This is the strategic framework for our research and innovation policy. The High-Tech Strategy 2025 underpins our goal of stepping up investment in research and development from the current level of approximately 3 per cent of Germany's gross domestic product per annum to 3.5 per cent by 2025.

We want Germany to remain at the cutting edge of innovation worldwide. And to achieve this, we must do more. This is because innovation is becoming more and more dynamic and digital, which creates new challenges. We are facing up to these challenges – and breaking new ground as we go. We want to offer science, businesses and society an open environment in which to test new ways of acquiring, disseminating and exchanging knowledge, and we must engage new partners. Strategically opening up science, research and innovation is a response to the growing innovative drive.

We have already done a great deal to prepare Germany well for the future. Last year, we launched a range of research and innovation policy measures within the High-Tech Strategy 2025 and set out important milestones. Interministerial missions such as combating cancer, reducing plastic discharged into the environment, and achieving substantial greenhouse gas neutrality in industry are being developed in collaboration with science, industry and society. Our major goal is to tangibly improve the quality of life of all citizens. It is therefore important to us to involve the people in our country in discussions on the future of research and innovation. After all, we can only further improve and strengthen our research and innovation policy if we all pull together taking account of the diverse perspectives.

Anja Karliczek
Member of the German Bundestag
Federal Minister of Education and Research

1. KEY FEATURES IN BRIEF

The High-Tech Strategy 2025 (HTS 2025) forms the strategic framework of the Federal Government's research and innovation policy. With this strategy, the German government is helping to meet the societal challenges of 'Health and Care', 'Sustainability, Climate Protection and Energy', 'Mobility', 'Urban and Rural Areas', 'Safety and Security' and 'Economy and work 4.0'. The aim is to shape our economy, working life and lifestyles in such a way that competitiveness, the preservation of the natural life-support systems, and social equity become compatible. To drive innovation, HTS 2025 has adopted a mission-oriented approach bringing together the activities of the ministries involved with relevant players from the science and research community, the private sector and civil society.

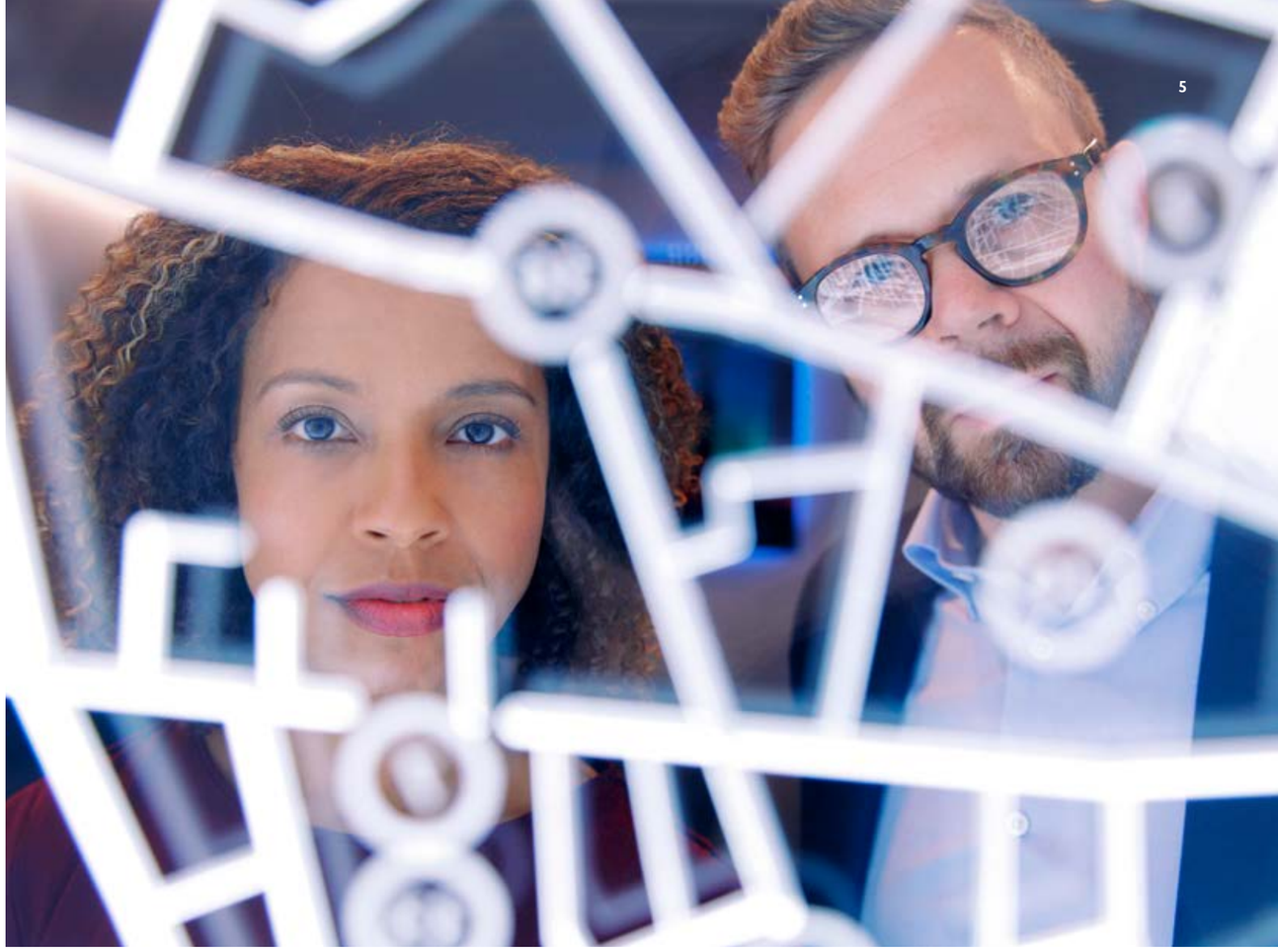
The development of the technological basis and the potential of skilled workers as well as citizen participation must go hand in hand. This is where important decisions in technology funding, such as the adoption of the Federal Government's Artificial Intelligence (AI) Strategy and education policy initiatives such as the 'Digital Pact for Schools' or the new Skilled Labour Strategy come together. The continuation of the Pact for Research and Innovation and the 'Contract for the Future of Higher Education and Teaching' were adopted in 2019, and the future Universities of Excellence were also selected in 2019. This will sustainably strengthen the scientific and research landscape in Germany.

HTS 2025 contributes to an open innovation culture that is characteristically dynamic and agile and puts knowledge into effect through the transfer of research results into practical application. Crucial decisions have been made: the Agency for Breakthrough Innovations (SprinD) is currently being set up to promote radical technological and market-changing innovations. The Innovation Cluster Initiative was launched in August 2019 with the aim of rapidly transforming emerging fields of knowledge and technology into new added value. In May 2019, the Federal Cabinet set a draft bill on tax incentives for research and development (R&D) in motion to provide even better support for the research efforts of German companies. Measures such as the 'GO!' start-up offensive launched in November 2018 will also further boost the start-up culture in Germany.

As a unifying component, twelve HTS 2025 missions form the framework for current initiatives of the Federal Government. The missions cover health, good living and working conditions, mobility, AI and an open innovation culture. In addition, a number of the missions also address environmental and sustainability challenges for present and future generations. We have achieved important milestones.

In January 2019, for example, the National Decade Against Cancer was launched with the aim of reducing the number of people newly diagnosed with cancer, detecting cancer earlier, and providing better treatment in the future.

As part of the mission to achieve greenhouse gas neutrality in industry, the Competence Centre on Climate Change Mitigation in Energy-intensive Industries (KEI) will be opened in Cottbus in 2019. Another research institute for low-carbon industrial processes will be located in Cottbus and Görlitz/Zittau.



The establishment of a sustainable circular economy is promoted by contributions from the framework programme Research for Sustainable Development (FONA) and the Bioeconomy research strategy. Also, from 2020 onwards, the new Lightweight Construction Technology Transfer Programme will promote knowledge and technology transfer in lightweight construction taking a life cycle assessment into account.

In June 2019, a further mission on mobility saw the adoption of the Action Plan Automated and Connected Driving, a joint research framework of the Federal Ministries of Education and Research (BMBF), Economics and Technology (BMWi), and Transport and Digital Infrastructure (BMVI). The first funding phase of the research agenda for 'Sustainable Urban Mobility' will conclude at the end of 2020 with ideas for mobility from 50 local governments.

As an adaptive strategy, the HTS 2025 aims to react quickly and purposefully to changing trends in the innovation system. The implementation and further development of HTS 2025 is therefore accompanied and supported by the High-Tech Forum (HTF) made up of experts from science, industry and civil society. The results of HTF consultations are consistently being provided to the round table of State Secretaries for HTS 2025. This establishes a constant dialogue between policy makers and the HTF.

The measures described fall within the remit of the relevant Federal Ministries, where they are financed under the budgetary and financial principles currently in force (including positions/permanent posts). Additional demand for material resources and personnel is counter-financed in each respective individual plan.

2. PROGRESS OF KEY INITIATIVES WITHIN THE FRAMEWORK OF THE HIGH-TECH STRATEGY 2025

The HTS 2025 provides impetus for innovation. It forms the strategic framework of the Federal Government's research and innovation policy and is intended to encourage a large number of actors to play an active role in shaping progress in our country.

Three fields of action of HTS 2025 focus on research that benefits the people – tackling the grand challenges, developing future competencies, and establishing an open innovation and venture culture. HTS 2025 covers a broad spectrum of societal challenges that can be assigned to the focus areas of 'Health and Care', 'Sustainability, Climate Protection and Energy', 'Mobility', 'Urban and Rural Areas', 'Safety and Security' and 'Economy and work 4.0'. As recommended by the Expert Commission on Research and Innovation (EFI), digitalisation has been set as a cross-cutting topic in HTS 2025.

To promote the implementation of research results, HTS 2025 adopts a mission-oriented approach to bring together the activities of the ministries involved in the fields of action and relevant players from the science and research community, the private sector and civil society. In this way, the missions contribute to research and innovation having an even greater orientation towards overcoming pressing societal challenges. It is the goal of HTS 2025 to achieve tangible progress in the quality of life of all citizens. For this reason, we aim to ensure that the acquisition and implementation of knowledge is supported by a broad social consensus and that reflection on the social consequences is an inherent part of the strategy.

Our aim is to shape our economy, working life and lifestyles in such a way that competitiveness, the preservation of the natural life-support systems and social equity are compatible. In many areas, innovation is the key to promoting development that is at once economically, socially and environmentally friendly. HTS 2025 has close substantive links to the target system of Sustainable Development Goals (SDGs) adopted on an international level in 2015. In a time when rapid changes are taking place, all players must stay alert to the constantly shifting landscape. As an adaptive strategy, HTS 2025 is designed to react quickly and purposefully to new trends. The Federal Government's research and innovation policy is therefore open to a variety of technologies and non-technological approaches to tackling problems or meeting challenges.

Never before has so much research and development been taking place in Germany as there is today. In 2017, expenditure on R&D rose to 3.04 per cent of the gross domestic product (GDP), of which 2.1 per cent came from the private sector and 0.94 per cent from government funding. In 2018, Federal investments made under the umbrella of the HTS amounted to more than 15.8 billion euros (target). The Federal Government, in conjunction with the Länder and the private sector, has set itself the target of investing 3.5 per cent of GDP per annum in R&D by 2025. This target is in line with the EFI's recommendation. HTS 2025 underpins the goal of stepping up investment in research and development. This is one of the central challenges of the coming years. This goal can only be achieved if policymakers and the private sector work together.

To enhance the development of HTS 2025, we need innovative forms of cooperation that create spaces for ideas, involve new players, and increase civil society's participation in the dialogue on the future of research and innovation in Germany. A commitment to strengthening participation is therefore firmly enshrined in HTS 2025. The Federal Government's successful research and innovation policy in the framework of the HTS has also been supported for three legislative periods by comprehensive consultation that includes all groups of stakeholders involved in innovation activities.

2.1 Tackling the grand challenges

The Federal Government is contributing to overcoming societal challenges through a variety of measures within the framework of HTS 2025. The aim is to achieve leaps in quality that are tangible and perceptible to people in their environment in the six fields of action 'Health and Care', 'Sustainability, Climate Protection and Energy', 'Mobility', 'Urban and Rural Areas', 'Safety and Security' and 'Economy and work 4.0'.

Health and Care

For an active and autonomous life for people in Germany, we rely on high-performance health research, international research partnerships, and the use of digital innovations in medicine and healthcare.

The following milestones have been achieved to date:

- The National Decade Against Cancer began in January 2019. This will concentrate our resources over the next ten years to reduce the number of people developing cancer, to detect cancer earlier and to better treat it in the future (see also the 'Combating cancer' mission, page 24).

- February 2019 saw the establishment of the 'Global Health Hub Germany'. This provides a German base from which we can fight diseases worldwide and forge ahead with prevention projects.

- With our 'Future of Care' competition, we have established a national nursing care innovation centre with four nursing care practice centres. We are promoting cutting-edge technologies for health applications with innovative human-machine interfaces in two innovation clusters for prosthetics/orthotics and networked microimplants.

- We are continuing our efforts to ensure that a research-compatible electronic health record (EHR) is available at all German university hospitals by 2025 (see also the mission 'Digitally networking research and healthcare – for intelligent medicine', page 26).

Sustainability, Climate Protection and Energy

For the benefit of present and future generations, we have firmly enshrined the guiding principle of sustainable and climate-friendly development in both our research and innovation policy and our education system. Innovations make an important contribution to sustainable development. They are urgently needed to achieve the sustainability and climate goals of Agenda 2030 and the Paris Agreement (see also the missions 'Achieving substantial greenhouse gas neutrality in industry', page 28, and 'Creating sustainable circular economies', page 33).

The following milestones have been achieved to date:

- In September 2018, the Federal Government adopted the 7th Energy Research Programme. Transformation of the overall system is moving into the focus of research funding, with the central research fields being energy efficiency and renewable energies, as well as cross-system research topics on digitalisation, sector coupling, and energy system transformation in the heating, industrial and transport sectors, and including investigation of social issues. To this end, around 6.4 billion euros will be made available in the period from 2018 to 2022, an increase of around 45 per cent over the previous programme. In July 2019, the 20 winners of the ideas competition on 'Real-World Laboratories for Energy System Transformation' were announced. Work is being carried out in selected real-world laboratories in the fields of green hydrogen technologies, energy-optimised neighbourhoods, and large-scale power storage facilities to promote research for climate protection and energy system transformation.

These and other initiatives under the auspices of the German government's 7th Energy Research Programme such as Carbon2Chem and Synthetic Fuels lay the foundation for new value-added models.

- June 2019 saw the launch of the science platform for the Climate Protection Plan 2050. The platform provides scientific expertise to support the Federal Government in the implementation and ongoing development of Germany's long-term strategy for climate protection (Climate Protection Plan 2050) and of programmes of initiatives. An interdisciplinary steering group with up to ten scientists and researchers from renowned institutes will manage the platform.

- In future, the bioeconomy will be promoted in a united effort as part of an overall strategy. This will create a comprehensive framework for increasing the focus of future strategic activities on the bioeconomy, which were previously divided into a research strategy and a policy strategy. According to current planning, the cabinet session will take place in late summer 2019.

- The 'Dialogue Platform Industrial Bioeconomics' was launched in October 2018. Four working groups have been set up to deal with a variety of topics. The first interim reports are to be presented at the end of September 2019.

- The content design for the planned continuation of the FONA framework programme was discussed with representatives from science and research, civil society, the private sector, politics and administration. We are continuing our interministerial work to develop a sustainable approach to plastics and to counteract the loss of biodiversity (see also the missions 'Substantially reducing plastic discharged into the environment', page 30, and 'Preserving biological diversity', page 35).

- July 2019 saw the launch of the Innovation Programme Future Building. This programme provides important impetus for the construction industry concerning climate protection, energy and resource efficiency, affordable construction, design features in the (urban) planning context and for coping with demographic change. New features are to be found in particular in the research funding aspect of the Innovation Programme Future Building, which has introduced the new categories of basic research, industrial research, experimental development and feasibility studies to support all stages of innovation development through to market-driven activities.

Mobility

To achieve intelligent and low-emission mobility, we want to jointly shape change in the mobility sector with stakeholders such as the Länder, local governments and their citizens, a high-performance science and research community, and a competitive private sector. Mobility research is focusing more intensively on the entire range of mobility provision in urban and rural areas, taking account of climate policy and sociological perspectives and insights from the social sciences (see also the mission 'Developing safe, networked and clean mobility', page 40).

The following milestones have been achieved to date:

- In February 2019, we published the projects 'MobilitätsWerkStadt 2025' (for local mobility concepts) and 'MobilitätsZukunftsLabor 2050' (a mobility innovation lab) as part of the research agenda for 'Sustainable Urban Mobility'. Project launch is planned for spring 2020, with the aim of funding communal models that develop locally relevant, integrated and sustainable mobility concepts and test their implementation, as well as integrating mobility research on overarching issues, practical trials and sophisticated impact and synthesis research.
- Since June 2019, the new 'Action Plan Automated and Connected Driving', a joint research framework of the BMBF, BMWi and BMVI has bundled priorities and guidelines for the future orientation of research funding for autonomous driving. The action plan offers many benefits, ranging from increased road safety and efficiency to concepts for low-emission, intelligent and innovative mobility.
- The national competence network for Sustainable Urban Mobility (NaKoMo) was founded in spring 2019. NaKoMo serves to improve networking between local governments, the Federal Government and the Länder and disseminates the findings from the projects supported under the 'Digitalisation of Municipal Transport Systems' funding directive.

- Through the Federal Aviation Research Programme (LuFo), the Federal Government and the Länder support projects that work on technology for the next generation of commercial aircraft and beyond. The LuFo VI programme, which is currently being rolled out, will step up the promotion of climate-friendly innovations, for example through its own funding line in (hybrid) electric manned flying. It also supports the development of new low-emission and low-noise aircraft configurations that are suitable for urban air mobility. In the industry 4.0 programme line, new production technologies are being researched along with their digital modelling and networking with the aim of implementing autonomous, highly automated manufacturing systems and advancing the development of classic maintenance processes into needs-based maintenance strategies.

Urban and Rural Areas

It is our concern that all regions, cities and rural areas develop into and remain viable and sustainable living and economic areas. Through R&D, we are contributing to the development of new technologies, social innovations and creative business ideas and are thus positively influencing economic performance and quality of life even in structurally weak regions (see also the mission 'Ensuring good living and working conditions throughout the country', page 42).

The following milestones have been achieved to date:

- We have set up 'futures centres', which track and accelerate dynamic trends, to support digital change in the east German Länder. The European Social Fund (ESF) and the Federal budget alone have set aside more than 36 million euros for the futures centres until June 2022. The futures centres will support the states of Brandenburg, Mecklenburg-Western Pomerania, Saxony, Saxony-Anhalt and Thuringia in coping with the major transformation processes and, above all, in shaping them in a socially positive way. The programme is thus aimed at promoting the autonomous learning and organisational skills of small and medium-sized enterprises (SMEs), their employees and self-employed people, in particular sole traders, in transformation processes and at boosting their performance and competitiveness.
- The 'Chancen.Regionen' concept amalgamates funding instruments to promote structurally weak regions in Germany, while integrating different perspectives from education, research and innovation. The core of the concept is the 'Innovation and Structural Transformation' family of programmes, whose measures are based on existing potential in these regions in order to stimulate new regional dynamics.
- The Institute for Social Cohesion (FGZ) will examine, among other things, the structures of participation and cohesion in rural and urban living spaces. This will focus in particular on the dialogue between the science community and society. The institute is currently in the start-up phase and will begin its research work in 2020.
- In April 2019, the Federal Government and the Länder agreed on an immediate action programme to shape structural change in the lignite mining areas. These districts are provided with initial incentives through the immediate action programme, which include the establishment of the CASUS research centre in Lusatia and initiatives in the Rhineland district to create a model region for security of energy supply and resource security.
- In November 2018, eight cities were selected as part of the 'City of the Future' competition to implement ideas for sustainable development that citizens developed jointly with representatives from research and science.
- We have earmarked 750 million euros to promote and support around 50 model projects for smart cities. The aim is to spread the experience of the model projects through comprehensive knowledge transfer and to enable all local governments to deal with digitalisation in a creative and strategic way.

- Based on the recommendations of the expert working groups in the 'Equivalent Living Conditions' commission, whose task it was to examine the fair distribution of resources and opportunities for all people living in Germany and to make proposals to foster equivalent living standards in Germany, the Federal Cabinet adopted twelve implementation initiatives of the Federal Government on 10 July 2019 as a first step towards this. This includes the establishment of a nationwide German support system for structurally weak regions. Both urban and rural regions are under scrutiny so that they can catch up more quickly with the structurally stronger regions through growth and innovation.

- Since 2019, the Federal Government has been supporting model and research projects throughout Germany through the Federal Rural Development Scheme in order to create and process knowledge for rural development. The topics are as varied as the societal challenges and range from digitalisation and voluntary work through to mobility. The model project 'Smart Rural Areas' is currently under preparation. Seven rural districts will be selected which will be supported for five years in the development and implementation of digital and innovative solutions. The 'Land.Digital' model demonstration project for digitalisation in rural areas runs until 2022.

Safety and Security

We want people in Germany to be able to rely on security and order and to contribute to the protection of an open and free society. By funding research into civil and IT security, we aim to meet new security requirements and new risk potentials. We want to be among the global leaders in quantum technology. We want to be pioneers of this technology for tap-proof communication and a strong driving force in the European Union (EU).

The following milestones have been achieved to date:

- We have continued and further expanded our support for civil security research. The Federal Government's framework programme 'Research for Civil Security', which runs until 2023, also engages with the opportunities and potentials associated with digitalisation and artificial intelligence. For example, with the help of two competence centres for robotic systems in hostile environments, security-relevant autonomous innovations are being developed and supported in their transfer into practice.

- The Federal Government's research framework programme on IT security 'Self-determined and Secure in the Digital World', which runs until 2020, supports the development of innovative IT security solutions for application areas such as production, transport, medicine and critical infrastructures. In particular, three competence centres for IT security research were established in Saarbrücken (CISPA), Darmstadt (CRISP) and Karlsruhe (KASTEL), which have developed into outstanding locations in IT security research. The transfer of CISPA to a permanent research centre in January 2019 and the establishment of the new Max Planck Institute for Cyber Security and Privacy Protection are part of the targeted development of the German research landscape.

Economy and work 4.0

Our goal is to design a modern, data-based economy that is competitive, secure and sustainable. In exploiting the opportunities offered by digital change, people and their skills will continue to be the focus of the world of work and social policy (see also the mission 'Shaping technology for the people', page 44).

The following milestones have been achieved to date:

- In the research programme on 'Innovations for Tomorrow's Production, Services and Work', new solutions were successfully developed for production technologies in industry 4.0 as well as for lightweight construction, medical technology and additive manufacturing, with a focus on application in German SMEs.

- The Competence Compass research project was launched in April 2019. The initiative aims to identify competences that will be required in the future so as to provide orientation for the provision of education and training.

- The 'QI Digital' project brings together the expertise of the relevant authorities in the quality assurance infrastructure to successfully transfer the 'Made in Germany' quality seal into the digital world with digital certificates, cloud-based processes and new collaborations.

2.2 Developing Germany's future competencies

In order to find solutions to the major challenges, we will systematically and continuously develop Germany's future competencies. This is taking place on a three-tiered basis through technology, skilled workers and the participation of committed citizens. Through the three major science pacts 'Pact for Research and Innovation', 'Contract for the Future of Higher Education and Teaching' and 'Innovation in Higher Education', we will fund universities and research institutions with more than 160 billion euros over the next ten years. These three pacts set a decisive course for the scientific and research system in the coming decade.

The following additional milestones have been achieved to date:

The technological base

- In November 2018, we adopted an Artificial Intelligence (AI) Strategy, which focuses on the benefits of AI for humans and the environment. With this strategy, we want to remain at the forefront of AI research worldwide. For example, we are attracting top international researchers to Germany with the 'Artificial Intelligence Global Futures Labs' competition and creating the excellent requisite conditions by funding 100 additional AI professorships. As a first step, the Federal budget for 2019 will provide a total of 500 million euros to strengthen the AI strategy as of 2019. A further 500 million euros are to be made available from the 2020 financial year. The aim of these reinforcement funds is above all to promote the transfer of results from AI research into industrial practice and thus also allow new forms of work (see also the mission 'Putting artificial intelligence into practical application', page 47).

- The 'Framework Programme Quantum Technologies – from the Fundamentals to the Market' was adopted by the Cabinet in September 2018. The funding volume amounts to 860 million euros in the current legislative term.

- To ensure technological sovereignty in the area of our satellite infrastructure, we are currently establishing the Institute for Satellite Geodesy and Inertial Sensors of the German Aerospace Center e.V. (DLR) in Hanover and Bremen, the DLR Institute for Quantum Technologies in Ulm, and the DLR Galileo Competence Center in Oberpfaffenhofen. Furthermore, the Quantum Technology Competence Centre (QTZ) is being established at the national metrology institute Physikalisch-Technische Bundesanstalt (PTB). The most important objective is to support industry in the transfer of research results from the field of quantum technology into practical application.

- As part of an Important Project of Common European Interest (IPCEI), we are making one billion euros available until 2021 to support microelectronics as a key element in the digitalisation of the economy and the successful implementation of industry 4.0.

- In January 2019, we published the concept framework 'Battery Research Factory', which describes the strategic framework of battery research in Germany. The concept framework builds on the existing structures of German battery research. As part of the concept framework, results that are suitable for industrial use will be validated and demonstrated on a large scale in a research facility for battery cell production, which is to be located in Münster. In total, 500 million euros are to be made available over the next four years for the initiatives within the concept framework (see also the mission 'Building up battery cell production in Germany', page 38).

- In November 2018, a process was launched to develop an interministerial agenda dubbed 'From Biology to Innovation'. In autumn 2019, we will present the Cabinet with a key issues paper on the Bio Agenda which will set the framework for the further development and implementation of measures involving all relevant stakeholders. In this way, the Federal Government wants to contribute to the use of more biological resources, principles and processes in industry, taking into account the environment and nature conservation requirements. Among other things, this also aims to make an important contribution to achieving the climate protection targets.

- The Action Plan ErUM-Data, which aims to develop initiatives in digitalisation and research data management in basic research, is set to be published at the end of 2019. The action plan is part of the framework programme 'Exploration of Universe and Matter – ErUM'.

The skills base

Universities and research organisations:

- With the 'Contract for the Future of Higher Education and Teaching', we are investing in comprehensive improvements in the quality of studies and teaching at universities. To this end, the Federal Government and the Länder are providing around four billion euros each year for universities in addition to the basic funding (two billion euros from the Federal Government and two billion euros from the Länder).

- The aim of the 'Innovation in Higher Education' pact between the Federal Government and the Länder is to establish a permanent organisational body with an unlimited time frame and with permanent funding of 150 million euros per annum (initially provided by the Federal Government alone and from 2024 with Länder participation of over 40 million euros). The organisational body will promote projects for the implementation of new strategies, concrete topics or individual innovation projects in university teaching and the exchange and transfer of knowledge.

Education

- We have launched the Digital Pact for Schools. Over the next five years, the Federal Government has earmarked five billion euros for digital municipal education infrastructure and IT equipment at general and vocational schools.

- Our BAföG (student financial aid) amendment came into force on 1 August 2019, in time for the following winter semester: 1.3 billion euros will be invested in tangible improvements for students and their families. This eases the burden on mainstream society.

- The Federal Cabinet has resolved to modernise the Vocational Training Act (BBiG). This will make vocational education and training in Germany even more attractive, for example through the establishment of transparent advanced training levels and internationally compatible qualifications as well as a balanced minimum training allowance.

- In June 2019, a National Continuing Education Strategy was presented with which the Federal Government, the Länder, industry, trade unions and the Federal Employment Office intend to amalgamate and enhance their work in continuing training and qualification. Through this we are committing ourselves to a new continuing education culture in Germany that sees continuing education as a self-evident part of life.

- In December 2018, we adopted the Federal Government's strategy for developing domestic, European and international skilled labour potential. One focus in the area of domestic potential is to establish a new continuing education culture in Germany. In concrete terms, it is important to support those in employment in maintaining and adapting their qualifications and skills within the changing world of work and thus to ensure that the skilled workers we need to ensure Germany remains a strong business location are in the labour market of the digital future.

- The Vocational Education and Training Pact brought together a wide range of activities and initiatives for the ongoing development of a modern, attractive and dynamic vocational education and training system to form an overall strategy and comprehensive implementation agenda for the 19th legislative period.

- We are pooling a large part of the Federal Government's research funding in the field of education in the Framework Programme for the Promotion of Empirical Educational Research, for which around 250 million euros are to be made available until 2024.

- The Federal competition 'Shaping the Future – Innovations for Excellent Vocational Education and Training' (InnoVET) is providing 82 million euros to enable regional and industry-specific players to jointly develop and test innovative training and continuing education programmes.

- The second phase of the special programme to promote digitalisation in inter-company vocational training centres and their competence centres sees the investment of a further 120 million euros in modern training courses for trainees from SMEs by the end of 2023.

- The 'Vocational Training 4.0' umbrella initiative pools the diverse activities aimed at the structural and substantive orientation of dual-strand vocational training towards the requirements of an increasingly digitalised and networked economy.

- The MINT action plan, published in early 2019, pools funding measures and new initiatives to strengthen STEM education in Germany. This aims to systematically inspire young people for STEM topics and career prospects to ensure there will be enough skilled workers in the future so Germany remains capable of innovation.

- In May 2019, the Federal Cabinet updated its 'Strategy for International Cooperation in Vocational Education and Training'. This will augment existing instruments through joint Länder strategies so as to coherently and collaboratively serve the future needs of the cooperating Länder in vocational education and training, including the involvement of governmental and non-governmental actors.

- With Education for Sustainable Development (ESD) we are promoting the acquisition of skills for sustainable thinking and action. The Federal Government is committed to anchoring ESD in all areas of education as part of the UNESCO Global Action Programme on ESD. The National Action Plan on ESD will be continuously in effect until the target year 2030. This is the first time that an agenda for education for sustainable development has been jointly devised and supported by the Federal Government, the Länder, local authorities and representatives from business, science and civil society.

Societal participation

- We have further strengthened and expanded the area of citizen science. Increasingly, the funding lines of specialist programmes are including citizen science projects. In addition, 13 pilot projects are currently being funded to the amount of around five million euros as part of the 'Citizen Science' open-theme funding initiative. A second call for proposals with more funding for citizen science projects will be published in autumn 2019. The funding of the citizen science networking platform 'BürgerSchaffenWissen' will also continue. This reinforces the transfer between the science community and civil society through shorter innovation cycles and the use of crowd knowledge.

- We have carried out detailed processes in participative agenda setting. An example of this is the 'Agenda Process for Social-Ecological Research', which was ongoing until 2018 and defined topics for the future funding of socio-economic sustainability research. Concrete funding measures for the next five years will be decided on the basis of the results of this process.

- We believe in the involvement of civil society in committees. For example, civil society actors are represented in the HTF, the advisory body for HTS 2025. Various bodies with civil society participation have also been set up to implement the UNESCO Global Action Programme on Education for Sustainable Development (2015–2019) and are also envisaged in the planned successor programme from 2020.

- In order to discuss current research issues and the development of research and education policy at national and European level with people in Germany, regular dialogues are held with citizens on current topics, for instance within the framework of the 'Citizens' Dialogues on the Future of Europe' or on AI at the occasion of the Futures Conference 2019.

- The participation of society in the findings and successes of science is one of the strategic key objectives of the ErUM framework programme. The aim is to intensify the dialogue between the science community and civil society and to allow citizens to participate directly in the research process through new formats. Since 2019, the pilot project 'KONTAKT', which develops and tests such participation formats and new communication channels for basic research in physics, has been funded to the sum of 1.3 million euros.

2.3 Establishing an open innovation and venture culture

We are working to establish an innovation culture in Germany that is characterised by openness, agility, foresight and trust (see also the mission 'Finding new sources for new knowledge', page 50). We want to put knowledge into effect by transferring it into practical application, strengthen entrepreneurial spirit, and use knowledge and innovation networks in national and international cooperation. To this end, we want to support new forms of collaboration and open up spaces to specifically promote creative ideas and mobilise unused potential in Germany. This requires a broad concept of innovation that takes into account technical, non-technical and social innovations in equal measure and includes society as a central actor.

A strong research and innovation location also requires a regulatory environment that invites openness to innovation. Innovation is not an end in itself, but serves to ensure prosperity, promote social progress and achieve ecological compatibility. This also includes discussions on the relationship between the precautionary principle and the principle of innovation, which are conducted both among interested members of the public and with as well as within the Federal Government. In the Federal Government's view, the concept of innovation upholds the precautionary principle and existing protection standards. In addition, it also highlights innovations that add to reducing risks to people and the environment.

The following milestones have been achieved to date:

Putting knowledge into effect: Transfer into practical application

- March 2019 saw the official launch of the transfer initiative 'More ideas – more successes: How do we improve the German innovation ecosystem?' The transfer initiative will help companies translate scientific research results into products and processes. Building on the 'from idea to market' approach, we will continue developing and expanding the existing portfolio in collaboration with the innovation stakeholder to support the transfer of knowledge and technology.

- The nationwide establishment of digital experimental fields (digital test fields in agricultural enterprises) and the 'Digital Agriculture' competence network initiated in March 2019 are intended to support and promote the transfer of knowledge and technology from research to agriculture and the general public. The aim is to show how digital technologies can be optimally used in green professions to protect the environment, animal welfare, and biodiversity and make farmers' work easier.

- The funding guideline 'Mathematics for Innovations', published in March 2019, aims to promote innovative collaborative projects between scientific institutions and business enterprises to develop methods for dealing with large amounts of data, with the aim of transferring digital mathematical methods into practical application. Up to twelve million euros will be made available for the projects, which are scheduled to kick off in spring 2020.

- The guidelines for the new innovation programme for business models and pioneering solutions were published in summer 2019. Pilot funding for non-technical innovations broadens the scope to ideas from target groups such as digital start-ups, the cultural and creative industries and social innovators.

- The Next Generation Cluster Initiative was launched in August 2019 with the aim of rapidly transforming emerging fields of knowledge and technology into new added value. This transfer is also promoted within the framework of the 'go-cluster' excellence programme by supporting the most efficient clusters in Germany.

- In July 2019, the founding commission for the SprinD completed its work and submitted its consensual recommendations to the Federal Government. The agency is now to be set up without delay. It aims to promote radical technological and market-changing innovations and help them to achieve leverage.

- In autumn 2019 – subject to consultation with the Budget Committee of the German Bundestag – we will establish the Agency for Innovation in Cyber Security (Cyber Agency) in the Leipzig/Halle region. The first ideas competitions and the awarding of targeted research contracts are planned for 2019/2020.

Strengthening entrepreneurial spirit

- In May 2019, the Federal Cabinet launched a draft law on tax incentives for R&D (Forschungszulagengesetz – FzulG). With the introduction of a research allowance, we want to support the research efforts of German companies and give them a global competitive edge. The funding is intended in particular to encourage SMEs to expand their R&D activities. One of the EFI's central recommendations is to implement tax incentives for research.

- With the 'GO!' start-up offensive launched in November 2018, we want to boost our start-up culture and encourage more people to become entrepreneurs. Among other things, we have expanded the 'University-based Business Start-ups' (EXIST) programme and almost doubled its funding in 2019 to more strongly promote innovative start-up concepts at universities and in science.

- The new KfW investment company KfW Capital commenced operations in October 2018. The aim of the spin-off is to create a marketable structure with which KfW's commitment in the area of venture capital and equity financing can be quantitatively and qualitatively strengthened.

- The third venture capital fund of seed-stage investor High-Tech Gründerfonds (HTGF III) has been active since autumn 2017, providing finance of up to three million euros per enterprise for highly innovative, tech-driven companies. The prerequisites for financing are promising research results, an innovative technological basis and a promising market situation. In addition to the Federal Government and KfW Capital, private investors have also invested in HTGF III.

- In 2019, the number of private investors rose to 33, increasing the size of the fund to 319.5 million euros.

- Since the end of 2018, there have been two new modules in the modular Tech Growth Fund through the KfW 'Venture Tech Growth Financing' programme (total amount until 2022: EUR 250 million). The programme allows venture capital loans to be granted to innovative growth companies in the technology sector. The most recent module 'ERP–EIF Co-Investment Growth Facility' is currently being set up.

- As of 1 July 2019, the conditions for funding the ERP digitalisation and innovation loan were improved and the range for applicants was extended to include start-ups and young companies. In the summer of 2019, the comprehensive evaluation of the 'Central Innovation Programme for SMEs' (ZIM) was completed with positive results. This is an important milestone in the revision and further optimisation of the ZIM guidelines in 2020.

Using knowledge and innovation networks:

- The continuation of the Pact for Research and Innovation between 2021 and 2030 will make available 120 billion euros for non-university research. In this way, the Federal Government and the Länder are boosting the international competitiveness of German science and research and creating the requisite political and financial framework for research and innovation to thrive in Germany.

- In November 2018, the action plan 'ErUM-Pro' was published as part of the ErUM framework programme, which funds the networking of universities with innovative large-scale facilities. Around 212 million euros were available for 320 new projects in 2018 and 2019.

- In July 2019, the future Universities of Excellence were selected. This decision will foster top university research and support outstanding university locations with international appeal. Each year, the Federal Government and the Länder provide more than half a billion euros for the Excellence Strategy.

- The 'National Research Data Infrastructure' programme promotes the development of a sustainable and interoperable basis for research data management and data-based research in Germany. This lays the foundation for funding developments in the 'European Open Science Cloud Initiative'.

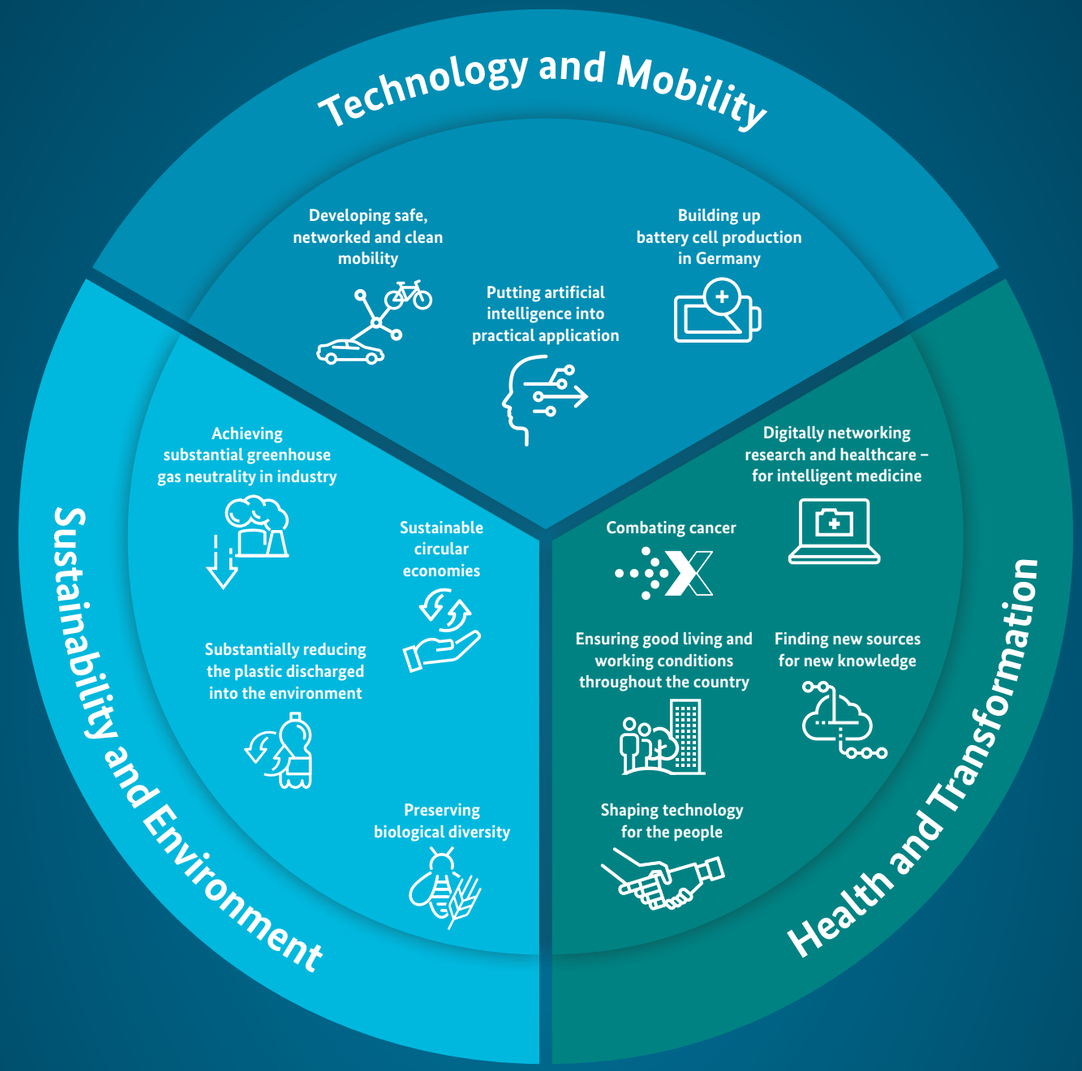
- A pilot project to foster international innovation networks was launched in 2018. The extension of national network funding as part of ZIM is meeting with lively demand and is already demonstrating considerable success.

3. MISSION-ORIENTED RESEARCH AND INNOVATION POLICY TO DRIVE INNOVATION

The twelve HTS 2025 missions form a unifying framework for diverse current initiatives of the Federal Government. During the preparation of HTS 2025, the ministries defined these missions in fields where it is necessary for all relevant players to unite forces behind a common goal in order to achieve further progress. With these missions as a new instrument of innovation policy, we want to strengthen interministerial cooperation in research and innovation policy and to implement research results in a targeted manner. This will increase the drive, connectivity and impact of research and innovation in many national policy areas. The missions of HTS 2025 cover health and care, decent work and living standards, mobility, AI and an open innovation culture. In addition, a number of the missions also specifically address environmental and sustainability challenges for present and future generations. The missions are designed for the long term; the first milestones and interim goals are to be reached during this legislative term.

Against this background, the individual missions of HTS 2025 have made varying degrees of progress. The current state of development and implementation is presented below. The ministries and partners involved in science, business and society and also the activities can still change.

The missions of HTS 2025 at a glance



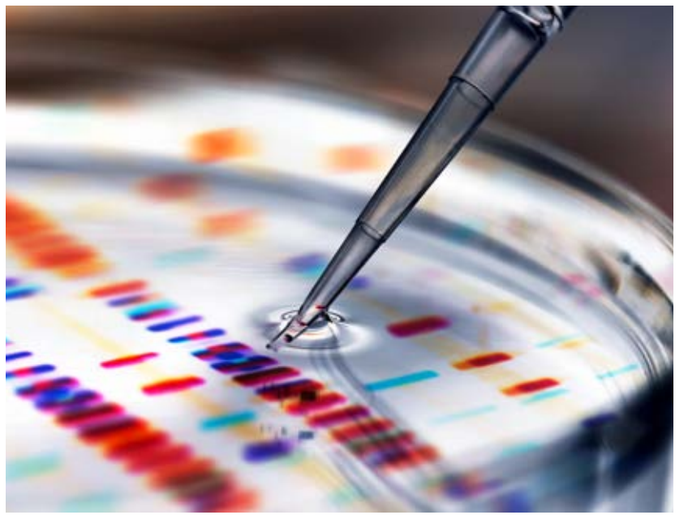
3.1 Combating cancer

Cancer is the second leading cause of death in Europe. In the next 20 years, the number of new cancer cases will double worldwide – despite great progress being made in understanding the underlying mechanisms. The causes are our ageing society and an unhealthy lifestyle. Approximately 40 per cent of all new cancer cases are attributable to controllable risk factors. This illustrates the great potential for preventing cancer. In order to further improve the prospects of patients after a cancer diagnosis, new possibilities for early detection, diagnosis, therapy and aftercare need to be researched, and the patients affected need to benefit as quickly as possible. Effective ways of prevention must be developed and implemented to reduce the number of new cancer cases in the long term. In addition, the networking of research and care must be improved so that innovations reach the general public more quickly and specifically and benefit all people.

Goals of the mission

We want to improve the transfer of results from cutting-edge research so that every patient in Germany can benefit from medical progress. The aim is for results of research to get to the people quickly and to measurably increase the percentage of early diagnosed, curable cancers. Our aim is to prevent as many new cases of cancer as possible and enable cancer patients to lead a better life. The following measures are planned to achieve this:

- We want to establish a new research culture by actively involving patients in the research process in the National Decade Against Cancer: from the development of the research question through participation in the research itself to the dissemination of the results.
- As part of this initiative, the relevant oncological funding activities of the partners of the Decade concerning prevention, diagnosis, therapy and healthcare will be pooled and coordinated.
- Cancer research will be stepped up systematically in the areas of prevention, early detection, diagnostics and innovative therapies.
- The results of the research will be fast-tracked to the people, and the experiences and findings from oncological healthcare will be used for research to ultimately achieve further improvements in treatment.
- Improvements in the requisite conditions to achieve this, for example for the training of young medical scientists and infrastructures for early clinical studies, will accompany the National Decade against Cancer.
- Additional locations of the National Centre for Tumour Diseases (NCT) will be established.



Current milestones and activities of the Federal Government

At the end of January 2019, we proclaimed the National Decade Against Cancer under the umbrella of the new Health Research Framework Programme. Within this initiative, a strategy group was established under the joint auspices of the BMBF and the German Cancer Research Center (DKFZ). The DKFZ has published a joint declaration with objectives, fields of action and initial contributions from the partners and set up its first working groups. In January 2019, we published the funding announcement for the promotion of 'practice changing developments which lead to more effective prevention, diagnosis and treatment of cancer'. This is intended to review and compare established measures.

On the part of the Federal Government, the BMBF and Federal Ministry of Health (BMG) are involved in the implementation of the mission.

Integration of science, industry and civil society

In addition to the German government, German Cancer Aid, the Felix Burda Foundation and the DKFZ are participating in the Decade. Partner organisations that have joined the Decade to date include medical societies such as the German Cancer Society, associations of physicians in private practice, health insurance funds, research-based industrial companies and the German Working Group for Self-help Groups. Ordinary citizens are also expected to be able to play an active role in shaping the Decade. In autumn 2019, the working groups will put their topics online for discussion.

The industrial healthcare sector, with over 30 associations, companies, service providers and partners, will contribute its expertise in biotechnology, medical technology, telemedicine and diagnostics. In particular, data-driven innovations for healthcare research will be brought into oncology.

There is close coordination and cooperation with the National Cancer Plan initiated in 2008, particularly in the areas of care, prevention and patient participation.

Moving forward

The Strategy Group of the National Decade Against Cancer is developing the work programme for the next ten years in dialogue with the partners and will accompany its implementation. The planning foresees continuous adaptation to current developments. The following results are targeted for achievement by the end of the current legislative term:

- Important stakeholders will be networked, patients will be integrated via associations, and additional research funding will be initiated.
- An accompanying communication concept will have advertised the Decade initiative to the broader populace beyond the scientific community.
- An open, competitive project funding programme will have been set up to answer the major unresolved questions in cancer research. All existing Federal Government funding measures related to cancer research will be pooled under the umbrella of the National Decade in terms of communication and budget.
- In order to step up translation of results within cutting-edge research, new NCT locations are to be established, thus enabling improved access to multidisciplinary research and healthcare from a single source.

In addition, the DKFZ and German Cancer Aid intend to enter into a new strategic partnership to establish a 'National Cancer Prevention Centre', which will also be a pioneer on an international scale, in order to systematically expand prevention research and applied prevention in Germany and to promote it nationwide with other partners. To ensure that the results of cancer research transfer more quickly into broader treatment and care, we are working on better networking in oncological research and care in the spirit of 'knowledge-generating healthcare'.

3.2 Digitally networking research and healthcare – for intelligent medicine

Digital innovations offer opportunities in the healthcare system to contribute to the well-being of as many patients as possible. This requires the consistent collaboration of many actors. A significant quality leap in medical care and in research can be achieved if patient data is available in a research-compatible manner, i.e. if research – with the patient's consent – can use relevant healthcare data and if this data can be transmitted across all institutions. In this sense, cross-institutional EHRs can make a significant contribution to a networked digital health system, and the findings of research can in turn be used directly and purposefully for the treatment of patients.

Goals of the mission

The Federal Government aims to continue developing the efficiency of health research and healthcare with a seamless flow of information between the various players and sectors at an international level. The Federal Government will work together with the science community, industry, civil society and all stakeholders in the healthcare system to ensure that a research-compatible EHR is available at all German university medical centres by 2025. The introduction of cross-institutional EHRs in healthcare is an important first step in this direction. Patient benefits, data protection and data security are important prerequisites, as is the development of common technical and semantic standards.

Current milestones and activities of the Federal Government

- In order to rapidly establish the use of electronic health records in healthcare, the German Appointment Services and Supply Act (TSVG), which came into force on 11 May 2019, obliges statutory health insurers, among others, to offer their insured persons an electronic health record approved by 'gematik – Gesellschaft für Telematikanwendungen der Gesundheitskarte' as of 2021. In order to take into account the interests of research in connection with the electronic health record, it was resolved that its contents should be determined in consultation with the relevant Federal research associations.

- Use cases for a research-compatible EHR are being carried out as part of the Medical Informatics Initiative. The funding volume amounts to around 160 million euros in the funding period of 2018–2021. In addition, the pilot project DataBox, which is being accompanied in close cooperation by the BMG, is doing the groundwork for a research-compatible EHR (funding period 01/2018–12/2019). The DataBox project aims to provide patients with a virtual data room for their individual health data.

- As part of the flagship initiative 'Digital ProgressHubs Health – New Approaches to Better Research and Care in the Health Sector', the feasibility of the research-compatible EHR will be tested in medical practice and the added value for patients, medical professionals and science for defined fields of application (e.g. cancer) will be examined. The call for proposals for the flagship initiative 'Digital ProgressHubs Health' is planned for the end of 2019.

- The use cases for the medical informatics initiative for cancer research, the DataBox project and the flagship initiative 'Digital ProgressHubs Health' can create synergies with the missions 'Combating cancer' and 'Putting artificial intelligence into practice'.

On the part of the Federal Government, the BMBF and BMG are involved in the implementation of the mission.

Integration of science, industry and civil society

The Medical Informatics Initiative is committed to improving research opportunities and patient care through the exchange and use of data from patient care as well as clinical and biomedical research beyond the boundaries of institutions and locations. Almost all German university hospitals and the associated medical faculties are involved. The development of a research-compatible health record, which is a topic of the HTS 2025, is being carried out jointly with a range of academic partners, such as universities, colleges and non-university research institutions.

The Association of German University Clinics (VUD) and the Association of Germany Medical Faculties (MFT) have joined forces to promote the introduction of a research-compatible EHR in university clinics through a networking initiative of German university medical centres.

Other players who make significant contributions are the data protection officers of the Federal Government and the Länder, ethics committees, citizens and other stakeholders, in particular from health research and healthcare.

Moving forward

The integration of all university hospitals into the Medical Informatics Initiative will be achieved in the course of 2019. Support for new research groups in medical informatics will also start in 2019. The currently ongoing development and networking phase ends in 2021. A subsequent development and expansion phase up to 2025 is planned. By 2021, data integration centres will have been set up and IT systems for use cases will have been developed and implemented. An audit will demonstrate their added value. By 2022, data sharing between consortiums through a central application and registry office, among other modes, will have been established and other cross-application use cases should be in place. The call for proposals for the flagship initiative 'Digital ProgressHubs Health' is planned for the end of 2019.

3.3 Achieving substantial greenhouse gas neutrality in industry

Germany has committed itself to ambitious sustainability targets. In order to achieve the objectives of the Paris Agreement, a high degree of greenhouse gas neutrality must be achieved by the middle of the century. All sectors must contribute to this, including industry in particular. While energy-related emissions in the industrial sector can be gradually reduced by increasing energy efficiency and switching to renewable energy sources, the avoidance of process-related emissions requires a technological leap forward. There is a considerable need for research to adapt or replace established processes and procedures in German primary industries, such as the iron and steel industry, chemical industry, cement and lime industry, and non-ferrous metal industry. Furthermore, immense financial investments are required to put these new technologies into practice.

Goals of the mission

The aim of the mission is to use research and innovation funding (research, development, demonstration and market launch) of new technologies to enable industry to contribute to the long-term goal of achieving substantial greenhouse gas neutrality (i.e. 80–95 per cent less greenhouse gas emissions by 2050 than in 1990) in accordance with the Climate Action Plan 2050, while at the same time securing and expanding Germany as an industrial location. The innovations required for this are to be prepared by R&D and brought to market in connection with an efficient and technologically open CO_2 reduction strategy for industries in Germany.

Current milestones and activities of the Federal Government

On the part of the Federal Government, the BMWi, the Federal Ministry for Environment, Nature Conservation and Nuclear Safety (BMU) and the BMBF are involved in the implementation of the mission. With certificate prices of around 25–30 euros/tonne of CO_2 (as at July 2019), incentives for emission reductions in industry (and the energy sector) are currently being created via European emissions trading. Further price increases are to be expected. The Federal Government supports the mission objective through the following activities:

- The Federal Government is contributing to the reduction of greenhouse gas emissions in energy-intensive industries with its funding and research programmes on Decarbonisation in Industry, its 7th Energy Research Programme, the FONA framework programme and the research programme within the Climate Action Plan.

- In real-world laboratories for energy system transformation, intensive work is being carried out on the use of renewable hydrogen in industry, with a focus on sector coupling and hydrogen technologies. This is a crucial step in advancing the transfer of technology innovations for industrial decarbonisation on an industrial scale.

- The Kopernikus projects, part of a fundamental research initiative for energy system transformation, were launched within the framework of the 7th Energy Research Programme. The Kopernikus project ‘Synergy’, for example, develops technologies and processes for adapting key industrial processes to fluctuating power generation.

- Autumn 2019 will see the opening of the KEI in Cottbus. In addition, a DLR Institute of Low Carbon Industrial Processes will be located in both Cottbus and Görlitz/Zittau. The aim is to develop approaches for low-carbon industrial processes and high-temperature pumps to convert coal-fired power plants into storage power plants.

In 2019 and 2020, various funding programmes will be published to develop, test and implement greenhouse gas-neutral technologies in industrial practice. Depending on the degree of innovation, various projects along the innovation chain in the economic sectors of iron and steel, chemicals, cement and lime, and non-ferrous metals will be funded, for example the new funding initiative on the topic ‘Avoidance of climate-relevant process emissions in industry’ (KlimPro-Industrie). But also within the framework of the existing Environmental Innovation Programme (UIP), a funding window dubbed ‘Decarbonisation in Industry’ has already been opened.

Integration of science, industry and civil society

Since 2017, industrial companies and trade associations have been discussing technical options for the direct avoidance of greenhouse gas emissions in industry with representatives of the German government. This ‘Decarbonisation in Industry’ sector dialogue is developing the terms and conditions for funding initiatives that are geared towards reducing greenhouse gas emissions. The ‘Energy in Industry and Trade’ research network brings together industry, science, civil society and research policy stakeholders in intensive dialogue and, among other things, provides impetus for funding strategies and innovative concepts and ideas for low-carbon industries.

Moving forward

In keeping with the Climate Action Plan 2050, a programme of measures will be drawn up in September 2019 to achieve sectoral targets for industry by 2030 in order to reduce CO_2 emissions by 49–51 per cent compared with 1990 emissions.

Crucial for this project grant is the strong participation of the private sector, ideally under industrial leadership. A particular focus will be on projects that take a systemic approach to the research and development of new technologies and process combinations and consider larger areas of the different value chains. Upstream and downstream processes and energy and resource requirements are to be taken into account and cross-sector opportunities for avoiding greenhouse gases developed.

3.4 Substantially reducing plastic discharged into the environment

Plastic litter is a global environmental problem with unforeseeable ecological consequences. Despite countless activities and preliminary studies, there is so far only limited conclusive knowledge of the discharge and distribution pathways and the effects of plastics on animals and humans. Research is needed in all areas of the plastic life cycle, from production, consumption and recycling to pollution of inland waters and seas, to close knowledge gaps and develop effective design levers. However, it is also a question of transforming our careless attitude to plastics and examining the acceptance of substitutes. Sociopolitical issues therefore play an important role, including agenda-setting policy, instigating entrepreneurial action, achieving broad impact and raising awareness in the population.

Goals of the mission

The mission aims to substantially reduce the plastic discharged into the environment. The activities of the various ministries involved will be pooled in the framework of the mission to facilitate the transfer of research results. In order to achieve a reduction in the discharge of plastic into the environment, the following key issues will be addressed:

- Identification of major points of discharge, as well as strategies for reducing and avoiding discharge and for removing (micro-)plastic (this includes material development and elimination procedures).
- The improvement of the circular economy (including recycling-friendly design, development of new recycling technologies and processes, high-quality recycling products).
- The development of ecologically sound solutions for dispensing with or replacing plastic.
- Significant improvement in the biodegradability of certain plastics.
- The sustainable production of plastics from bio-based raw materials.
- Promotion of awareness of the plastics problem in the broader population.

Current milestones and activities of the Federal Government

With the 'Osaka Blue Ocean Vision' adopted at the G20 Summit in Japan in July 2019, the Japanese G20 Presidency is pursuing the goal of reducing additional marine pollution through plastic debris to zero by 2050. This will be achieved through a comprehensive life cycle approach that includes reducing the discharge of poorly discarded plastic waste through improved waste management and innovative solutions, while taking into account the important role of plastics in society.

The importance of the issue is also increasing at EU level. The EU Plastics Strategy 2018 can be seen as a starting point for EU-wide measures to avoid plastics. In addition, with the adoption of the Single-use Plastics Directive in May 2019, the EU has created a new legal basis for the sustainable use of plastics.

On the part of the Federal Government, the BMBF, BMU, Federal Ministry of Food and Agriculture (BMEL), Federal Ministry of Justice and Consumer Protection (BMJV), BMWi and Federal Ministry of Economic Cooperation and Development (BMZ) are involved in the implementation of the mission. The Federal Government supports the mission objective through the following activities:

- The research focus 'Plastics in the Environment – Sources, Sinks, Solutions', which runs until 2021, is currently implementing 20 joint projects with a total of more than 100 partners from science, industry and business practice. The aim is to initiate a systemic approach to better understand the behaviour of plastics in the environment. To support the transfer of results into practice, a support group was set up with representatives from the Federal Government, the Länder, local authorities and non-governmental organisations.
- The call for proposals launched in 2018 as part of the European Joint Programming Initiative (JPI) 'Healthy and Productive Seas and Oceans' has attracted the participation of 14 European countries and Brazil. Starting from 2020, collaborations will be funded that develop methods for the analysis of smaller particles (< 10 µm) as well as faster measurement methods and practical monitoring strategies.
- In November 2018, a five-point plan for the avoidance of plastics was presented which aims at avoiding unnecessary products and packaging, promoting environmentally friendly packaging design and products, gradually increasing the recycling quotas for plastic packaging, reducing the discharge of plastics into the bio-waste sector, and supporting the export of technologies to counteract marine littering.
- The Packaging Law, which came into force on 1 January 2019, aims to increase the recycling rates of packaging materials and reduce packaging waste.
- R&D funding for biobased plastics is part of the bioeconomy research strategy, for instance within the framework of the 'ZeroCarbFP' strategic alliance. It develops innovative processes for the biotechnological synthesis of intermediates for the plastics industry. In addition, a new funding initiative for the biodegradability of plastics is in preparation.
- Synergies exist with the mission 'Creating sustainable circular economies'. The research concept for 'Resource-efficient Recycling Management' addresses, among other things, plastics as a priority material flow for the circular economy.

Integration of science, industry and civil society

Numerous players have joined forces in support of the mission:

- For instance, partners at EU and international level are active in the context of the JPI Oceans plastics strategy of the EU, the 'G20 Action Plan on Marine Litter', and the PREVENT Waste Alliance 'Together for a circular economy'.
- Cities and local governments have also committed themselves to the goals of the mission, for example by implementing the 2018 anti-littering campaign 'Jetzt ist Zähltag' as part of 'Let's Clean up Europe', while nature conservation non-governmental organisations (NGOs) such as the Bund für Umwelt und Naturschutz Deutschland (BUND), the Naturschutzbund Deutschland (NABU) and the WWF have engaged in research alliances and citizen science projects.
- In the newly founded 'Alliance to End Plastic Waste', around 30 companies active internationally along the value chain for plastics and consumer goods (including BASF, Henkel and Covestro) will invest around 1.5 billion euros worldwide in projects and collaborations to prevent plastic waste.
- Private sector enterprises and various research institutions are active in joint projects within the research priority 'Plastics in the Environment', working on topics such as recycling, tyre and textile abrasion, and the development of elimination processes in wastewater treatment. In addition, the PlastX junior research group is studying the social role of plastics and the associated environmental impacts until 2021.
- Since 2016, the Round Table on Marine Litter has provided a platform for coordinating national measures against marine litter and supporting their implementation. Around 130 experts regularly take part.

- The international travelling exhibition ‘Ocean Plastics Lab’, which has been extended until 2020, had presented contributions of research on the avoidance of marine plastic pollution to around 70,000 international visitors by 2019. The ‘Plastic Pirates’ citizen science campaign for school classes and young people will be continued until 2020 as part of the research priority ‘Plastics in the Environment’.

Moving forward

The following additional activities are planned for implementation:

- Further coordination of interministerial activities.
- Participation of the public using instruments to communicate the issues in a generally comprehensible way, if necessary also through participative processes or within the framework of real-world laboratories.
- Implementation of the research results from the research priority ‘Plastics in the Environment’. The results will be used, among other things, in the development of methods for microplastic analysis, in optimised processes for the removal of microplastics (for example at sewage treatment plants), in new recycling technologies, and in the development of marketable processes for the production of plastics from biobased raw materials. The final conference on this research priority is planned for the end of 2020.
- Transfer of suitable results into regulations, norms and standards with the involvement of relevant stakeholders (e.g. regulatory associations, standardisation committees) and the raising of environmental standards.
- Integration of other specific target groups depending on the topic, e.g. local governments, agriculture, industry, educational institutions. This can also occur within the framework of cross-project networking.
- Increasing the number of European and international cooperations to reduce the plastic discharged into the environment, especially with emerging countries, where the greatest challenges for reducing the discharge of plastics into the environment lie.

3.5 Creating sustainable circular economies

Against the backdrop of a growing world population and limited resources, we must step up the further development of sustainable economic forms. So far, 91 per cent of the global economy has been linearly oriented (production – use – disposal), while only 9 per cent of the resources used are kept in the cycle. The central challenge is to master a transformation from a linear economy to a resource-efficient, ecologically worthwhile circular-flow economy.

Goals of the mission

We will work with industry, science and consumers to link economic growth to sustainability goals and achieve a 30 per cent increase in overall raw material productivity by 2030 compared to 2010, which amounts to 1.5 per cent per annum. Material efficiency will be given priority in the manufacture of products. Innovative business models in conjunction with digitalisation will support the conversion of the traditionally linear economy into a resource-efficient economy. The aim is to achieve a decoupling of economic growth from resource consumption, a significant reduction in greenhouse gases, waste and environmental pollution, and less dependence on imported raw materials.

Current milestones and activities of the Federal Government

Politically, the goal of a resource-efficient circular economy is already anchored in the German Resource Efficiency Programme (ProgRess). Bioeconomy funding also contributes to tailor-made solutions for the realisation of a form of economy that is based on circularity. On the part of the Federal Government, the BMBF, BMU, BMWi and BMEL are involved in the implementation of the mission. The Federal Government supports the mission objective through the following activities:

- The German government is making a contribution to establishing a sustainable circular economy through the FONA framework programme and the Bioeconomy research strategy. Additional measures include the VDI Centre for Resource Efficiency, the funding measures for resource efficiency and lightweight construction and for innovations in small and medium-sized enterprises, a market development programme, and the ‘Renewable Resources’ funding programme.
- The research concept for ‘Resource-efficient Recycling Management’, published in 2018, will be implemented through various funding measures (150 million euros in the period 2018–2023). There will also be synergies with other missions, in particular in the area of plastics, to reduce the discharge of plastic into the environment through more comprehensive and higher-quality recycling.
- From 2020, the new Lightweight Construction Technology Transfer Programme is also intended to promote knowledge and technology transfer across materials and industries in lightweight construction taking a life cycle assessment into account.

Integration of science, industry and civil society

Companies are actively involved in all funded joint projects and contribute their own funds to the research projects. Representatives from the private sector and associations are also involved in programme development and the selection of projects for funding. The acatech initiative Circular Economy was launched in March 2019 with considerable industry participation. Specific applications for recycling management are being developed for packaging and batteries. The established National Resource Efficiency Platform (NaRess) serves to involve the private sector, civil society groups and other stakeholders.

- Projects within the funding measure for a 'Resource-efficient Circular Economy – Building and Mineral Cycles' (ReMin) starting in February 2020.
- The continuing development of ProgRess III planned for 2020 and the associated measures, such as increasing the proportion of secondary raw materials and recycled materials.
- The development, in collaboration with industry, of a national 'Research and Innovation Strategy for Resource Protection Technology'.

Moving forward

As part of HTS 2025, the first concrete implementations in industry are to be initiated by 2025. The target to increase overall raw material productivity is set for the year 2030. As a next step, a regular survey of the indicator on overall raw material productivity is planned as a reference value for the goals of the sustainability strategy and ProgRess. Goals and indicators within the framework of ProgRess will be further developed for better evaluation of progress in expansion of the circular economy. A monitoring framework is to be established as part of the EU Circular Economy Package in order to compare developments in Germany with those in other EU member states. The current focus is on indicators for recycling and waste management. Additional milestones are:

- The transnational research projects on Resource-efficient Recycling Management starting in November 2019 as part of ERA-Net ERA-MIN 2.
- The continuation of the Federal Government's Raw Materials Strategy with a stronger emphasis on the circular economy.

3.6 Preserving biological diversity

At the present time, species are declining at an unprecedented rate. Populations are becoming smaller and genetically poorer or are disappearing altogether. The dramatic decline in the number of insects harbours risks that we have been unable to fully assess so far. After all, nature's benefits for human beings (ecosystem services) form the basis for their prosperity and well-being. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) makes this clear in its current report by, among other things, disclosing the immense importance of pollinators for food security. Further intensive research is required to conserve biodiversity. To this end, the negative effects of exerting social and economic influence on nature must be better understood and eliminated.

Goals of the mission

Counteracting the loss of biodiversity is as much a challenge as combating climate change. Climate change increases the risk of irreversible impacts on ecosystems. At the same time, damaged ecosystems can lead to climate change impacting more severely on humans. The mission's objectives are the preservation of biological diversity and the promotion of resilient ecosystems to safeguard the very basis of our life. Through systemic approaches, the research will

- develop innovative technologies and methods to improve and accelerate data collection on the status of biodiversity (biodiversity monitoring),
- deepen the systemic understanding of the causes, dynamics and consequences of changes in biodiversity,
- clarify the links and dynamics between ecological and socio-economic systems and examine conflicts of interest and synergies in different areas and sectors,
- develop system solutions and portfolios of measures in dialogue with actors involved in practice in industry, civil society, and local and regional planning and enforcement authorities.

Building on this, in order to counteract the loss of biodiversity, the measures currently in place are to be adapted where necessary and supplemented by new instruments. These are intended to have a leverage effect on social activities and economic decisions to conserve biodiversity.

Current milestones and activities of the Federal Government

The mission contributes to the United Nations Convention on Biological Diversity (CBD), the EU Biodiversity Strategy and the National Biodiversity Strategy (NBS). On the part of the Federal Government, the BMBF, BMU and BMEL are involved in the implementation of the mission. The Federal Government supports the mission objective through the following activities:

February 2019 saw the launch of the 'Research Initiative for the Conservation of Biodiversity' (200 million euros are earmarked for the next five years) as the fourth flagship initiative of the FONA framework programme. It will play a key role in advancing biodiversity research and pooling research activities to an even greater extent. The aim of the long-term research initiative is, in particular, to close gaps in knowledge about the intersystem linkages at play in species loss and to develop measures for the conservation, improvement and sustainable use of biodiversity. Innovative ideas are to be promoted through projects and funding priorities. The first of these is the funding announcement for 'Valuing and safeguarding biological diversity in politics, business and society' published in June 2019. Projects on specific topics (e.g. causes of the decline in insects in protected areas/insect-friendly management of protected and adjacent areas) have already started. In 2019, short-term funding measures will also be launched to address urgent research questions.

- The Insect Protection Action Plan was also put to ministerial vote in February 2019. With the Insect Protection Action Plan, the Federal Government intends to improve living conditions for insects and biological diversity in Germany in order to counteract insect mortality.
- The German government plans to set up a scientific monitoring centre on biodiversity. One of its aims is to develop methodological standards and provide reliable data for policy advice.
- In March 2019, the go-ahead was given for the programme for 'National Monitoring of Biodiversity in Agricultural Landscapes'.
- June 2019 saw the publication of the funding announcement for 'Coastal Research in the North and Baltic Seas', with its focus on biodiversity changes in coastal waters.

Synergies with other HTS missions (e.g. 'Creating sustainable circular economies', 'Putting artificial intelligence into practical application') will be used as far as possible. For example, digital and AI technologies for the collection and processing of biodiversity data are being developed, information from biodiversity archives and natural history research collections is being digitised, databases are being mobilised, better networked and made available, and system solutions for sustainable activities in business, politics and society that foster biodiversity are being developed.

Integration of science, industry and civil society

The Research Initiative for the Conservation of Biodiversity is closely interlinked with programmatic research, such as the Helmholtz Association, the Leibniz Association, the Max Planck Society and other actors. Overall, the initiative pursues a broad communication approach. Under the umbrella of the 'Biodiversity Dialogue Platform', actors from business and society are brought together with research and policymakers and involved in the content design via various committees and regular specialist workshops and conferences. In addition, practitioners are involved in the development and implementation of research projects in order to contribute their practical knowledge and express research needs. These actors can be state or local authorities, nature conservation and business associations, companies and other civil society actors. In addition, research results are translated into environmental standards and legislative processes. For example, the results of the international 'Mining Impact' project on the impact of deep-sea mining on seabed biodiversity were directly transmitted to the International Seabed Authority (ISA), which regulates deep-sea mining.

The 'Enterprise Biological Diversity 2020' forum and the 'Biodiversity in Good Company' initiative, in which associations from industry and nature conservation and companies from numerous sectors have joined forces to promote the protection and sustainable use of global biodiversity, are good starting points for research project partnerships with players from industry. The establishment and work of a scientific monitoring centre on biodiversity involves actors from Federal institutions, the Länder, the science community and volunteers.

Moving forward

The interim results of the newly launched funding offers will be available in the short to medium term (foreseeably in one to three years), depending on the initiative. Innovative monitoring methods and citizen science approaches for data collection on species are also being developed. In approximately three years, new findings on ecological tipping points, including economically relevant fish stocks and grassland ecosystems, can be expected. Similarly, research on insect diversity is expected to lead to a medium-term increase in knowledge about the causes of the decline in insect diversity. Together with key players and decision-makers from business, nature conservation, politics and administration, options for action, guidelines, management plans and models are being developed and supported in their implementation and application in practice.

The concept for the new scientific monitoring centre is currently being agreed on in the Federal Government; construction will begin after approval by the Federal Cabinet.

The progress of the Federal Government's activities for the preservation of biological diversity will be measured using specially developed indicators. Proposals for this currently include:

- Long-term application of the developed approaches in politics, economy and society which achieve a qualitative improvement in the condition of ecosystems at local and regional level.
- Replacing practices that have proven harmful effects with new, more biodiversity-friendly approaches.
- Further contributions from research projects on the implementation of Federal programmes and strategies focusing on the conservation of biodiversity. These could be measured, among other things, by the impact of successful measures in the 'Accountability Report on the National Biodiversity Strategy', German contributions to the CBD or CBD activities, and the Insect Protection Action Plan.

3.7 Building up battery cell production in Germany

The establishment of battery cell production by German or European investors is of great strategic importance for Germany as a location for industry and technology. The fields of application range from microbatteries for consumers, to industrial applications such as power tools and batteries for electrified vehicles, to large stationary battery storage units to buffer the fluctuating supply of regenerative electricity. Battery technology is therefore a key enabling technology for a wide range of applications in industry, mobility and the context of energy system transformation.

Goals of the mission

In view of the importance of battery technology for a large number of applications, the German government wants to secure Germany's technological sovereignty in this technology. Sustainable structures will be created to lay the foundations for battery cell production, both with current concepts such as liquid electrolytes and with future concepts such as solid-state batteries or approaches from the post-lithium era. We aim to cover as completely as possible the value chain of battery technology in Germany and Europe – from the efficient use of raw materials to the manufacture of electrodes and other components, from mastery of electrochemistry and cell production to complete battery systems and their re-use and recycling. By facilitating the transfer of research results into industrial applications, we want to secure the generation of added value and jobs.

Current milestones and activities of the Federal Government

On the part of the Federal Government, the BMBF and the BMWi are involved in the implementation of the mission. The Federal Government supports the mission objective through the following activities:

- The framework concept for the 'Battery Research Factory' was published in January 2019. It follows an integrated approach from fundamental materials research in the laboratory to process and production development, scaling, and automation in a new research facility for battery cell production (FFB).

- In March 2019, a call for expressions of interest for battery cell production was launched. The proposals received are currently undergoing technical examination and further qualification. A dialogue was initiated with the EU Commission and other interested EU member states on the design of a possible IPCEI battery cell production facility. Germany coordinates one of two IPCEIs for battery cell production with other European member countries and participates in both.

- On the research side, the Federal Government also supports the establishment of battery cell production by expanding the three competence clusters for battery cell production (ProZell), solid state batteries (FestBatt) and battery materials, which integrates the research institutions active in this field.

Integration of science, industry and civil society

A large number of research institutions are working on the further development of battery technology and the associated production processes. Various companies are working on concepts to build production capacities on different scales for battery cells and their components and active materials.

The concept framework for the 'Battery Research Factory' builds on the existing structures for German battery research. The aim of the concept framework is to give the industry in Germany in particular an innovative edge through new material and battery cell concepts and to more closely coordinate the research activities. Discussions with industry will take place at national level and at European level within the framework of the European Battery Alliance.

National and European corporate groups have already been identified that are capable of implementing large-scale battery cell production projects with the support of the science and research community.

Moving forward

Parallel to supporting industrial efforts, we will initiate a research facility for battery cell production, known as FFB, which will research production processes, test them in practice, and then transfer them to industrial application. The FFB research facility is an essential element of the 'Battery Research Factory' framework concept to research new technologies and accelerate the transfer to industrial application. The German government will fund R&D for batteries with around 500 million euros over the next four years as part of the framework concept.

We will consistently pursue our funding strategy, which includes building up knowledge of battery materials and the production of battery cells, increasing the number and quality of electrochemical competence centres and their facilities, developing new batteries and further developing existing batteries for the future. We also take account of aspects of strategic international significance and cooperations to strengthen know-how in Germany, as well as the training of specialists.

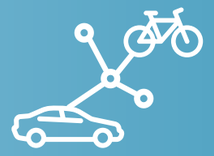
- Investments in battery cell production and related value-creation networks are expected to start around the end of 2019 or the beginning of 2020. This means production could start in 2022.

- The first production line for battery cells will be set up in Münster as part of the FFB research facility.

- The funding conditions and the scientific and technical infrastructures will be created to ensure the faster transfer of new scientific developments to business enterprises.

- A new competence cluster for battery materials will be established in addition to the 'ExcellentBattery' initiative. This means the science and research community is contributing to high-performance materials, battery cell formation, the improvement of production processes (also in the sense of industry 4.0), process-property relationships, and the digitalisation of battery cell production.

3.8 Developing safe, networked and clean mobility



Mobility is crucial to individuals determining their own lifestyle and to social coexistence. The steady increase in traffic can, however, also lead to negative impacts on people and the environment. The challenges here lie in emissions impacts. Since the transport sector is in competition with other land uses, such as housing, agriculture and nature conservation, individual and economic mobility needs are already increasingly reaching their limits. Designing the mobility of the future poses major challenges for urban and rural areas.

Goals of the mission

Mobility secures our prosperity. It is a decisive economic factor and the basis for innovation. The mobility industry is undergoing a radical change. It is no longer only shaped by the vehicle industry, but increasingly also by the IT sector. Electronic vehicles (EVs) are connected to the power grid, so that the integration of electric mobility into the grid links the transformation of the transport sector with the conversion of the energy sector. These changes pose challenges. But there are also many opportunities for new value creation and transformation, as well as job creation.

Answers to the challenges must be found in the overall picture. Mobility needs and traffic flows, infrastructures, employment, regional structures, technical innovations (e.g. automated and networked driving) and new business models (e.g. ride sharing, mobility as a service, vehicle-to-grid charging) must be equally taken into account in a networked, digitalised and electrified mobility sector.

Current milestones and activities of the Federal Government

The Federal Government is supporting technological developments in the field of safe, networked and clean mobility through the following interministerial initiatives and funding programmes. These include, among others:

- The Federal Government's Strategy for Automated and Connected Driving, in particular the action plan 'Research for Autonomous Driving – An Overarching Research Framework of the BMBF, BMWi and BMVI', which was adopted in implementing the Innovation field of activity.
- R&D projects in the 'Clean Air Immediate Action Programme 2017–2020' with a focus on 'EV Charging Infrastructures' and 'Digitalisation of Municipal Transport Systems'.
- Mobility2Grid research campus.
- The research agenda 'Sustainable Urban Mobility'.
- National Platform City of the Future (NPZ).
- The technology development programme 'New Vehicle and System Technologies'.
- R&D measures for ongoing development of electromobility.

- R&D measures and procurement subsidies for the ongoing development and market activation of fuel cell technology (National Innovation Programme Hydrogen and Fuel Cell Technology NIP II and the 7th Energy Research Programme).

These measures will be supplemented in future by the funding of systemic mobility research – with the aim of effectively steering technological developments towards sustainability with the help of social innovations.

Integration of science, industry and civil society

The following stakeholders, among others, are important for the mission:

- Citizens and their mobility needs to increase acceptance of the introduction and establishment of new technologies.
- Local governments as central actors for local transport planning and mobility provision, taking into account locally tailored and sustainable mobility concepts.
- Companies that develop innovative technologies and offerings – if necessary, in collaboration with the scientific community – and convert them into viable business models.
- Research institutions that can contribute to technological developments, sustainable mobility concepts and the sound assessment of options for action.
- Specialist ministries at Federal and State level (in particular transport, economy, research and environment).
- NGOs.

Moving forward

The funding measures under the 'Sustainable Urban Mobility' research agenda are expected to run until 2026. The first funding phase is expected to be completed in 2021, when around 50 municipalities will be mobilised to develop integrated mobility concepts. The best approaches will be funded from 2024 for up to three more years to carry out planning, implementation and testing.

Electromobility is a key technology for designing a sustainable transport system so as to achieve climate protection goals in the transport sector. It remains our goal to make Germany into the leading supplier and market for electromobility. The long-term and continuous funding of R&D projects lays the foundation for future innovative capability. In addition, the electrification of the transport sector is supported by a number of measures (purchase premiums, procurement subsidies, electromobility concepts, establishment of EV charging points, tax incentives).

The NIP was launched in 2006. The first phase (NIP I) lasted from 2006 to 2016, while the second phase (NIP II) is currently running from 2016 to 2026. The fuel cell developments for mobile applications within the Energy Research Programmes (currently the 7th Energy Research Programme) are part of the NIP. The NIP covers the technology maturity levels of all development stages, from fundamental research to field trials, demonstration and market activation/introduction. Both fuel cells in applications for all modes of transport, including vehicle tanks, and the associated infrastructure, such as the construction of the petrol station network for road vehicles, are the subject of the NIP.

The R&D measures in the 'Clean Air Immediate Action Programme 2017–2020' will have been launched by the end of 2020. The projects funded under the funding guidelines run for several years and are expected to be completed by the end of 2024.

The first annual conference of the NaKoMo will take place in November 2019.

3.9 Ensuring good living and working conditions throughout the country

The regions of Germany are faced with the task of coping with the structural change that will result not least from digital transformation, demographic development and the challenges posed by climate change. The innovative strength and economic performance of individual regions vary greatly. Innovative economic centres stand in contrast to structurally weak regions, which are particularly affected by structural changes. The potential of new (digital) technologies, social innovations and new, creative business ideas will be used to positively influence economic development and quality of life, especially in structurally weak regions. This also contributes to strengthening social cohesion in the country.

Goals of the mission

The aim is to achieve innovation-based, sustainable and socially just structural change in structurally weak and disadvantaged rural areas – by incorporating and further developing the regional know-how and experience of local people. In addition to the continuation of proven development paths, new innovation paths will also be established in the local regions. The Federal Government is relying on the power of research, development and innovation.

Current milestones and activities of the Federal Government

On 10 July 2019, the Federal Government adopted twelve measures to implement the recommendations of the ‘Equivalent Living Conditions’ commission. The commission’s mandate was to develop proposals on a wide range of issues (including technical infrastructure, public services and employment, economy and innovation, digitalisation, social cohesion) to create equivalent living conditions. A key result concerns the development of a ‘nationwide support system for structurally weak regions’, which pools suitable support programmes of the Federal Government. Funding programmes previously limited to East Germany will be extended to all structurally weak regions; programmes offered nationwide may receive special funding conditions for these regions. The promotion of innovation has an important role to play here, with the basis being a broad understanding of innovation. The Federal Government has already made its first visible contributions to the achievement of the objectives with the addition of innovation aspects to the funding spectrum of the joint task ‘Improvement of Regional Economic Structure’ (GRW), the conception of the new range of programmes offered under ‘Innovation & Structural Transformation’ for structurally weak regions and with other activities.

The Federal Programme for Rural Development is also an important contribution by the Federal Government to creating equivalent living conditions. The most promising exemplary approaches will be tested, monitored and evaluated nationwide. The aim is to derive transferable findings, translate them into practice, and make recommendations for changes in government policy approaches.

Further support for rural areas is provided as part of the joint task ‘Improving Agricultural Structure and Coastal Protection’ (GAK), in particular through the ‘National Strategic Plan for Rural Development’ (SRPLE) launched in 2018.

The planned expansion of the Wettzell Geodetic Observatory in the Bavarian Forest is a further contribution to strengthening rural areas by creating high-quality employment opportunities for engineers, natural scientists and IT specialists in a region that is relatively weak in structural terms. In August 2019, the Federal Agency for Cartography and Geodesy was commissioned to carry out the expansion project. The observatory, which belongs to the Agency, will be considerably expanded into a beacon of innovation for high-tech geodesy, thus also contributing to the UN resolution to secure a sustainable Global Geodetic Reference Frame (GGRF). The plans for expansion include 25 additional job positions.

Integration of science, industry and civil society

In implementing the mission, the Federal ministries involved and, in particular, the Länder and relevant regional and local stakeholders from business, science, civil society, politics, and local government bodies and administration must be taken into account. Depending on the initiative, other actors may also be involved, such as the EU or neighbouring countries.

The participating ministries, the Länder and the local associations were also represented in the respective technical working groups of the ‘Equivalent Living Conditions’ commission. This ensured intensive coordination and interlocking of activities.

Moving forward

The concrete activities of the mission ‘Ensuring good living and working conditions throughout the country’ will be aligned with the results of the Commission according to content. Suitable measures and milestones, which can be introduced by the relevant departments, will now be coordinated on this basis. The nationwide support system for structurally weak regions will be set up in the coming year.

3.10 Shaping technology for the people

The future of Germany as a high-tech location crucially depends on how well it succeeds in using technological innovations for social progress. The mission of 'Shaping technology for the people' aims to use technological change for the benefit of society as a whole and in the world of work. To this end, the opportunities and risks of new technologies and the social innovations that they generate and enable must be researched and evaluated, and there must be a transfer of knowledge to companies and civil society groups.

Goals of the mission

Technological and economic transformation will be used to shape the world of work in a way that fosters people's health, is compatible with family, healthcare and civic commitment, and takes account of active ageing and equality between women and men. To achieve this, the opportunities and risks of new technologies must be researched and evaluated. This requires more knowledge about the social consequences of technological innovation. These include, for example, digital assistance systems, human-robot collaboration, exoskeletons to support employees in their physical work, but also solutions that allow the more flexible organisation of work processes, support of mobile work, and the means by which risks can be mitigated by the state, the economy and society.

Interactive technologies also play an increasingly important role in people's everyday lives outside the world of work. It is important to bring together information and communication technologies, electronics, robotics and bionics with the humanities and social sciences in order to achieve optimum synergies between people and technology. The challenges and needs that arise in daily life and are addressed by society must also be heeded and included. This results in innovative solutions that support people in more and more areas of their lives.

Current milestones and activities of the Federal Government

On the part of the Federal Government, the Federal Ministry of Labour and Social Affairs (BMAS), Federal Ministry for Family Affairs, Senior Citizens, Women and Youth (BMFSFJ), BMEL, BMWi and BMBF are involved in the implementation of the mission. The following measures have been launched:

- Funding of research on social and sociopolitical issues through the Funding Network for Interdisciplinary Social Policy Research (FIS), including the development of a data basis for interdisciplinary social policy research on digitalisation and the changing world of work.

- Funding of R&D on safety and health in the digitalised work environment, including a new research priority of the Federal Institute for Occupational Safety and Health (BAuA) dubbed 'Safety and Health in the Digital Workplace'.

- Funding of R&D within the programme line 'The Future of Work – Innovations for the Work of Tomorrow', in particular through the establishment of 'Regional Centres of Excellence for Labour Research' and support measures for 'Working With and For People'.

- Funding of R&D as part of the 'Bringing Technology to the People' research programme, in particular through the establishment of clusters on interactive medical and healthcare technologies, as well as targeted funding measures, including healthcare innovations, the use of virtual reality and AI in care, and digital platforms for assistance systems.

- DLR institutional funding for R&D in medical and assistance robotics.

- Exchange of experience on the development and implementation of approaches to enhance compatibility within the framework of the business programme 'Success Factor Family'.

- The funding priority 'New Enterprises: Innovative Start-ups for Human-Technology Interaction' specifically supports start-ups and spin-off activities in science.

- Funding of research projects on the opportunities, risks and effects of digitalisation in rural areas within the framework of the Federal Rural Development Programme.

Integration of science, industry and civil society

The BAuA is networked both with the traditional occupational health and safety players and with the various social groups that are involved in shaping a humane work environment. In the New Quality of Work Initiative (INQA), the Federal Government, the Länder and municipal associations, employers' associations and chambers, trade unions, businesses, and the Federal Employment Agency as well as social security agencies and foundations work together to promote a modern work culture and personnel policy and develop concrete and practical solutions that support companies and institutions in shaping their working conditions.

Within the framework of the business network 'Success Factor Family', which was initiated jointly with the German Chambers of Industry and Commerce (DIHK) and has 7,300 members, companies of various sizes and in various industries engage in continuous collaboration and exchange on topics of compatibility.

The science community is broadly researching the directions of development, the dissemination and the consequences of emerging technologies, thus laying the foundation for working towards humane design. The programme line 'Future of Work – Innovations for the Work of Tomorrow' as well as the research programme 'Bringing Technology to People' will support in particular collaborative projects in which companies and science work together in multidisciplinary and transdisciplinary teams and in which there is regular exchange with trade unions and employers' organisations.

At the multilateral level, the Organisation for Economic Cooperation and Development (OECD), the G7 and the G20, among others, are addressing the issue of digital skills for the working world of the future.

Moving forward

The mission is ongoing. Independent social policy research will be successively expanded through the FIS. In the case of endowed professorships, the Länder have committed to ensuring continued, long-term financing after the end of the funding period. From 2020, networking and cooperation between actors across the silos of their disciplines will also be strengthened, and approaches for the effective transfer of knowledge between science, politics and society will be expanded.

The research priority 'Safety and Health in the Digital Workplace' aims to provide impetus to the scientific community through practical research results and to promote the implementation of findings in practice. Success can be measured by the number and type of publications, the demand and resonance of practitioners at events and to publications, and evaluations of measures implemented within the framework of projects.

The 'Compatibility Progress Index' is currently being developed as part of the 'Success Factor Family' business programme for companies to annually measure and visualise their family-friendly corporate culture on the basis of key figures. The pilot phase will be launched in 2019. Once the instrument is established, comparable key figures on the status of family-friendly corporate culture, differentiated by size and sector, will be available on a regular basis.

Furthermore, research is planned on the potential of using digital aids in everyday family life and on measures to network users, providers of care services and developers of digital parental aids. In this context, the results of a study on the digitalisation and well-being of families will be published in 2019.

Within the framework of the 'Future of Work' programme line, new collaborative projects will be regularly selected for funding. In the coming years, in particular the 'Regional Centres of Excellence for Labour Research' are close to being established.

3.11 Putting artificial intelligence into practical application

AI technologies are currently finding their way from the experimental stage into commercial and non-commercial applications. The vision for human-centred AI has far-reaching potential for increasing scientific knowledge assets, dealing with societal challenges, securing long-term social prosperity and generating more growth and productivity in many sectors of the economy. The broad scope of AI-based applications includes contributions for overcoming complex challenges such as climate change, mobility, sustainability and healthcare to increasing individual benefits at work and in everyday life, for example through assistance systems. Due to the steep hike in competition, particularly in investments, specialists and data, the challenge is to create suitable terms and conditions for the development and use of AI.

Essential prerequisites are a strong research base that is as broad as possible, sufficient availability of skilled workers of all qualifications, and legally secure and non-discriminatory availability and usability of data. The use of AI must comply with our social values and standards. The mission will be further developed in the various fields of application. Against this background, the current status is presented below, which will be further substantiated by the participating ministries in the process of implementing the mission.

Goals of the mission

As a key enabling technology, AI has manifold effects on the entire breadth of social development. Accordingly, social dialogue must be conducted on opportunities, risks and the conditions for the use of AI. The objective is to achieve AI that is consistent with European values such as the inviolability of human dignity, respect for privacy and the principle of equality, ensuring transparency and security without restriction, and assuring environmental and climate benefits.

The mission is to make Germany and Europe a leading global location for research, development and application in the field of AI and to guarantee competitiveness. We want to harness the potential of AI as a horizontal technology for the broad range of potential fields of application. In addition to fostering research and the skilled labour base for AI in Germany, this includes above all transferring research results into economic practice. In particular, we would like to support the start-up dynamics triggered by AI-based business models and products.

The application areas Industry 4.0, Aviation and Aerospace/Communication/Navigation, Energy, Mobility, Health, Environment, Agriculture and Logistics are of particular importance.

We are working to make all economic players aware of the potential of AI technology and to ensure that companies develop their business models accordingly. Sustainable investments are equally important. In addition, we want to promote cooperation among businesses and industry in the production and operation of industry-specific and cross-industry data infrastructures.

Current milestones and activities of the Federal Government

On the part of the Federal Government, the BMBF, BMWi, BMVI and BMU are involved in the implementation of the mission. At the international level, the OECD Council adopted recommendations on how to deal with AI in May 2019. The issue of AI is also central to the deliberations of the G7 under the French Presidency and the G20 under the Japanese Presidency.

- With its AI strategy, the Federal Government is giving new impetus to the research, development and application of AI technology. To this end, investments are to be made in structures of both fundamental and applied research, in specialists at all required qualification levels and in economic transfer. Targeted funding measures will be established.

- In this context, a funding initiative 'AI Lighthouses' for the protection of the environment, climate and resources will be launched in autumn. Funding will be provided for projects that use AI to meet ecological challenges and are role models for digitalisation that is in harmony with the environment, climate, health and nature. In particular, these include projects for digital ecological innovation that contribute to the achievement of the climate protection goals to preserve biodiversity, promote nature-friendly agriculture, sustainable consumption and sustainable mobility, increase access, transparency and utilisation of environmental data, reduce energy and resource requirements, ensure protection standards, strengthen environmentally oriented programming of AI algorithms and knowledge transfer, and promote social discourse on complex data-driven systems.

- Germany's 'Learning Systems' platform for AI conducts dialogue between science, industry and society in order to anchor AI for the benefit of society, to strengthen Germany's economic power, and to reduce risks in the application of this technology.

- The six AI Competence Centres each form a focal point for the research, development and application of AIs in their respective regions.

- The use of AI methods holds great potential, particularly in the health sector, for example in the diagnosis and treatment of cancer or in the area of individualised medicine. In order to increase this potential, the 'Computational Life Sciences' initiative is currently promoting the development of innovative AI methods for evaluating biomedical data. In addition, 'digital hubs' will be established in the future in which new approaches for the collection and consolidation of patient data and the analysis of the data using AI will be developed, tested and disseminated. Initially, the focus will be on specific fields of application, such as cancer. Synergies exist with the missions 'Combating cancer' and 'Digitally networking research and healthcare'.

- The action plan 'Digitalisation and Artificial Intelligence in the Mobility Sector' brings together the key measures for designing modern, clean, efficient, sustainable and affordable mobility in the digital age. It contains measures that pave the way for exploiting the potential of AI applications to solve the current challenges in the mobility sector.

- In January 2019, the AI Innovation Competition 'Artificial Intelligence as a Driver for Economically Relevant Ecosystems' was launched with the aim of increasing the practical application of AI in Germany. Out of 130 applications, 35 outstanding design concepts for AI-based platforms in the economically relevant sectors of mobility, healthcare, industry, smart living, agriculture, retail and construction were selected to participate in the competition. In the first phase of the AI Innovation Competition (April to September 2019) applicants competed against each other to develop roadmaps and to recruit powerful teams to jointly implement their proposal. The most promising proposals will be given the opportunity to put their design concepts into practice.

- Since mid-2019, SMEs have received special support for artificial intelligence applications. At least 1,000 companies will be reached annually via the SME 4.0 competence centres, and SME-specific measures (raising awareness, demonstration, qualification, networking) will be implemented.

- Furthermore, in the future AI-powered infrastructures that are economically and systemically critical (communication, navigation and earth observation satellites, digitalised air traffic/airports, digitalised energy and traffic networks, automated/networked driving) will be secured against attack during access to external data sources; a new DLR Institute for AI security in St. Augustin and Ulm will focus on this in the future.

Integration of science, industry and civil society

Science forms the basis for the broad development of expertise in AI. Industrial applications are being researched and demonstrated in collaboration with industry. Of particular importance in this process are the Centres of Excellence for AI research, which are selectively supplemented by application hubs. Exchange between the different stakeholders is organised through the 'Learning Systems' platform. This brings together leading experts from science, business, politics and civil society organisations from the fields of machine learning systems and AI. The opportunities, challenges and requisite business and policy requirements for the development and responsible use of machine learning systems are discussed in subject-specific working groups. The platform was initiated at the end of 2017 with a term of five years. Initial results from the working groups in the form of application scenarios, publications and a map of AI applications in Germany are available.

Moving forward

The AI Competence Centres will be expanded by 2022. Discussions were started with the host Länder on the possibility of continuation. In the medium term, industrial AI projects will be set up and put into permanent use.

A funding priority for 'AI for Healthcare' is also being planned. Application-oriented research and development will tap into the potential of this technology for the socially important area of nursing care and healthcare.

3.12 Finding new sources for new knowledge

With digital technologies, it is possible to access existing knowledge in the shortest possible time, to participate in the creation of knowledge, and to translate knowledge into added value. This holds great economic and social potential. The strategic opening up of science and innovation can be a response to the demands of a dynamically evolving, digitalising innovation system. At the same time, however, companies still need secure spaces in order to test new utilisation strategies with their partners from science and civil society and to develop specific knowledge and core competencies. The central challenge is to profitably shape cultural and institutional change under the paradigm of the new openness and, at the same time, to bring about a healthy balance of interests between the advantages of open forms of innovation and individual utilisation interests.

Goals of the mission

An open innovation culture will be developed in collaboration with all relevant actors, and its potentials and limits will be explored. Part of this is to make more extensive use of the opportunities offered by open access, open science, open data and open innovation. In this way, we want to develop more effective solutions to social and technological challenges and also give our companies faster access to the latest scientific findings. To this end, we will significantly raise the proportion of open access publications in the scientific community and, with increased funding, substantially increase the number of new, more open forms of cooperation between companies, civil society stakeholders, citizens and scientific institutions. We want to make successful models accessible for the general public. We will offer science and business the experimental environment to open up to new ways of acquiring, disseminating and exchanging knowledge and to involve new actors in innovation processes.

Current milestones and activities of the Federal Government

Numerous measures are instrumental in establishing an open innovation culture:

- Federal Government funding initiatives such as the Leading-Edge Cluster Competition, the initiative for ‘Internationalisation of Leading-Edge Clusters, Futures Projects and Comparable Networks’, the ‘go-cluster’ excellence programme, the joint Federal Government–Länder ‘Innovative Higher Education Institution’ initiative, and the ‘Research Campus’ funding initiative are part of the tradition of an innovation culture that specifically promotes mutual exchange and innovation-oriented cooperation between universities, non-university research institutions and companies of different sizes in different sectors, while creating sustainable structures and also involving social actors. These are frequently already models of open innovation culture.

- For example, the most efficient cluster members of the ‘go-cluster’ excellence programme in Germany, which currently number just under 90, bring together around 15,000 players, including more than 10,000 SMEs, 450 highly innovative start-ups, 2,000 large companies, 1,000 university chairs and institutes, 550 non-university research institutions and other organisations.

- Building on these positive experiences, the Innovation Cluster Initiative will address early phases of innovation so that cutting-edge research on the threshold of application can become tomorrow’s leading-edge clusters. Part of the budget for each innovation cluster is reserved for innovation support activities such as the development of an open innovation culture. The ‘Innovation & Structural Transformation’ family of programmes also promotes open innovation approaches.

- In addition, 13 citizen science projects in which ordinary citizens create new knowledge will be supported.

- Implementation of the BMBF’s Open Access Strategy will fund innovative projects that will more firmly anchor open access in the broader German scientific community.

- Funding announcements and the funding decisions of individual ministries contain an open access clause obliging recipients to make their publications from funded projects (also) accessible via open access.

- The establishment of a National Research Data Infrastructure (NRDI) is a central project to open up the scientific data space, promote standardisation and significantly expand the (re-)use of research data. This opens up great potential for new scientific findings and innovations.

- Innovation and key technologies in the field of network and security technologies will be funded as part of the implementation of the Network Strategy 2030 for public governance. The Federal Government will establish a standard process for the identification and evaluation of innovations and trends. An integration platform will be made available for the nationwide utilisation of innovations.

- An open innovation culture requires more freedom to experiment. The real-world laboratory strategy creates new opportunities for testing digital innovations with real-world laboratories as test rooms for innovation and regulation. At the same time, new knowledge will be generated to learn about the economic and societal impact of innovations and to find answers for appropriate regulation in the future.

On the part of the Federal Government, the BMBF and the BMWi are involved in the implementation of the mission.

Integration of science, industry and civil society

The establishment of an open innovation culture and the topic of open science are already being addressed at international level, for example by the G7, the OECD and the EU. In Council Conclusions 8791/16, for example, the Council of the European Union formulated concrete demands for the European Commission which particularly concern aspects of open access and the re-use of research data, in addition to issues such as copyright law. To date, the activities have been carried out largely independently of each other. Examples of initiatives and other actors:

- The proposed European research and innovation framework programme Horizon Europe, which will strengthen the principle of open science. Beyond the current open access policy of Horizon 2020, open access to publications and research data (with the potential of refraining from publishing data in individual cases where data protection or exploitation interests conflict with this) will be further expanded.

- Establishment of the European Open Science Cloud. Researchers in Europe will be able to store, share and re-use data and results in a reliable and open environment.

- Many companies that now use ideas competitions and innovation labs as think tanks for the further development of their business models, often within clusters and networks. They make use of previously untapped potential from existing knowledge and systematically open up their innovation processes, thus creating scope and integrating new partners – right down to users and operators.

- Scientists who make their research results available as open access publications, for example on the publication server of their institutions or in open access journals online, thus opening up access to their research for the general public.

- Institutionally funded research institutions which, within the framework of strengthening collaboration between science, industry and society in the Pact for Research and Innovation, are increasingly also practising novel approaches to more open collaboration with industry and society. This also includes the expansion and increased use of open access.

- The specialist research funding programmes that successfully test new formats, such as maker spaces, and address new target groups, such as freelance programmers.

Moving forward

- Development of a national open access strategy involving relevant players such as the ministries and the Länder. Within the framework of the yet to be developed national Open Access Strategy, the Federal Government will obligate recipients of Federal project funding to make their publications freely available by means of open licences.

- Development of the NRDI (2019–2028; up to 90 million euros annually in the final stage).

- Launch of the first competition round of the Innovation Cluster Initiative in August 2019 with a six-month conception phase in 2020 and start of the implementation phase at the beginning of 2021, stretching over up to three times in three years with a maximum funding amount of five million euros per year and cluster.

- Launch of the funding initiative for ‘Regional Business Alliances for Innovation’ (RUBIN) in the family of programmes ‘Innovation & Structural Transformation’, with three selection rounds in 2020.

- Announcement of a new funding line for citizen sciences in autumn 2019, as well as various nationwide campaigns to anchor citizen science more broadly and firmly in the general population and the science community.

- Launch of funding for experimental spaces for social innovation.

- Establishment of the ‘Open Innovation Culture’ forum (2019–2022; 1.6 million euros). The forum is working towards networking the many existing initiatives and bringing relevant players together.

- Further development of activities in the area of open data, including implementation of the EU Copyright Directive into national law and consequently formulation of the legal requirements for text and data mining, as well as implementation of the PSI Directive on the re-use of public sector and research data.

- Further development, dissemination and systematic use of real-world laboratories. The first real-world laboratories competition will take place in autumn 2019. The guide to real-world laboratories, ‘Handbuch Reallabore’, published in July, and regular exchange in the real-world laboratories network are used to encourage practitioners to create real-world labs and to ensure the transfer of knowledge into legislation.

4. IMPLEMENTING THE HTS 2025: COORDINATED. ADAPTIVE. PARTICIPATIVE.

The Federal Government coordinates its activities across ministries and actively involves science, industry and society in shaping its research and innovation policy. The possibility of adapting to current technological and social developments and broad participation are firmly anchored in the HTS. The governance of HTS 2025 was established with the Round Table of State Secretaries and the HTF accordingly.

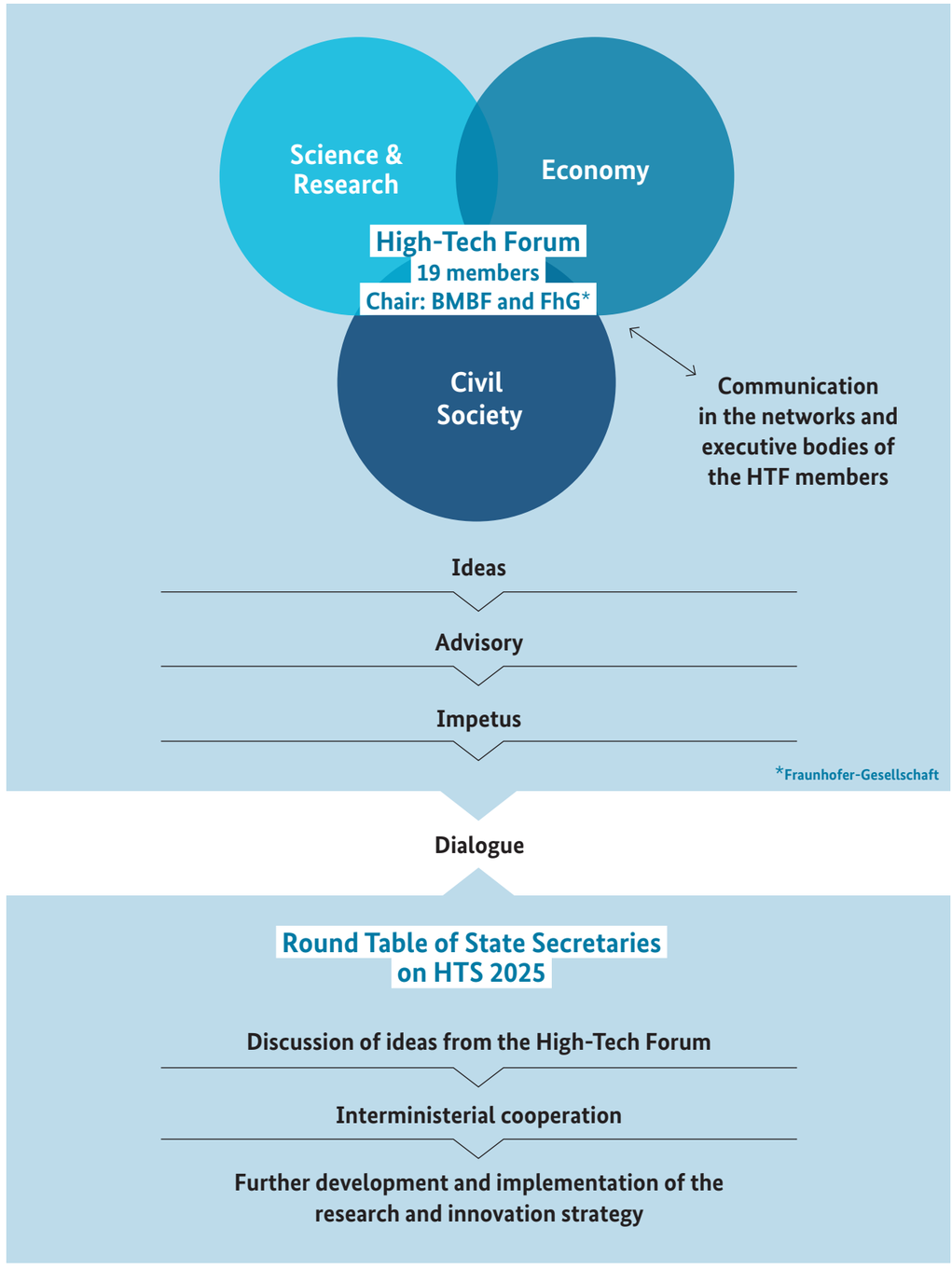
4.1 HTS 2025 as an adaptive research and innovation strategy

As an adaptive strategy, HTS 2025 is designed to react quickly and purposefully to changing trends in the innovation system. Also in this legislative period, implementation and further development of HTS 2025 will be supported by an advisory body, the HTF. At their constituent meeting in January 2019, the 19 experts from science, business and civil society took up their work and will discuss the implementation and further development of HTS 2025 with policymakers in up to three meetings a year. Topics on the agenda include pathways to the 3.5 per cent target, agility of the innovation system, social innovation, sustainability, innovation and skills qualification. In particular, this also provides an opportunity to further expand the already existing content references of HTS 2025 to the Global Sustainability Goals and to anchor sustainability even more firmly in the HTS as the overarching guiding principle. The Federal Government and the Fraunhofer-Gesellschaft share the chairmanship in order to ensure a close link between the HTF and policymakers.

A declared goal of HTS 2025 is to improve interministerial cooperation. A new intra-governmental coordination mechanism was created in the form of a ministerial round table at state secretary level. The (interim) results of the deliberations of the HTF are constantly passed on to the Round Table of State Secretaries on HTS 2025, which meets around the same time as the meetings of the HTF, as well as to existing bodies and political networks of the HTF members. This establishes a constant dialogue between policymakers, the HTF and other actors in the innovation system.

Evaluations of HTS 2025 measures and ongoing consultation by the EFI also provide information on successes and optimisation potential.

Governance of HTS 2025



4.2 Intensification of dialogue through science communication and participation

The Federal Government aims to reinforce science communication in order to increase society's openness towards science and to broaden the base for joint discussions on research and innovation.

According to the EFI's recommendation, research and innovation topics should be brought more into public debate and the implementation of HTS 2025 should be accompanied by vigorous public relations activities.

The science community itself has a duty to better explain itself and to make science more tangible and comprehensible to the general public. Scientists can best communicate their research results themselves with the appropriate support, for example through training courses and professional science communicators, so as to secure social support for fundamental research, technology development and the associated investments.

Citizens and civil society groups should also be more closely involved in the further development of research and innovation policy. In line with the EFI recommendation, preparations have started for a participatory process to further develop research and innovation policy under HTS 2025. The participatory process is part of the Open Government Partnership (OGP), an initiative currently run by 79 countries for open government and administrative action in which the German government has been involved since 2016. The aim of the participatory process is to involve society in the further development of the Federal Government's research and innovation strategy, particularly with regard to societal factors and implications. A series of decentralised dialogue events, interlinked with digital participation formats, will be held from spring to summer 2020.

Published by
Bundesministerium für Bildung und Forschung/
Federal Ministry of Education and Research (BMBF)
Division for Innovation and Transfer Policy Issues;
Coordination
11055 Berlin, Germany

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in writing to
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September 2019

Edited by
BMBF

Layout
familie redlich AG Agentur für Marken und Kommunikation
KOMPAKTMEDIEN Agentur für Kommunikation GmbH

Printed by
BMBF

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