



Federal Ministry
of Education
and Research

Action Plan Artificial Intelligence by the BMBF

Tackling new challenges – seizing opportunities



Introduction

Dear readers,

Artificial intelligence (AI) is currently one of the most talked about new technologies. Announcements of new AI tools, new skills, new cooperations, new potential but also of new risks have been issued on an almost daily basis, ever since ChatGPT was launched just under a year ago. At the same time, there has been intense public debate concerning AI seen from a wide range of different perspectives. The extreme positions – AI as the universal remedy or a hazard to human kind – have been attracting the greatest attention here.

For me it is clear that AI is a key technology, and quite possibly the most decisive advancement of the 21st century. Smart development and use of AI will give rise to huge opportunities, and regulations and bans alone are not going to help. What we need is technological sovereignty in the field of AI. We must be able to develop and use our own AI systems in line with our vision and core values. Our goal is to create trustworthy AI made in Europe. Competences in research, business and the society are crucial in this regard, and so are the right infrastructure and enabling conditions.

The Federal Ministry of Education and Research has been a key driver in the field of AI for many years: the German Research Center for Artificial Intelligence (DFKI) was founded over 35 years ago.

There has hardly been such a thing as an AI winter in German AI research. This is one of the reasons why researchers trained in Germany now hold key positions in AI development worldwide. Furthermore, the BMBF was among the leading contributors in drawing up the Federal Government's AI Strategy that was adopted in 2018. As a consequence of all these aspects, we have a strong foundation: we continue to be among the world leaders in AI research, have been able to attract many AI experts in recent years, and have a very active start-up landscape.

However, generative AI has not only created new dimensions for the individual use of AI, but also for AI policy. Progress in this field is too dynamic for us to tackle it with the usual strategies and attention cycles of the political system. We must become more agile. A new impetus for the German AI ecosystem is urgently needed.



The AI Action Plan is therefore all about conscious progress. It is not a new AI strategy. Instead, the Action Plan is designed to set out new paths for implementing the AI strategy in our areas of responsibility.

There are three areas that are particularly important to me. The first one is to strengthen and interlink the central elements of AI development and usage. Data, computing capacity, skilled workers and research efforts are the key building blocks that are essential for a broad use of AI. Secondly, we want to cooperate more closely in Europe, and to this end we seek coordination in the European Research Area. The third aspect is to deliberately focus on the concrete economic and societal benefits of AI: we want to take the lead in the fields of robotics, healthcare, education and also in AI start-ups.

The AI Action Plan is also linked to a clear commitment to AI as a vital pioneering field that is reflected in the budget.

The goal to position the German AI ecosystem as a global leader is, without a doubt, a task for society as a whole. Contributions from other departments, the economy and society are essential when it comes to exploiting the potential of AI and minimising associated risks. This AI Action Plan is therefore also an invitation to other stakeholders to get involved and contribute their own ideas. Let's realise AI made in Europe together!

A handwritten signature in black ink that reads "B. Stark-Watzinger".

Bettina Stark-Watzinger

Member of the German Bundestag
Federal Minister of Education and Research

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1 AI policy after the “ChatGPT moment”

On November 30, 2022, the American company OpenAI made its language model ChatGPT publicly available. One million users registered within just five days. This was the first time that the general public tested and used artificial intelligence (AI) on a large scale and became aware of the technology’s possibilities.¹ ChatGPT stood out by being easy to use, suitable for a wide range of applications and clearly labelled as an AI system (AI has obviously been in use much longer, but has often gone unnoticed, for example in the case of online searches). Generative AI has given rise to a new dimension especially for the individual use of AI. The publication of ChatGPT can therefore be described as a **milestone of AI development**. This perspective is confirmed by the public debate triggered by its launch. The reactions to ChatGPT were split here, ranging from an optimistic, opportunity-

focused outlook,² via a risk-focused and cautious perspective that ultimately led to a discussion about bans and an AI moratorium,³ to downplaying the technology as merely the latest hype free of any substance.⁴

A more detailed assessment of the AI technology used finds ChatGPT to be particularly suitable for everyday use.

However, far more impressive results are possible from a research point of view. Ever since the turn of the millennium, AI research has been delivering increasingly high-performing application examples (Deep Blue, AlphaGo, ...).

1 See (Menn 2023)

2 See (Scheuer 2023) or (Gates 2023)

3 See (FAZ 2023) and (Future of Life Institute 2023)

4 See (Meineck 2023)

In addition, AI development has been steadily gaining momentum over the past few years.⁵ Generative AI systems of the latest generation have therefore primarily been demonstrating to the general public the possibilities afforded by AI systems that process large data sets in combination with a high and steadily increasing computing power. The **possibilities with regard to further development and improvement of such systems** are immense, owing to the fact that AI features a far broader spectrum of methods than the currently discussed generative systems, which operate largely based on statistical methods, rather than using genuine AI methods. The extension of such statistical methods with well-understood AI methods offers considerable new potential that has not yet been fully exploited.

AI as a key technology

One thing is certain: **AI is a key technology** – much like electricity – that is transforming business activities and societies around the world. As a broadly used tool, AI offers a wide range of opportunities for research, as well as for promoting growth, prosperity, competitiveness and societal benefits. It is extremely likely that we are currently at the very start of a development that could accelerate considerably over the next few years.⁶ Those who close their eyes to this development, who primarily focuses on risks and bans or try to slow it down, will miss the chance to benefit from the opportunities available and to contribute to shaping the developments in their own interest. We must aspire to more than that! Instead, we should think of the provision of AI as a public service. It is to be expected that AI tools, AI competency and AI infrastructure will be regarded as essential utilities for companies and citizens alike, much in the way that easy and legally sound access to high-speed internet is considered nowadays. This will turn AI into an important location factor.

We want to achieve technological sovereignty in the field of AI. Our goal is for Germany and Europe to take on a leading role in a world that is powered by AI. We want to continue to improve the general conditions for this.

The BMBF promotes AI innovation

The Federal Ministry of Education and Research (BMBF) previously addressed the issue of AI in the Federal Government’s **Future Research and Innovation Strategy**, as a key technology and a central topic within the mission to “ensure Germany’s digital and technological sovereignty and utilise the potential of digitalisation” (Mission IV), and as part of various goals within the other missions, comprising, e.g., the use of AI for new business models and a resource-efficient and competitive industry, AI-based diagnostics and therapy, AI-based social innovation, AI in geological, ocean, biodiversity and climate research, as well as astrophysics and particle physics research, and strengthening AI competence in civil society, to name just a few examples.⁷ A key element of the future strategy’s mission-orientation is the cooperation with other European states, such as the joint development of AI solutions by Germany and France, or establishing AI competency at the leading European AI research institutions. We are going to advocate for a further strengthening of European AI policy, and will be holding a European workshop on this issue shortly.

Germany has had a national AI strategy since 2018, and investment in AI has increased considerably in this context. Foundations were laid, processes were initiated and milestones were reached. The BMBF has been a key player in this: It received the largest share (just over a third) of the dedicated AI funds provided, used it to start vital initiatives in the areas of research, talent and skills, infrastructure, and transfer, and thus established an excellent basis for AI research and the training of AI experts in Germany for years to come. The BMBF’s annual budget for AI increased more than twenty-fold since 2017.

⁵ The number of publications per year almost doubled between 2011 and 2021 to currently almost 500,000. The number of AI projects on GitHub, private investment in AI but also cases of unethical use of AI have increased on a similar scale. See in particular (Maslej, et al. 2023).

⁶ See e.g. (Martin-Jung 2023)

⁷ See (BMBF 2023b)

The BMBF currently promotes research, development and application of AI through **50 ongoing measures** focusing on research, competency development, infrastructure development and transfer into application. These are now going to be supplemented by **at least 20 further targeted initiatives**. The BMBF alone will be investing **over 1.6 billion euros** in AI in the current legislative period. The following table contains an overview of budget development:

Year	2017 (ACTUAL)	2018 (ACTUAL)	2019 (ACTUAL)	2020 (ACTUAL)
AI Budget (in million euros)	17.4	20.5	41.9	85.7
Year	2021 (IST)	2022 (IST)	2023 (SOLL)	2024 (SOLL)
AI Budget (in million euros)	120.2	280.4	427.2	483.3

Building on this, we are taking the **BMBF's commitment to the next level** with this AI action plan. The clear goal is to give the German AI ecosystem new impetus, in particular concerning its interfaces with education, science and research, as well as with the industry. To this end, the BMBF has been exchanging ideas with AI experts and stakeholders, especially during the annual conference of Germany's Platform for Artificial Intelligence held on 14 June 2023⁸, in various technical discussions about AI with stakeholders, for example on June 20, 2023, September 21, 2023 and October 18, 2023, during the opportunities talk on "AI in education" on July 4, 2023⁹ and a series of visits to the AI competence centres and the Minister's summer tour. The results are **eleven specific fields of action** that illustrate where action is needed most urgently, how the BMBF is already addressing this and what should and must be done over the next few months and years. The BMBF sees itself as a **key driving force** within the Federal Government, also in the future.

Overarching goals

One essential goal of the AI Action Plan is to translate Germany's **excellent foundations in the areas of research and skills into visible and measurable economic success and tangible benefits for society**.

After all, the reason why an AI system developed for specific purposes such as ChatGPT became the reference point of the AI debate, was the fact that it enabled people to experience the usefulness of AI at first hand and therefore demonstrated the path from AI research to value creation. Meanwhile, similar systems from Germany and Europe and qualitative research developments in particular often remained unnoticed and have rarely been associated with specific benefits and value creation. Visible results and achievements are necessary not only from the perspective of technological sovereignty and competitiveness. They are also essential in order to convince the general public of the potential and opportunities afforded by AI, and for bringing this type of debate about handling AI regulation far closer to people's everyday realities, focusing on the technology's specific benefits. AI is not primarily about enabling business models for a small number of US corporations or a tool for enemies of democracy. Instead, it is a key technology that, as a driver of innovation, can give rise to great future potential as well as helping us reach the sustainability goals, provided that we develop and use it wisely.

To this end, we must find answers to the questions of what could be the **unique selling point of AI made in Germany** (or made in Europe) and how we can **most effectively interlink AI with our existing assets**. Imitating the American or Chinese way is not very promising here, as we do not wish for a small number of technology companies to take over the field and are not seeking AI-based government monitoring either. One promising approach is to interlink AI with digitalisation of the industry (Industry 4.0), which is considered a model for success made in Germany.¹⁰ Germany also has strong players who are active on the interfaces between AI and biotechnology, as well as AI and energy and environmental technology. Another possibility is to focus more strongly on the area of B2B and the advancement of development ecosystems based on open source solutions.

⁸ See (Germany's Platform for Artificial Intelligence 2023)

⁹ See (BMBF 2023a)

¹⁰ See e.g. (Acemoglu and Johnson 2023), chapter 8

Another positive aspect is that, according to a study conducted by the AI association, 40 percent of start-ups in Germany are based on scientific foundation work, implementing ideas developed in research.¹¹ While the difficulties in competition for risk capital prevail; the Federal Government has been addressing these in another context.

In addition, it is also essential to conduct the current **debate concerning risks associated with AI** and the necessary general legal conditions on a **scientifically and empirically sound basis**. We should not allow ourselves to be guided by extreme scenarios and prophecies of doom. Current questions, concerning, e. g., the appropriateness, feasibility and effect of an AI labelling obligation or the adequate interpretation and possibly necessary adaptation of affected legal regulations such as copyright law, should not only be discussed in a democratic process involving various relevant groups of stakeholders, but should also be answered in close coordination with representatives of multi-disciplinary AI research. The same is true for **risk classification of AI systems**. The BMBF generally welcomes the risk-based approach of the current draft of the AI Act. However, this must be designed in such a way that it does not stifle innovation. We also support a research-based approach for identifying and assessing specific risks on a case-to-case basis. For this purpose, we seek to advance the required research, for example in the area of education.

The BMBF’s AI Action Plan does not only contribute to reaching the goals of the Federal Government’s Future Research and Innovation Strategy, but it is also an **update of the BMBF’s contribution to the Federal Government’s AI Strategy**. Close collaboration of all departments is the best way to make full use of the opportunities afforded by AI as a key technology. We therefore attach great importance to a **tight interlinking of the BMBF’s activities with the AI measures taken by other departments**. Cooperation with AI experts from the fields of science, business and the civil society is just as important, as their ideas and investments are crucial. Against this background, we think of this AI Action Plan as the preliminary work for a further development of the Federal Government’s AI Strategy together with

other departments and stakeholders, both in general and with regard to addressing the newest challenges.

At the same time, it is also important to bring the German AI activities, strengths and interests **to the European context** in a targeted and coordinated manner, and to take the cooperation to a new level, also in terms of quality. Germany must take on a leading role in shaping and further developing the **European AI Strategy**. To this end, we are going to ensure coordination within the European Research Area at an early stage in order to be able to unfold the full power in the sense of the “Team Europe” approach at the global level and to achieve a new level of quality in our collaboration. This applies in particular to the EU Research Framework Programme. Around 1 billion euros per year are already earmarked for AI-related activities in the current programme “Horizon Europe”.

We want to build on this and rely on a strong 10th Research Framework Programme to ensure that the future of Europe as an AI location is secured, shaped and strengthened further through research and development, also beyond 2027.

AI can also help in the area of administration and provide assistance for employees. This is why we are going to look into this option more closely at the BMBF, too. To this end, we plan to experiment more and to start using generative AI internally as part of a pilot project. We plan to use AI also for external purposes by next summer.

After all, we think of the Action Plan as a “learning strategy” that we will continue to develop further based on new developments and ongoing conversations.

AI has far too rarely been made in Germany or Europe to date. We want to change this through targeted stimulus that will contribute to making sure that Germany continues to be an AI nation. We are committed to utilise the enormous opportunities offered by AI.

¹¹ See (Klüwer, et al. 2023)



2 Infrastructure

2.1 Further strengthening the research base

Research will remain the basis of the AI revolution also in the future, as research work regarding the technology is far from done. To be able to exploit its potential, we must make the technology better and more efficient, but also safer, more transparent and more reliable. Further potential of AI, but also associated risks and ways to handle them can only be identified through additional research.

Initial situation: status quo

- Germany and Europe are still among the world leaders in the field of AI research. When it comes to the number of AI publications and citations as well as contributions to AI open source software development, Germany is regularly among the five/six strongest nations. However, far greater dynamism can be observed in other countries (China, USA, India).¹²
- In the field of large generative AI models or AI foundation models, Germany has also been involved in pushing ahead development on the global scale and has produced competitive products such as

Luminous (Aleph Alpha) and Stable Diffusion.¹³ On the whole, the field is nevertheless dominated by the USA.¹⁴

- AI research has increasingly been shifting towards the private sector. This has an impact on the focus areas of AI research, and topics that are of importance for society – such as AI applications for the healthcare sector, improvements to the resource efficiency of AI, or the social and ethical consequences of AI – could be sidelined in the medium and long term.¹⁵

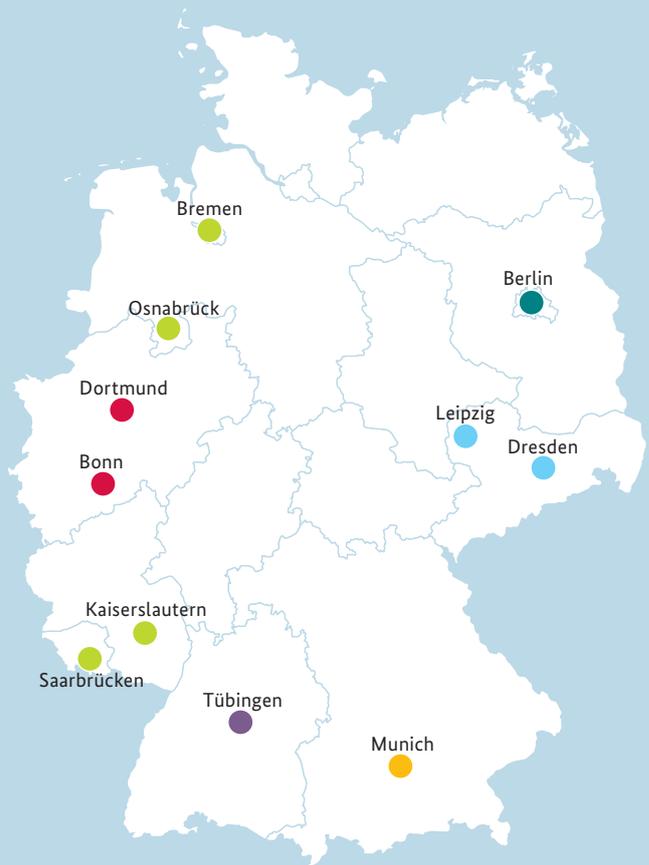
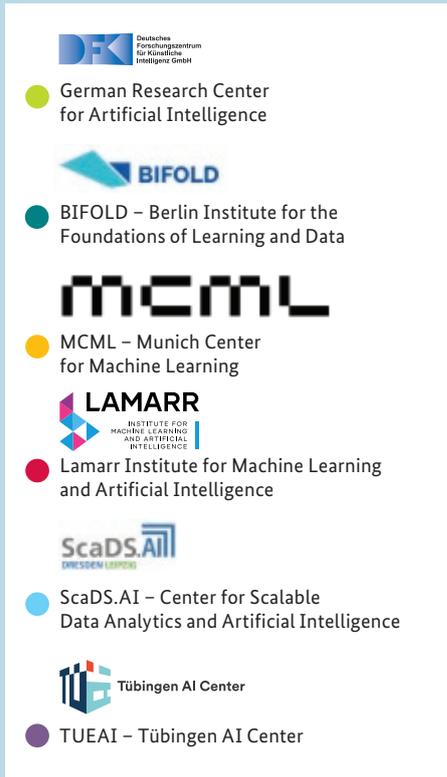
¹² See e.g. (Germany's Platform for Artificial Intelligence 2022) and (Maslej, et al. 2023)

¹³ See e.g. (Böschel 2023)

¹⁴ See (Maslej, et al. 2023)

¹⁵ See (Ahmed, Wahed and Thompson 2023)

Centres of Excellence for AI Research



- The AI Act envisaged by the EU Commission gives rise to questions related to AI research and development. The intended requirements for high-risk AI applications – concerning transparency, robustness, reliability and verifiability, for example – need to be translated into technical solutions, as well as into norms and standards. Requirements that are not technically feasible will otherwise have the same effect as bans. The same is true for excessive bureaucratic obstacles.

Objectives: what we want to achieve

Germany must reinforce its strong position in AI research to achieve excellence and use its position as a prominent asset. It must be our goal to maintain a leading position in research and to establish ourselves as a clear driving force in Europe. To this end, we want to pursue the following concrete goals:

- To reach the top spot in Europe in AI publications, ahead of the United Kingdom
- To establish the AI competence centres as leading European AI research institutions

- To demonstrate significant progress in the areas of explainability and trustworthiness of AI
- To position Germany as a leading player in the area of large generative AI models, in particular multi-modal AI models and to establish unique characteristics
- To reinforce inter-disciplinary networking between machine learning research and other approaches, disciplines, and areas of application

The BMBF's contribution

- **Initiation of a new funding line for flexible, resilient and efficient machine learning models**
- Reinforcing the focus on excellence and the strategic direction of the **AI competence centres** (61 million euros per year)
- Targeted research funding for topics such as **explainability, robustness, and databases** of AI



2.2 Fostering a research agenda for new perspectives

AI advancements that attracted a lot of publicity in recent years were based primarily on statistical methods of machine learning combined with a significant increase in the data and computing power that is available and used. However, the spectrum of AI methods is far greater. Enhancing the existing statistical methods by adding well-understood genuine AI methods alone provides for considerable new potential that has not been exploited to date. In addition, there are further challenges, such as small-data and energy-efficient AI or interconnection of AI with innovative computer architectures.

Initial situation: status quo

- Large AI models feature systematic limitations. These include hallucinations and biases, a lack of understanding of mathematics, logics, chronology and causality, a lack of insight into what has been learned, and the models' large data and energy demands. Further research is needed here, for example regarding multi-modal and hybrid AI systems or contextualisation.¹⁶
- Small AI models that can run on commercially available standard PCs have already proved to be surprisingly powerful.¹⁷
- The environmental impact of AI, e.g., due to energy consumption, is examined more and more critically. This calls for new methods for ensuring energy and resource-efficiency of AI.¹⁸
- New computer architectures are opening up new possibilities for AI research.¹⁹
- Furthermore, AI gives rise to both opportunities and new risks from an IT security point of view.²⁰

¹⁶ See (Löser, et al. 2023)

¹⁷ See (Bager 2023)

¹⁸ See (Maslej, et al. 2023)

¹⁹ See e.g. (Merkel 2023) and (Bacho, Boche and Kutyniok 2023)

²⁰ See (Mittelstand 4.0 Kompetenzzentren Deutschlandweit 2021)

Objectives: what we want to achieve

Germany must not lose sight of new trends in AI research, including beyond the most popular subjects. We must establish a strong research base and must address emerging trends early on in order to create opportunities for achieving comparative advantages. Our goals are therefore these:

- To make hybrid AI systems a focus topic of German AI research
- To promote research and application of small-data and energy-efficient AI systems, federated learning and edge AI, as well as of “small AI models”
- To strengthen the interface between AI research and IT security research and to thus translate Germany’s strengths in the field of IT security research into secure AI and AI-based security solutions made in Germany, also with regard to data protection and privacy rights
- To interlink AI research and research concerning new computer architectures at an early stage, in particular with regard to neuromorphic computing and quantum computing
- To promote hardware and software development for and with AI

The BMBF’s contribution

- **Development of AI foundation models for science with a focus on the topics of earth, the environment, energy, and climate by large research institutions, possibly with involvement of European partners**
- Establishing a research network in the area of “**neuroscience-inspired AI**”
- Funding measure: **Secure future technologies in a hyper-networked world: AI**
- Establishing a testing environment for **evaluating generative AI in IT security** in order to identify risks and opportunities related to the technology and to promote appropriate key research areas in an agile manner.
- Further development of **microelectronics research structures for neuromorphic computing and quantum computing**, in particular as part of the “NeuroTEC II” project and at the “Forschungsfabrik Mikroelektronik”



2.3 Purposefully expanding the AI infrastructure

Data and computing power are the key drivers of the AI revolution, besides talent. Generative AI models in particular show what a synergy of these three factors can give rise to. The leading edge of industry, especially when it comes to generative AI models, is enabled mostly by privileged access to these three components. Data centres and data platforms are increasingly turning into essential facilities as a result, whose provision is becoming a basic social service.

Initial situation: status quo

- The amount of data that is created, used and stored, the available computing power and the computing power used by leading ML systems (i. e., AI systems based on machine learning) have grown exponentially over the past few decades.²¹
- The most recent initiatives have been calling for the provision of computing centres with at least 100,000 GPU.²²
- Two of the 36 most important ML systems launched in 2022 are from Germany, and 12 are from Europe including the United Kingdom. Germany is ranked 7th with regard to the developers involved.²³
- On the list of the top 500 super computers, Germany is in 3rd place (behind the USA and China) when it comes to the number of systems and in 6th place regarding the overall computing power (behind the USA, Japan, China, Finland and Italy).²⁴

²¹ See (Löser, et al. 2023), figures 1, 2 and 3

²² See i.a. (LAION.ai 2023)

²³ See (Maslej, et al. 2023), Section 1.2

²⁴ See top500.org/statistics/list

Objectives: what we want to achieve

Availability of and access to world-class AI computing infrastructure are key, if we want to be in the top bracket of AI research, development and application. In order to achieve this, we want:

- To provide internationally competitive high-performance computing infrastructure for scientific purposes, including in particular for AI researchers from the academic and business sector
- To significantly increase the number of AI users on German and European HPC systems and to establish the AI community in the top 10 of HPC user communities
- To ensure availability of quality-assured data as a basis for AI
- To enable access to computers and data also for the business sector and in particular for small and medium-sized enterprises and start-ups
- To pave the way for research and development of a significant share of large AI models to take place in Germany and Europe

The BMBF's contribution

- **Making infrastructure AI-ready through targeted initiatives and improving access for the AI community and start-ups in particular**
- Promoting targeted **cooperation between public and private stakeholders**, for example by encouraging the establishment of a **European industrial computer** in the context of EuroHPC
- Further strengthening the **Gauss Centre for Supercomputing, national supercomputing** and European cooperation in the context of **EuroHPC** as the foundation for the German computing infrastructure, and opening these up for applications, especially in a European context
- Taking **exascale supercomputers** into operation, starting with the JUPITER computer in the 4th quarter of 2024 at the Jülich Research Centre, followed gradually by the LRZ in Munich and the HLRS in Stuttgart
- Providing access to AI-specific computing infrastructure on a large scale via the **AI service centres**
- Further improving data availability in science through the **NFDI**, the **EOSC** and further funding initiatives, for example in the healthcare sector
- Improving retrievability, access and connectivity of data through a **research data act**



2.4 Promoting an AI competency offensive

Adequate skills are key when it comes to handling AI confidently as well as for realising the technology's full potential, and for ensuring technological sovereignty and a competitive and exemplary role for Germany in the field of AI. This applies to research challenges that cannot be overcome without the best researchers. However, it increasingly also applies across many other scientific disciplines as well as in the business world, as AI has been turning more and more into an essential tool for all areas. Expertise is also key when it comes to successful research transfer, as close cooperation with domain experts is essential when it comes to practical application and everyday use of AI systems. AI skills are therefore increasingly becoming part of the basic digital qualification across many areas of academic and professional training: doctors, laboratory chemists, engineers, retail workers, economists, media designers, ethicists, dental technicians and many others will need to use AI with its opportunities and risks in an informed and confident way as part of their working life, and the same is true for all citizens in their everyday life. The AI Act thus describes rights for users that can hardly be exercised without adequate AI skills.

Initial situation: status quo

- The shortage of skilled professionals continues to intensify in the AI sector, despite a growing number of training and education options. This is regularly named as one of the greatest obstacles to use of AI.²⁵
- Deficits can also be observed with regard to adequate participation of society in AI development. Women, for example, continue to be under-represented.²⁶
- The new Skilled Workers Immigration Act gives rise to new opportunities also concerning this key technology. These must be seized in a targeted manner.

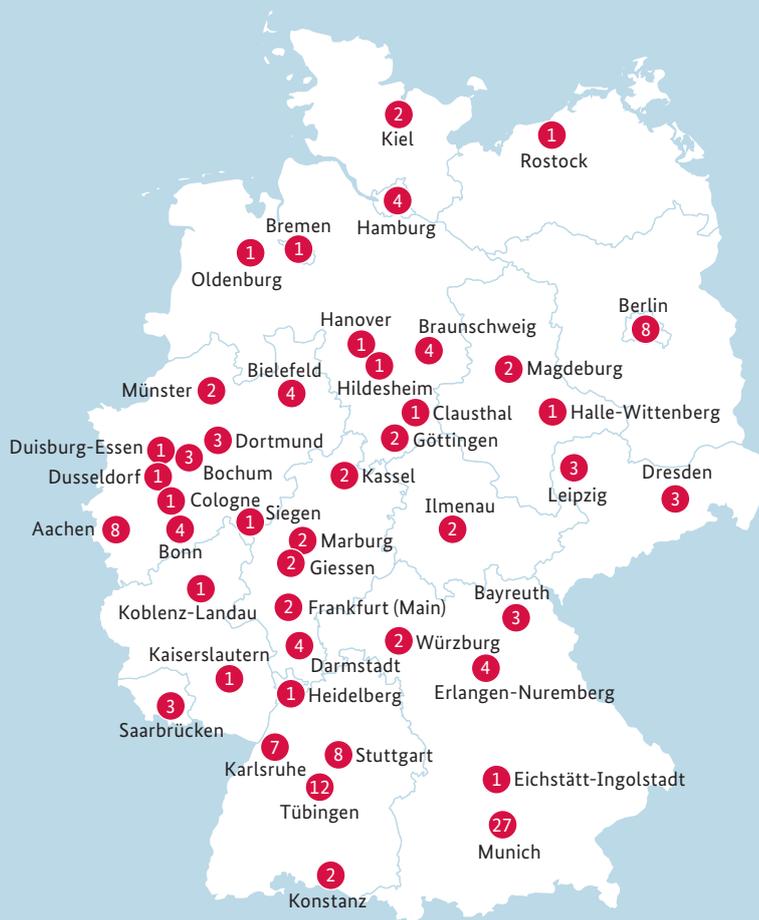
²⁵ See e.g. (Bitkom 2023), (Klößner 2023) and (Rammer, et al. 2023)

²⁶ See (Maslej, et al. 2023), figure 4.1.14

AI professorships at German universities

Universities

RWTH Aachen University · University of Bayreuth · Freie Universität Berlin · Humboldt Universität zu Berlin · Technische Universität Berlin · Bielefeld University · Ruhr University Bochum · University of Bonn · Technische Universität Braunschweig · University of Bremen · Clausthal University of Technology · Technical University of Darmstadt · TU Dortmund University · TUD Dresden University of Technology · HHU Düsseldorf · University of Duisburg-Essen · Catholic University of Eichstätt-Ingolstadt · Friedrich-Alexander Universität Erlangen-Nürnberg · Goethe University Frankfurt am Main · Giessen University · University of Göttingen · Martin Luther University Halle-Wittenberg · TU Hamburg · Universität Hamburg · Leibniz University Hannover · Heidelberg University · University of Hildesheim · Technische Universität Ilmenau · Karlsruhe Institute of Technology · University of Kassel · University of Kaiserslautern · Kiel University · University of Koblenz-Landau · University of Cologne · University of Konstanz · Leipzig University · University of Magdeburg · Philipps-Universität Marburg · Ludwig-Maximilians-Universität München · Technical University of Munich · University of Münster · University of Oldenburg · University of Rostock · Saarland University · University of Siegen · University of Stuttgart · University of Tübingen · Julius-Maximilians-Universität Würzburg



● Number of new AI professorships at this location

Objectives: what we want to achieve

Availability of AI skills in science, business, and society is a key prerequisite for a confident use of AI, for realising the technology's full potential and for ensuring and expanding technological sovereignty in the field of AI. This is why we want to ensure AI skills across all levels in the long term. To this end, we are setting ourselves the following concrete goals:

- To permanently increase AI skills development across all levels from basic to expert knowledge and along the entire education chain
- To attract the best young AI talents from around the world and to retain these for German science and industry at home and abroad, including a targeted use of the opportunities offered by the Skilled Workers Immigration Act
- To encourage networking of science and industry in the AI sector across disciplines and locations in order to aid training and research
- To establish a funding pipeline of young AI researchers from students through to candidates for professorship, with a share of at least 50% women

The BMBF's contribution

- **New funding initiative for junior research groups in the field of AI led by women**
- Making use of and further strengthening existing structures such as the **AI competence centres**, the currently **150 additional AI professorships** with BMBF support (e.g. Alexander von Humboldt Professorships for AI, TenureTrackProgramme), the ongoing initiatives for **supporting young AI researchers** (e.g., 42 existing junior research groups on AI, Zuse Schools of Excellence in AI, International AI Future Laboratories, KINachwuchs@FH), and the **AI Campus**
- Strengthening basic AI skills through the **STEM Action Plan 2.0**, the **Data Competency Toolbox** and the **Data Competency Centres** for science
- **"The Future of eHealth"** funding programme for targeted training of scientists on the interface between AI, data science, and healthcare research



3 Application and transfer

3.1 Promoting transfer of AI into growth and business opportunities

As a key technology, AI affords enormous potential across numerous industries and areas of application. More than 1,100 application examples from all over Germany are already listed on the AI map by Germany's Platform "Lernende Systeme" (PLS). However, the path from an application example to growth and prosperity is a long one. Apart from a few remarkable exceptions – such as Celonis, Aleph Alpha, and DeepL – Germany has so far not attracted a lot of attention worldwide with economic successes in the field of AI. This has to change. Translating the strong scientific basis into economic strength and societal benefits is indispensable for a foundation technology such as AI, whose provision will be considered a basic social service in the medium term. One of the biggest challenges in this context is to integrate autonomous systems such as robotics into business practice in a systematic, human-centred manner, in order to be able to develop innovative products and services as well as sustainable work processes and to promote transfer and utilisation skills.

Initial situation: status quo

- Only 15 percent of German companies use AI.²⁷
- Germany has an extensive AI start-up scene.²⁸ The number of German AI start-ups more than doubled in 2023.²⁹ In addition, these tend to have a strong scientific basis:
 - more than 40 % of these are university start-ups, compared to only 2.4 % of all German start-ups.³⁰
 - Nevertheless, when it comes to the number of AI start-ups founded between 2013 and 2022, Germany is only in 9th place with 245 start-ups, behind Japan, India, France, Canada and the United Kingdom, and far behind China (1,337) and the USA (4,643).³¹

²⁷ See (Bitkom 2023)

²⁸ See (Rammer, et al. 2023)

²⁹ See (appliedAI 2023)

³⁰ See (Klüwer, et al. 2023)

³¹ See (Maslej, et al. 2023), figure 4.2.17

- In 2022, the total of **private investment in AI** was 2.35 billion US dollars in Germany. This is about half of the amount recorded in the United Kingdom (4.37 billion US dollars), one sixth of the amount invested in China (13.41 billion US dollars) and one twentieth of the amount record in the USA (47.36 billion US dollars).
- In terms of **AI patents**, Germany regularly ranks in the front midfield (between ranks 5th and 7th place), behind the USA and China, but also Japan and South Korea.³²
- The majority of generative AI models are closed source models that are developed by large American or Chinese corporations.³³

Objectives: what we want to achieve

There is a substantial need to take action, especially with regard to translating our excellent AI research into new products, services, business models, work processes, and start-ups. This is why we are going to focus on the following goals:

- To establish regional innovation ecosystems with international visibility for AI applications in areas that are essential for Germany
- To substantially increase the range of applications, integration and transfer into practice of AI, to develop competency in companies and as a result increase the share of companies that use AI
- To make proven AI methods and models available in a production-related application, especially for small and medium-sized companies
- To make use of the innovation potential of AI-based robotics
- To double the number of patents to catch up with Japan and South Korea
- To increase the number of university start-ups in the field of AI

³² See (Kroll, et al. 2022)

³³ See (Löser, et al. 2023) and (Solaiman 2023)

The BMBF's contribution

- **Further strengthening and pooling of top-level research in the field of AI-based robotics through a “Robotics Research” Action Plan by the BMBF**
- Targeted consultation and support for **small and medium-sized companies** for using AI, in particular via the **AI service centres**, the **regional competence centres for labour research – AI**, and the measure “**KI4KMU**”
- **Priority area production:**
 - Development of measures for increasing the capacity and functionality of production machines and equipment through intensified use of AI (**ProLern**)
 - Promotion of Industry 4.0 – GAIAX applications in value-creation networks using AI (**InGAIAX**)
 - Encouraging the use of AI in production through **transfer and demonstration centres**
- Targeted creation of **regional innovation ecosystems focusing on AI** based on outstanding research locations
- Improving conditions for **deep tech start-ups** in the area of AI, for example through cooperation with AI competence centres and AI service centres
- Development and testing of **low-threshold access to funding**, especially for small and medium-sized companies and start-ups
- Improving **possibilities for switching between science and business**, also in exchange with the federal states
- Promotion of **overarching projects** in which the different **elements/layers** and stakeholders of AI (research, computing infrastructure, data, application) are deliberately **combined**
- Support for AI projects by the Federal Agency for Disruptive Innovation **SPRIND**



3.2 AI in the healthcare sector: societal benefits for everyone

The potential of AI goes far beyond business applications and increasing competitiveness in various industries. There is a wide range of possible AI applications in the healthcare sector. AI can help to take care of patients more effectively and cost-efficiently and to reduce the strain on medical staff. There is also enormous potential for healthcare research. AI in data-based biomedical research now means that large and ideally representative datasets can be analysed quickly and intelligently and be used to address medically relevant questions. This means that AI can be used to realise vast innovation potential. AI is going to change the medical field in a future-oriented way.

Initial situation: status quo

- AI is already used to aid diagnostics and therapy as well as everyday care processes. AI-based clinical decision support systems can reduce the burden on medical staff in their daily work. However, the existing potential is far from exploited.³⁴
- AI-assisted methods and analysis tools help us to improve our grasp of biomedical processes and they form the basis for drawing up individual risk profiles at an early stage to aid prevention and diagnostics. AI analyses are used in cancer research, for example, to help doctors assess, which forms of treatment are most likely to be successful.
- The use of AI has also been steadily speeding up the development of new active substances. New potential for a more targeted and cost-efficient search for and review of active substances is being developed with the help of AI by the pharmaceutical and biotech industries in particular.
- The result of AI applications depends strongly on the amount, quality and representativeness of the data available. In addition, particular requirements apply to health data with regard to reliability, security and data protection.

Objectives: what we want to achieve

AI is a driver of innovation in the healthcare sector. AI enables progress in medicine from which everyone can benefit. This is why we want to continue realising the potential afforded by AI in the healthcare sector and implement the following measures:

- To promote AI research in the health and care sectors on a large scale, aiming to make use of opportunities and possibilities to the benefit of everyone
- To attract and develop young AI scientists and AI talent in the healthcare sector, in order to address demographic change and the shortage of skilled workers
- To expand and upgrade data infrastructure, in order to improve availability of biomedical data for AI applications

The BMBF's contribution

- Funding initiative **“Making repositories and AI systems usable in everyday nursing activities”** to support nursing staff and family members who provide care to help them use AI applications for improving autonomy and quality of life of individuals requiring care
- Funding initiatives for researching **ethical, legal and social aspects (ELSA)** of digitalisation in projects in the area of AI
- Sustainable recruitment of scientists from STEM disciplines for research in the area of eHealth with a new funding programme called **“The Future of eHealth”**
- Diverse range of measures by **institutionally funded facilities** from the areas of life science concerning AI applications in the medical field, such as the coordination of the Helmholtz Association's AI platform by the Helmholtz Centre in Munich (German research centre for health and environment (HMGU)) as well as the establishment of institutes and project teams that are focusing on an increased use of AI in the healthcare sector: Institute of Machine Learning in Biomedical Imaging at the HMGU, Initiative Metrics Reloaded led by the German Cancer Research Centre (DKFZ); use of swarm learning as a methodical approach for working with large amounts of data at the German Centre for Neurodegenerative Diseases (DZNE).
- The goal of the six **“Digital Hubs for Advances in Healthcare”** (as a module of the Medical Informatics Initiative) is to improve research possibilities and patient care through innovative IT solutions and shared use of data across university hospitals and regional healthcare facilities, for example through AI applications.
- The **Network of University Medicine (NUM)** has established various infrastructures, in part in cooperation with the Medical Informatics Initiative. These allow for more effective use of medical data, including for AI applications. In addition, there are sub-projects by the NUM that specifically address AI applications, e.g. for analysis and diagnostics using radiology imaging files.
- **Launch of a funding initiative for new approaches to data sharing and data analysis in long/post-COVID research**
- Establishing a research network titled **“neuro-science-inspired AI”** (Neuro AI) for further development of AI technologies based on findings in the area of neuroscience and (further) development of AI applications in the field of medical neuroscience
- Continuation and expansion of the funding measure for new approaches to **data analysis and data sharing in cancer research**
- Launch of a new round of the funding initiative **“Computational Life Sciences”** to foster the development of AI-assisted analysis tools for researching post-acute infection syndromes (PAIS)
- Continuation of the funding line **“promoting modelling competency concerning the spread of severe infectious diseases (MONID)”** for the use of AI in data analysis and model calibration
- Funding initiative **“AI-based assistance systems for process-related healthcare applications”** to support medical, organisational, and administrative processes in hospitals using AI methods



3.3 Realising societal and scientific advantages of AI systematically

AI offers considerable opportunities that should be utilised also in central societal areas of use, such as energy supply, civil security and journalism, but also when it comes to adapting to the consequences of climate change, the protection and sustainable use of natural resources, and safeguarding biodiversity and ecosystem services. Special requirements with regard to reliability, security and data protection must be observed in these areas, too.

AI will also be playing a key role in scientific processes in the future. There is a wide range of possibilities for future use, in addition to the already established use of AI in data analysis and simulation-based analyses. These include the development of research questions and hypotheses, and automated literature research, but also entire experiments as well as support functions for the writing process and peer reviews. At the same time, this gives rise to new questions concerning the prerequisites, criteria and functions of AI-powered science.

Initial situation: status quo

- AI can make a positive contribution to reaching 134 of the 169 sub-goals of the 17 UN Sustainable Development Goals (SDG).³⁵
- AI is already being used across various levels of the scientific process and offers far greater potential for increasing scientific productivity.³⁶ In 2022, for example, significant progress was made with the help of AI in the fields of mathematics, fusion energy research, and antibody research.³⁷

³⁵ See (Vinuesa, et al. 2020)

³⁶ See i. a. (Nolan 2023) and (Ghosh 2023)

³⁷ See (Maslej, et al. 2023), Section 2.9

- The use of AI in science also gives rise to new questions concerning, for example, scientific quality criteria, copyright and authorship, (infra) structural prerequisites of scientific work, training of researchers, and dual use.³⁸ AI contributes to an enormous increase of so-called fake science: allegedly scientific work with nonsensical content that is published in academic journals, nevertheless.³⁹
- AI-based applications can help to create new possibilities for science journalism in handling the flood of information and allowing for information about new topics and the latest trends in science to be provided quickly.
- To establish AI as a standard tool in science and create the necessary conditions, in particular at non-university research facilities
- To reinforce inter-disciplinary networking between AI research and other disciplines and areas of application

The BMBF's contribution

Objectives: what we want to achieve

Societal benefits of AI must continue to play a central role in the Federal Government's AI policy. We want to realise the enormous potential offered by AI for achieving a more sustainable, resilient and secure business world and society, as well as for new scientific methods. Our specific goals are these:

- To develop AI as a tool for digital sustainability innovation and transformation in line with sustainable development
- To establish sustainability as a priority of the German AI landscape and build networks between AI research and climate and environmental research
- To develop platforms that aid decision-making, in order to help municipalities to make faster yet still sound decisions for urban climate adjustments
- To use AI comprehensively as a tool in biodiversity research
- To increase civil security with user-friendly, AI-based digital tools
- **A new round of the funding guideline "Digital Greentech" focusing on the "water balance", including that of AI**
- Intensifying use of AI at **institutionally funded research facilities**
- Targeted funding initiatives for the use of AI, e.g. in **material research, climate research and basic research in physics on large-scale devices**
- **Measures in the context of AI and sustainability**, in particular AI application hub "plastic packaging", funding measure for use of AI in biodiversity research, intensifying use of AI in municipal planning to improve climate resilience
- Funding of projects for AI-based application-oriented security solutions in the **"research for civil security"** programme
- Funding of the Science Media Center (SMC) for technological strengthening, expansion and improvement (augmentation) of **science journalism**

³⁸ See i. a. (Flanagan, Ferri De Oliveira and Ribeiro 2023)

³⁹ See (Sabel, et al. 2023)



3.4 Researching and designing AI-based technologies for the education system

The use of AI-based innovations does not only have an impact on our everyday lives but also on our education system and the ways in which we teach, learn, and generate new knowledge. In the area of education, AI offers opportunities for individual support and can assist teaching and training staff. At the same time, AI gives rise to new challenges for the education system concerning competences and qualifications, teaching and learning processes, performance assessment and exam formats, quality control and certification for educational materials and media.

Initial situation: status quo

- There are few studies about the use of AI in the education sector and vocational training to date.
- It is apparent that the potential of AI in the areas of education and vocational training is not being exploited to date.⁴⁰
- In line with the advances in AI development, education and training providers are faced with the challenge to rethink and further develop not only teaching and training formats but also examination formats, school organisation, and administration processes.
- Learners and teaching staff alike need specific skills to be able to use AI confidently.⁴¹

40 See (Schmid, et al. 2021)

41 See (Long and Magerko 2020)

Objectives: what we want to achieve

AI is to be used in education in a responsible manner, wherever AI can help to improve learning and teaching processes and results (at a low risk).

Our goals are these:

- To promote research that will improve the knowledge base and help the education system to adapt to and handle AI
- To promote AI skills of students and teaching staff
- To encourage and support the use of AI in education based on pedagogical principals
- To (help) design national and international processes related to digitalisation and AI in education
- To make AI a part of the majority of educational biographies as learning content and as a tool
- To develop guidelines for usage and implementation scenarios related to issues such as data protection and data management, accountability, control and transparency, as well as inclusion and social well-being.

The BMBF's contribution

- **Strengthening educational research: Research concerning the possibilities and limitations of AI in supporting (I) learning processes, (II) lesson design and (III) the optimisation of organisational processes in education facilities⁴²**
- Reviewing the opportunities and challenges related to AI use and their impact on **vocational training** (by the BIBB)
- **Funding AI projects** as part of the **INVITE innovation competition**, the **Digital Pact for Schools**, the **OER Strategy**, the **competence centres for digital and digitally assisted teaching in schools and further education, in the key research area of digitalisation in education** and of **cultural education**
- **Fostering networking** between the **AI competence centres** and the **competence centres for digital and digitally assisted teaching in school and further education**
- Targeted initiatives (consultation, promotion) addressing the use of **generative AI** in the education system
- Promotion of cross-border initiatives for **developing AI guidelines for schools**
- Greater **involvement in international committees** and national public debate concerning the control and design of national and international AI processes in education (e.g. the EU Digital Decade or the AI Opportunities Talk)
- **“AI in higher education” initiative by the federal and state governments** for increasing the supply of skilled personnel in the area of artificial intelligence and for improving the quality of higher education through the use of AI

⁴² See (European Commission 2022)



4 Preconditions for success

4.1 Intensifying European and international cooperation

In view of the increasingly intense competition among states and companies, Germany will struggle to take on a leading role on its own when it comes to developing AI innovations and securing market and design power. The size of the market is a key factor in global technology competition. Individual European states are at a strategic disadvantage compared to large economic areas and innovation spaces such as the USA and China. The infrastructure needed for AI also requires joint investment. This is why cooperation at the European level and with other international partners who share our values is another important aspect.

Initial situation: status quo

- The number of international research cooperations in the field of AI has increased considerably over the past ten years. If measured by the number of joint publications, links are particularly tight between the USA, China and the United Kingdom. Joint AI publications by German and US scientists are the fourth most common.⁴³
- In the area of AI, Germany maintains particularly close links with European nations, especially with Austria, Switzerland, Italy and the Scandinavian countries.⁴⁴
- German higher education institutions and research facilities are partners and important driving forces of the European AI networks ELLIS and CLAIRE, the European “AI Data and Robotics” partnership as part of the “Horizon Europe” research framework, and the EU’s four “Testing and Experimentation Facilities (TEFs)” for AI that have been launched to date.⁴⁵

⁴³ See (Maslej, et al. 2023), figures 1.1.6 and 1.1.7

⁴⁴ See (Kroll, et al. 2022), tables 4–7.

⁴⁵ See ellis.eu, claire-ai.org, adr-association.eu, tefhealth.eu, agrifoodtef.eu, ai-matters.eu and citcom.ai.

Objectives: what we want to achieve

We want European and international networking to be a key characteristic of the German AI ecosystem, and for German researchers and companies to take on a leading role in cross-border cooperation. In addition, we want for German interests with regard to the use of AI systems in general and vocational education to be integrated into initiatives at the European level in close coordination with European partners. To this end, we want:

- To significantly increase the scope of European and international research cooperation with German involvement
- To promote international cooperation especially among young researchers, aiming to forge networks early on
- To get actively involved in shaping the European and international dialogue on AI, and in particular to introduce AI aspects to any relevant processes at the EU level.

The BMBF's contribution

- **Organisation of a top-level AI workshop for science at the European level, aiming to strengthen European AI cooperation through joint initiatives**
- Continuation of the **German-French** AI initiative (projects in the 2nd round of funding started in June 2023)
- Intensification of **bilateral and multilateral cooperation** in the area of AI with partners who share our values (so far these include the Czech Republic, Japan, South Korea and Canada, future cooperations are planned with Brazil and India)
- Establishment of **ELLIS** as a European and international networking platform for young AI researchers
- Promotion of internationally networked AI research and young scientists from around the world through the **International AI Future Laboratories**
- Active promotion of European and international networking and cooperation in the context of the 2024/25 German-Canadian **Eureka** Chairmanship
- Negotiation of current European AI-related initiatives of the European **Digital Education Action Plan** (currently two Council recommendations and one Council conclusions up to the end of 2023)
- Promotion of AI as one of the actions on the future **“ERA Policy Agenda”** that defines the topics of focused and result-oriented cooperation of the EU27 and the EU Commission for the years 2025–27
- Even more systematic anchoring of the issue of AI by means of the **National Action Plan for the European Research Area** that also aims to bring the issue to the European level
- Interlinking of national AI activities with activities in the context of the European innovation agenda
- Strong support for the demands of AI research in the negotiations for the **10th EU Research Framework Programme**



4.2 Promoting social dialogue and multi-disciplinary research concerning AI

As a key technology, AI will impact virtually all areas of society and will therefore affect the cornerstones of our social coexistence and our democracy. AI must therefore be designed in such a way that society as a whole and our democracy are taken into account. We must not leave this to the market power of a small number of technology companies or the ambitions of authoritarian states. A purely technology-driven perspective on AI is not enough here. Instead, we must integrate the different perspectives and points of view in a targeted manner and create appropriate conditions for an informed debate.

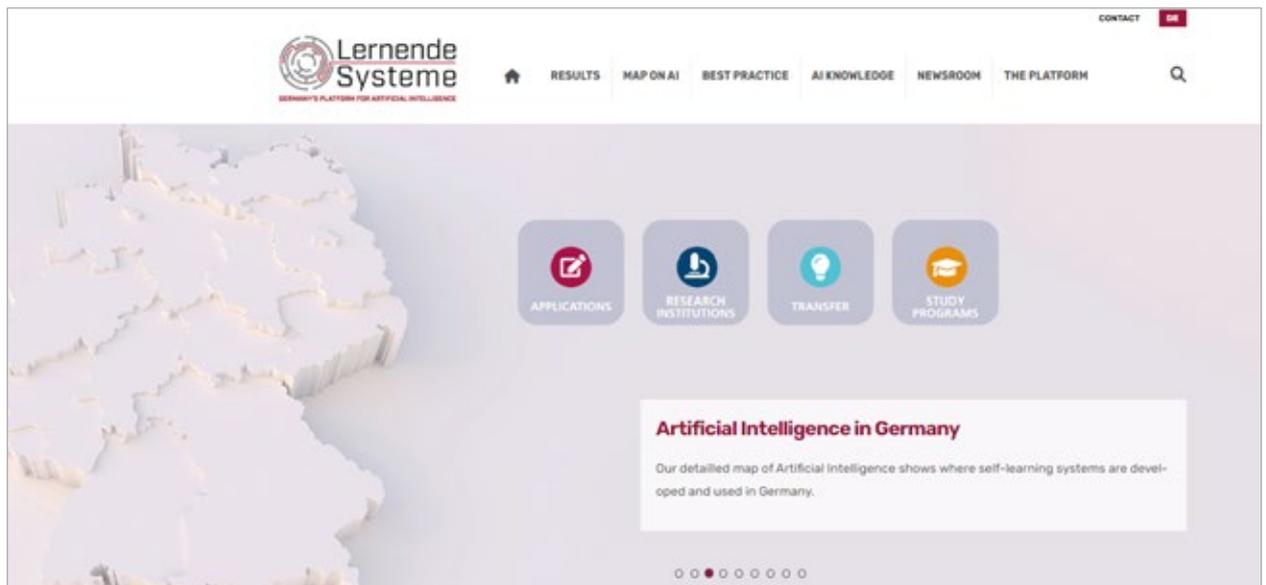
Initial situation: status quo

- Development of AI is currently driven by a small number of private sector and state players and their interests. This has immediate impact on the research and development approaches that are pursued and has already affected the cornerstones of educated democratic societies.⁴⁶
- AI affords a wide range of opportunities in the democratic process too, in particular for information and mobilisation processes. But it is also associated with risks, for example in the form of filter bubbles, fake news or abusive micro-targeting.⁴⁷
- Multidisciplinary and interdisciplinary AI research is essential if we want to understand AI to an adequate extent.⁴⁸
- With its “Science Year 2019” initiative, the BMBF made good progress in advancing the public debate about AI.

46 See (Acemoglu and Johnson 2023), chapters 8 & 9

47 See e.g. (Heesen, et al. 2021)

48 See e.g. (Rahwan, et al. 2019)



Objectives: what we want to achieve

AI should be integrated in our society as well as our legal, value and institutional system in a responsible manner. Broad public debate is necessary to achieve this, and the BMBF thinks of itself as an enabler and driver of such debate. Our specific goals are these:

- To create platforms for informed and science-based public debate on AI
- To promote multidisciplinary and interdisciplinary research about AI and to use these perspectives to inform the further development of AI methods and systems
- To promote data-based analyses about AI as a key technology, about the international state of development and Germany's position in the world
- To assess the opportunities and impact of AI with regard to our coexistence, individuals and society and ways to handle these
- To supplement further technological development of AI through appropriate social innovations

The BMBF's contribution

- **Organisation of an international symposium titled "AI in a digital democracy"**
- Launch of an **interdisciplinary project about socially trustworthy AI systems**, aiming to answer fundamental questions concerning the perception, expectations and use of AI in practical application
- Strengthening of **Germany's Platform Lernende Systeme** as the central stakeholder platform for the science-based debate about AI
- Promotion of **multidisciplinary and interdisciplinary accompanying research** on ethical, legal and social implications of AI that is fed back into AI research
- Promotion of **interdisciplinary AI research**, e.g. about explainability
- Opportunity-oriented **assessment of consequences** of the impact of new AI-induced possibilities
- Strengthening of AI-based **social innovation**



4.3 Adopting adaptable, agile and innovation-friendly regulation

The strong dynamism of recent months has also reinforced concerns about the hazards and risks related to uncontrolled AI development and use, and has prompted calls for control mechanisms and regulation.⁴⁹ Demands in this context range from voluntary self-monitoring of businesses⁵⁰ through to an AI moratorium or even a complete ban.⁵¹ One thing is clear: to be able to shape the AI revolution in a way that benefits society, we must identify and research the risks and control them through suitable measures. Regulation is one part of the solution here. To what extent AI will be accepted in Germany will depend largely on whether we will succeed in handling harmful or unethical effects of AI through suitable regulations. However, excessive AI regulation in the form of red tape, bans, or requirements that can hardly be met for technical or organisational reasons, is still considered a major obstacle to the use of AI. The challenge at hand is therefore to minimise risks while avoiding to restrain AI as a tool to such an extent that its potential cannot be used and we fall behind other more “careless” countries.

Initial situation: status quo

- The number of laws related to AI that were adopted around the world has increased rapidly since 2016.⁵²
 - With its AI Act, the EU is among the first global regions to draw up comprehensive, horizontal AI regulation. Following presentation of the
- EU Commission’s draft in April 2021 and the presentation of compromise proposals by the European Council (6 December 2022) and the European Parliament (14 June 2023), the triilogue is currently underway.
 - The AI Act is based on a risk-based regulation approach: the greater the (abstract) risk of an AI system with regard to the violation of basic rights or security, the stronger the regulatory requirements. AI systems associated with a high risk must meet special transparency and security requirements. These are voluntary for

49 See e.g. (Center for AI Safety 2023)

50 See e.g. (Wirtschaftswoche 2023)

51 See (Future of Life Institute 2023) and (Yudkowsky 2023)

52 See (Maslej, et al. 2023), Section 6.1

AI systems with a lower risk. AI systems associated with excessive risks are banned.

- Inspection and certification bodies are to be set up across Europe to ensure and safeguard compliance with these requirements. At the same time, the EU Commission has already instructed the relevant committees to draw up corresponding norms and standards, whose purpose is to facilitate the review process and compliance with the requirements.

Objectives: what we want to achieve

In general, the BMBF welcomes the risk-based approach of the current draft. At the same time, the following goals are essential for the further procedure:

- To continue to enable research and innovation, in particular by small and medium-sized companies, start-ups and tech-based social start-ups
- To regulate not AI research but AI use in a balanced manner, and to create special rules for research
- To consider technological possibilities when drawing up requirements for AI systems
- To develop norms and standards based on research with close involvement of researchers in this process and in the inspection and certification bodies

The BMBF's contribution

- Advocating in inter-ministerial circles for opportunity-oriented, innovation- and research-friendly regulation
- Use of AI for scientific research should not be subject to such regulation (supporting the position of the European Parliament)
- Expert support for drawing up the **AI standardisation road map**

4.4 Appendix

Appendix A. Initiatives by the BMBF

An overview of BMBF initiatives related to the AI Action Plan can be found on the BMBF website.

Additional links:

- Germany's Platform for Artificial Intelligence: plattform-lernende-systeme.de
- AI Strategy of the Federal Government: ki-strategie-deutschland.de
- AI Monitoring: kimonitoring.de

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