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Global Expert Mission
Germany AI 2020

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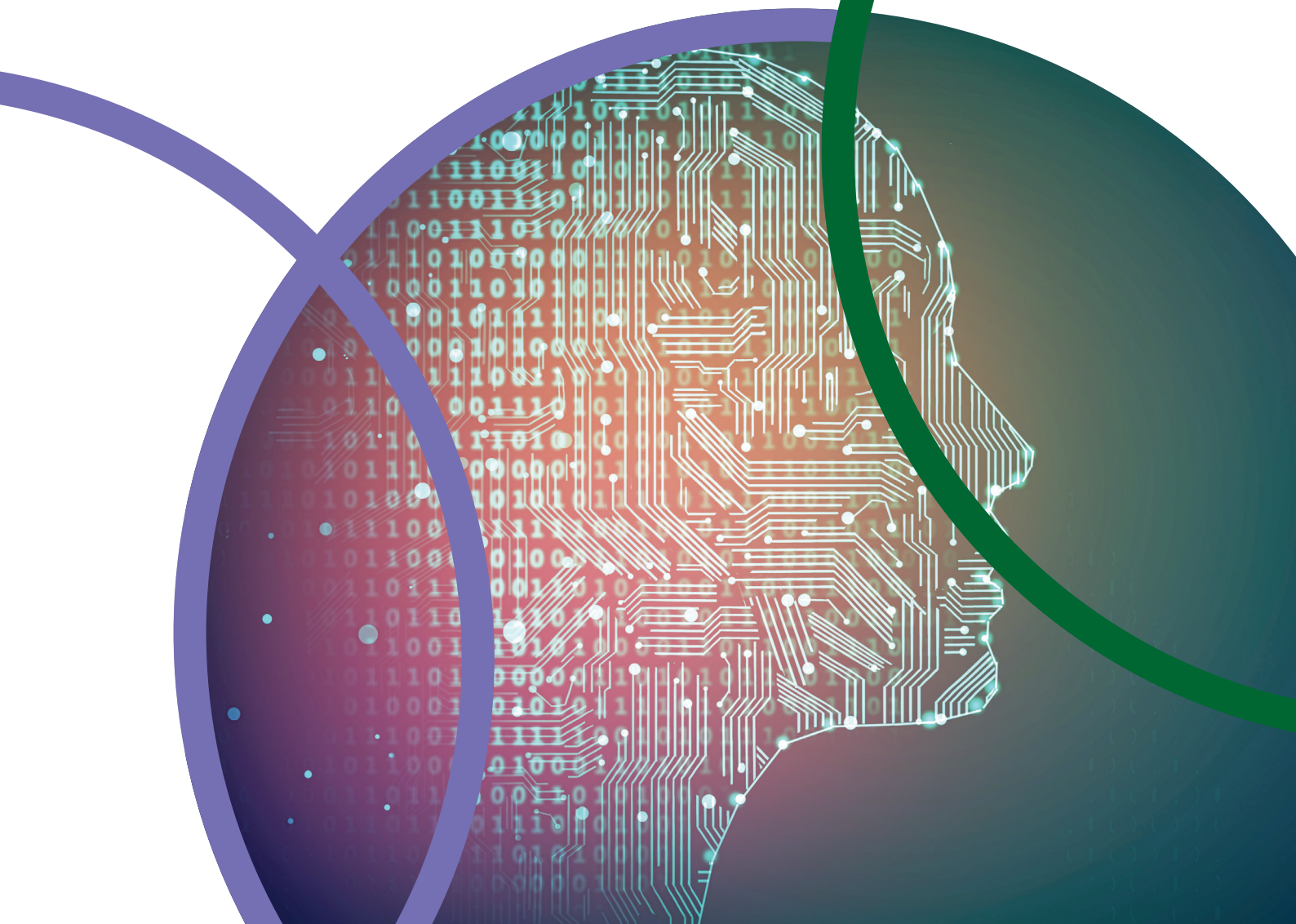

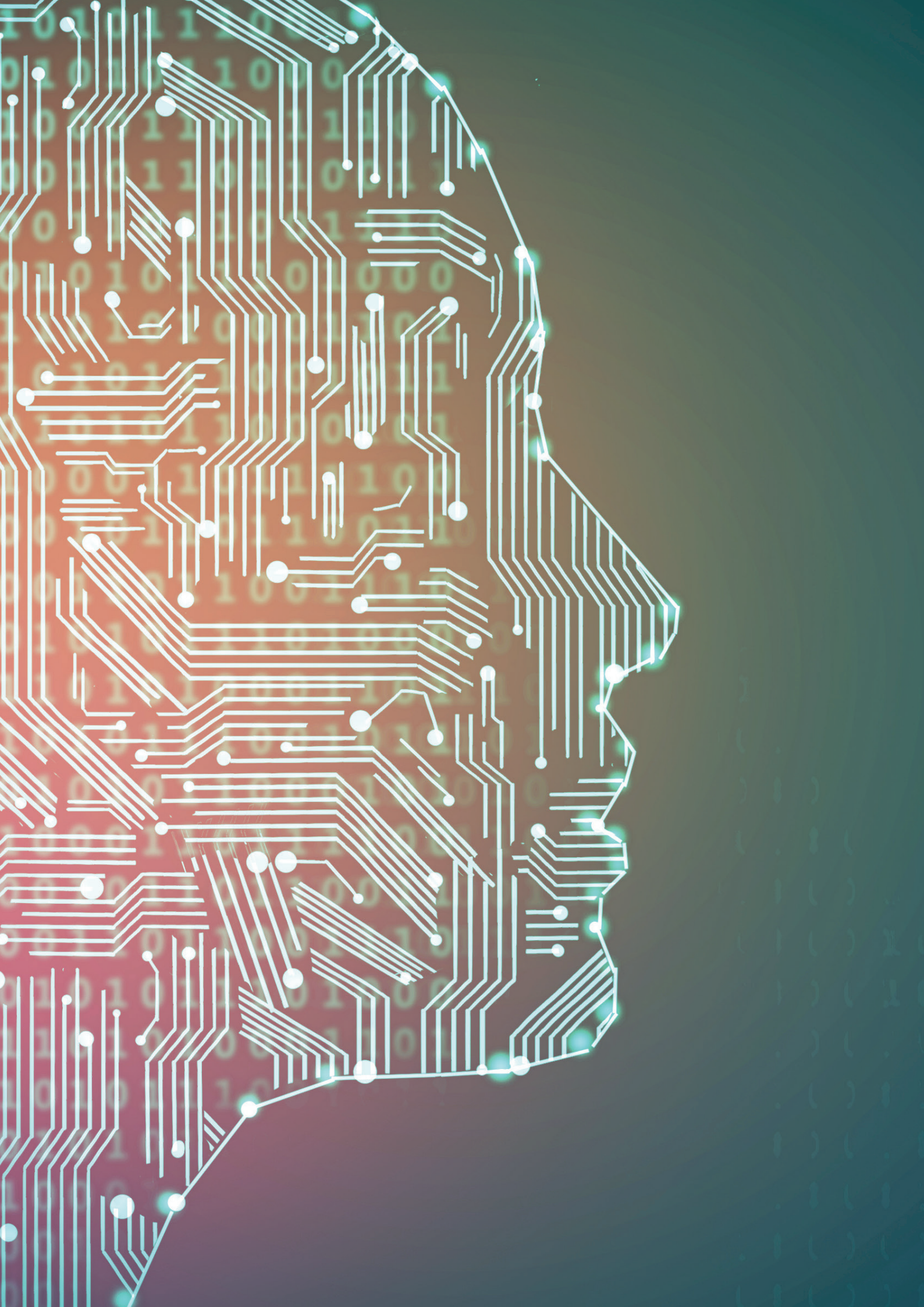

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Welcome

Innovate UK launched the Global Expert Mission (GEM) programme in October 2017 to help businesses become truly global enterprises through strategic international innovation collaboration. Delivered by the Knowledge Transfer Network (KTN) in partnership with the UK Science and Innovation Network (SIN), the Expert Missions provide an expert-led evidence base to strengthen Innovate UK's global investment strategy: how and where it should invest to create UK business opportunities in partnerships with key economies.

Each mission selects representatives from the UK's business, policy and research community, with objectives to:

1. **Inform UK businesses and government**
   The findings and opinions of experts on the topic of the mission are made available to UK businesses and the government after the overseas visit. These inform UK businesses about opportunities for innovation in the country and the UK Government on how it can help UK businesses make the most of those opportunities.
2. **Build international collaborations**
   The expert insights will help inform how Innovate UK can best help UK businesses find and exploit the opportunities for innovation partnerships. The mission creates connections with key organisations and people that will deepen and widen the collaboration with the partner country to benefit UK business.
3. **Showcase and share UK capabilities**
   During the overseas visit, the delegation of experts will use the opportunity to promote and showcase the UK's innovation strengths.

The Germany AI mission took place during a period of COVID-19 travel restrictions. So delegates met virtually with representatives from the public and private sectors, including government, industry, research and academia, to meet the following aims:

1. Understand Germany's AI capabilities, ecosystem and support available for individuals, research base and companies with innovative AI solutions.
2. Identify existing UK-Germany collaborations and strengthen these links.
3. Assess the willingness for bilateral collaboration in AI, more specifically, opportunities for joint funding.

This report summarises the information and insights gathered by the delegation.

A full list of the participating organisations is included in Annex 1.

Executive Summary

The Artificial Intelligence (AI) Global Expert Mission to Germany took place in December 2020 to better understand the innovation landscape in Germany and to identify synergies and opportunities for collaboration between the UK and Germany. The delegation focused on the key areas of Berlin, Bavaria and Baden-Württemberg.

Germany is a priority country for Innovate UK, with collaboration usually taking place through the European Framework programme. There is a strong appetite to identify bilateral collaborative opportunities, which the mission sought to better understand. This mission was led by Innovate UK, KTN, UK Science and Innovation Network and the Department for International Trade, joined by a delegation of business and academic leaders.

The delegation met with a wide range of stakeholders from federal and state government agencies to universities, incubators, SMEs and innovation networks. It was evident that there is a huge appetite at all levels to strengthen collaboration and build on the cultural and environmental similarities noted by both sides during the mission.

The German AI landscape is diverse and sophisticated, with significant amounts of funding being dedicated to AI. For example, the German AI Strategy, launched in 2018, allocated €5 billion to support growth in the space. Additional state-level funding and private investment makes Germany an attractive base to innovate.

As a result of this mission, we were able to identify a number of key opportunities for collaboration. In particular, these leveraged Germany's strength in robust engineering of AI solutions and the UK's interdisciplinary approach to AI adoption and ethics. This could be underpinned by building on the existing networks strengthening UK-Germany ties through shared programmes and initiatives.

1. The German AI Sector

Germany is seen as the economic and industrial powerhouse of Europe. It is one of the largest investors globally in research and development, technology, science and education. In the 2018 Global Competitiveness Index from the World Economic Forum, Germany ranked as the world's most innovative economy.[1]

It scored 87.5 out of 100 in the Innovation capability pillar, one of the 12 indicators used to measure a country's productivity. It outperformed the United States, China and the United Kingdom. Germany is in the top ten countries that devote a large percentage of economic output to research and development. Based on 2018 figures again, their spending on research and development (R&D) was 3.13% of GDP compared to 1.73% of GDP by the UK.[2] Germany is investing more in R&D in real terms year-on-year, and the federal budget for R&D has increased by €9 billion between 2005 and 2018 representing an increase of approximately 92% over the period. The federal R&D budget in 2018 was €17.3 billion. From 2017-2018 R&D investment from industry in Germany rose by 4.8%, and the combined government (federal and state) and industry spend on R&D for 2018 was €104.7 billion.[3]

Germany's AI ambitions have benefitted from the significant funding commitments at both federal and state levels. Driving this, however, has been the development of regional and national Digital and AI strategies that have brought meaning, focus and certainty to the research base, the growing start-up ecosystem, support initiatives and the engagement of the world's leading multinational industrial corporations with a growing interest in digital technologies and more specifically AI. As a result, "AI – Made in Germany" is a brand that is gaining traction globally. It is fast becoming associated with modern, secure AI applications for the common good that are based on European values.

[1] https://www.weforum.org/agenda/2018/10/germany-is-the-worlds-most-innovative-economy/
[2] https://data.oecd.org/rd/gross-domestic-spending-on-r-d.htm
[3] https://www.datenportal.bmbf.de/portal/en/research.html

2. German Digital and AI Strategies

2.1 Digital Strategy 2025[4]

The Digital Strategy was developed by the Federal Ministry for Economic Affairs and Energy (BMWi). A key motivation for creating the strategy was the recognition of the rate of progress in the development of digital technologies and that further progress at pace will continue to impact all aspects and sectors of the German and European economy. Driven by the positive impact that digital transformation could have on the German economy, the Digital Strategy 2025 sets priorities for developing capabilities and new tools that will create a "digitised Germany" and a potential €82 billion increase in GDP.

One of the key step-changes proposed, and deemed critical to success, is the need for collaboration as opposed to developing isolated solutions. The vision is one where there is collaboration across organisations, in a network, and together as communities and society to find and implement answers to the big challenges in the medium and long term.

In 2019, BMWi established the Digital Technologies Forum (FDT) to provide a platform to increase the visibility of excellent research projects. It promotes exchange and knowledge transfer both nationally and internationally. The forum's events and demonstrators focus on technical interfaces and pending societal issues of technological trends: the Internet of Things, Big Data, Artificial Intelligence, Security and Trust in the digital space.

2.2 The German AI Strategy[5]

The German AI Strategy, with an associated budget of €5 billion until 2025, was published in 2018 and developed by the Federal Ministry of Education and Research (BMBF), the Federal Ministry for Economic Affairs and Energy (BMWi) and the Federal Ministry of Labour and Social Affairs (BMAS). The strategy highlights the progress made in AI and outlines a plan of future goals; with policy paving the way to achieve them.

The first pillar of the strategy is to make Germany, and Europe, a world leader in AI whilst also safeguarding Germany's competitiveness. Competitiveness appears to be widely translated as "Digital Sovereignty" which includes encapsulating German and European values, regulations and standards into technological advances, products and solutions. Its aim is to make Europe less reliant on innovations from the United States and China, which, potentially, may not be based on those same values.

Achieving this strategic ambition involves a number of activities including enhanced support for SMEs to increase take-up and awareness of AI, creating a national network of AI Trainers, enhancing support for start-ups, enhancing funding opportunities for venture capital, establishing AI testbeds and providing a policy framework to encourage data sharing.

The second pillar of the strategy involves the development and use of "responsible AI". Delivery of this will be aided through several activities, including funding for in-company innovation spaces for AI applications in the "world of work" and funding for AI applications focused on bringing about a positive impact on the environment and climate change.

The third pillar is focused on integrating AI into society with all ethical, legal, cultural and institutional considerations taken into account. This is seen as involving considerable public engagement and dialogue supported by the appropriate political measures. The aim is also to use AI to promote social participation, freedom of action, and self-determination for citizens and foster the sustainable development of the society.

Based on the meetings undertaken as part of this mission, it is apparent that the majority of initiatives underway both federally and across the different states are closely aligned to the strategic ambition. Whilst there are considerable challenges in achieving the objectives, there is nevertheless a concerted effort supported by funding where necessary to make progress.

[4] https://www.de.digital/DIGITAL/Redaktion/EN/Publikation/digital-strategy-2025.pdf?__blob=publicationFile&v=9

[5] https://knowledge4policy.ec.europa.eu/ai-watch/germany-ai-strategy-report_en

3. The National AI Landscape – Research and Support Organisations

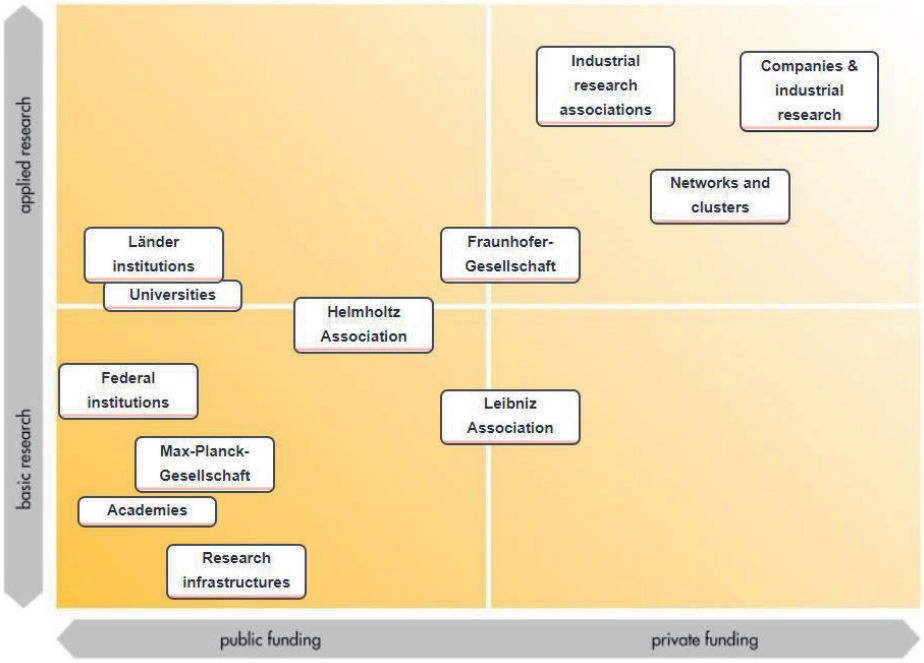


Figure 1: Research organisations landscape[6]

3.1 Research Base

Germany has approximately 400 higher education institutions offering the full breadth of academic and vocational studies. Twenty-one of these universities rank amongst the top 200 universities in the world alongside 29 universities from the United Kingdom.[7] The Max Planck Society[8], The Helmholtz Association[9], Fraunhofer and The Leibniz Association[10] are the four key Germany-wide non-university research institutions supporting world-leading basic and applied research. The Fraunhofer[11] is the leading organisation for applied research in Europe. It carries out research on contract for the private and public sector alongside collaborative projects funded through national and European funding programmes. The delegation met with several Fraunhofer institutes during the mission (Fraunhofer IKS[12], Fraunhofer IOSB [part of CC-KING], Fraunhofer IPA and Fraunhofer IAO [as part of the Mittelstand 4.0 Comp Centre in Stuttgart]). Figure 1 shows where these organisations sit within the ecosystem based on how they are funded and the type of research.

[6] https://www.research-in-germany.org/en/research-landscape/research-organisations.htm
[7] https://www.timeshighereducation.com/world-university-rankings/2021/world-ranking#!/page/0/length/25/locations/DE/sort_by/rank/sort_order/asc/cols/stats
[8] https://www.research-in-germany.org/en/research-landscape/research-organisations/max-planck-society.html
[9] https://www.research-in-germany.org/en/research-landscape/research-organisations/helmholtz-association.html
[10] https://www.research-in-germany.org/en/research-landscape/research-organisations/leibniz-association.html
[11] https://www.research-in-germany.org/en/research-landscape/research-organisations/fraunhofer-gesellschaft.html
[12] https://www.iks.fraunhofer.de/en.html

3.2 Mittelstand 4.0

With approximately 3.5 million SMEs in Germany[13], the "Mittelstand" SMEs and family businesses account for over 99% of all companies in Germany, 50% of all German employment and about 35% of national turnover[14]. Their ownership, control, leadership and liability models are often combined to create long-term sustainable businesses, smart investments, constant innovation, job security and local prosperity.[15] Since 2015, BMWi has established a total of 26 Mittelstand 4.0 centres of excellence as a specific support measure for SME digitisation, and between 2016 to 2019, 180,000 SMEs used their services. The vision of the centres is also reflected in BMWi's strategy "SMEs Digital: Strategies for Digital Transformation"[16], which highlights opportunities for SMEs and signposts ways in which they can successfully implement digital technologies.

Figure 2: The centres of excellence
Source: SMEs Digital

The centres combine regional centres of excellence across Germany with specific thematic centres, which deliver a wide range of support for all sectors and needs. They run workshops, training sessions, practical tests, webinars and surgeries targeted to SMEs and are available free of charge. Furthermore, they help companies develop a digitisation roadmap that is tailored to their particular needs. A package of support is provided to guide the company through the implementation of any specific actions within the roadmap.

The participants of the mission held meetings with the centre in Stuttgart.[17] Their specific focus is on supporting the full value chain and the digitisation process that goes alongside that. They focus on digital manufacturing, smart mobility, smart home (digital construction and building technology), smart health (digital technologies in nursing), development of digital business models and IT security. Based in the state of Baden-Württemberg, they are positioned in one of the "hotspots" of AI activity.

3.3 German Research Centre for Artificial Intelligence (DFKI) [18]

The German Research Centre for Artificial Intelligence (DFKI) is a non-profit public-private partnership. The centre's focus is on human-centric AI with a view to developing the future of intelligent solutions for the knowledge economy and society at large.

Application-oriented and basic research projects are carried out across 24 research departments, nine competence centres and eight living labs. The breadth and depth of topics covered by DFKI is comprehensive both in technology and application. From machine learning, through autonomous systems to applications as diverse as assisted living, autonomous driving and industry 4.0, research is driven by industrial and societal need.

Funding comes from government agencies including the European Union, BMBF, BMWi, the German federal states and the German Research Foundation (DFG), as well as from collaborative projects with industrial partners. DFKI's international reach extends to collaborations with over 650 researchers and 450 graduate students from more than 65 countries, all working on over 250 cutting-edge research projects driven by DFKI.

3.4 DLR - Project Management Agency (DLR-PT)

The DLR - Project Management Agency (DLR-PT) provides research funding and innovation management and manages research programmes funded by BMWi. Accordingly, it serves the broadest possible range of topics. Managing research funds totalling around €1 billion, in 2019 alone it supported 10,700 scientific projects in the areas of education, society, healthcare, key technologies and the environment. A key offering by DLR-PT is that of international collaboration. With its growing network of global partners, the agency assists German institutions seeking to work globally by designing and fostering international collaboration across the R&D space.

[13] https://universalhires.com/magazine/guide-mittelstand-germany/
[14] https://www.euopen4business.eu/2019/sba-fact-sheets-for-germany/
[15] https://english.bdi.eu/topics/germany/german-mittelstand/#/article/news/the-german-mittelstand-an-economic-success-model/
[16] https://www.bmwi.de/Redaktion/EN/Publikationen/Mittelstand/smes-digital-strategies-for-digital-transformation.pdf?__blob=publicationFile&v=4
[17] www.digitales-kompetenzzentrum-stuttgart.de
[18] https://www.dfki.de/en/web/

Observations: The delegates recognised the significant and comprehensive response to the German AI Strategy but also noted there had been difficulty achieving the expected engagement and AI adoption across the Mittelstand. There is a real concerted effort to increase this engagement and widen the take-up of AI and other digital technologies by providing full lifecycle support for companies looking to engage with AI. This commitment to increasing take-up, engagement and outreach is focused explicitly on SMEs, as they make up a dominant proportion of the economy in Germany. This has been through mechanisms such as the Mittelstand 4.0 centres - they provide AI Trainers to support the implementation of AI applications; AI Fridays to act as a forum for sharing AI knowledge across businesses; and Use Case Tuesdays to support feasibility and implementation.

A healthy scepticism towards data sharing and strong affiliation to data protection and data privacy across both German industry and the general public has perhaps put a break on the uptake of AI-based technologies across the board. The risk of financial damage resulting from personal data being abused, violation of privacy and identity theft has impacted the dynamism of the start-up ecosystem compared to countries like the US, but this is slowly changing as a result of increased public dialogue and engagement.

The delegates also noted that Germany clearly sees itself as not just advancing its own AI leadership, but also that of Europe's. This is as true in the area of "European Digital Sovereignty" as it is in regulation, standards and technology development. Collaborations in AI, like the Franco/German initiatives already underway, demonstrate this ambition. European Digital Sovereignty is a key pillar of the German AI Strategy, and the opportunity for the UK to help Europe achieve this was, up until recently, clear. **Significant appetite to maintain and create new collaborative relationships in this area were expressed, particularly in accessing UK expertise in the fields of responsible AI and AI ethics.**

4. The National AI Landscape – Industry

Where federal support for R&D, in general, is already both comprehensive and significant, the commitment by German industry to innovation is even more so.

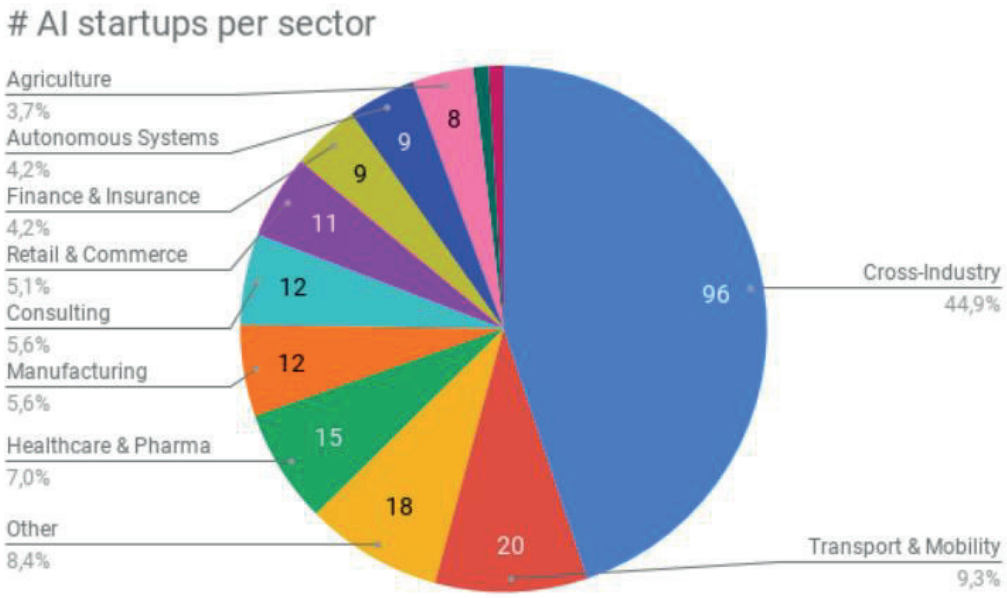


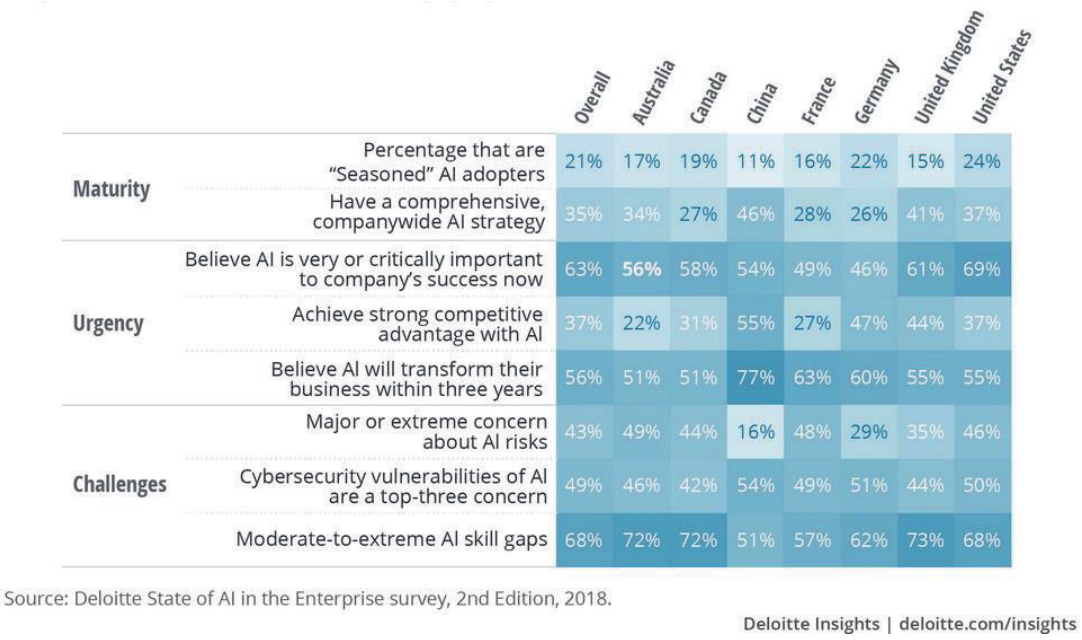
Figure 3: AI Start-ups by sector focus [23]

In 2018, R&D expenditure across all technologies by the private sector as a proportion of GDP equated to 2.2%, or a budget of approximately €72.1 billion[19]. A significant proportion of this investment was made, perhaps unsurprisingly, by the automotive sector which is turning to AI for autonomy, not just in the factories but also in the vehicles being produced. This, in turn, is driving AI innovation into their supply chains with the support of active collaborations with the leading German research institutes and universities. [20]

Alongside this, global technology companies like Amazon and IBM are making significant research and development investments in Germany and forging long-term collaborations in AI. Germany is increasingly seen as the destination of choice for AI start-ups across Europe, with Berlin and Munich hosting over two-thirds of all AI start-ups in Germany.[21] These start-ups have secured an impressive €2.2 billion in total funding since 2010, with the average funding for a start-up increasing by 24% in 2020. Germany's AI start-ups operate across a broad and diverse range of sectors with transport/mobility and manufacturing leading the way, both of which are key sectors in the German economy. Approximately 40% of start-ups operate across multiple sectors.[22]

Currently, Berlin is the fourth largest global AI hub, following Silicon Valley of the USA, London, and Paris.[24]

[19] https://www.research-in-germany.org/en/research-landscape/industrial-research/overview.html
[20] https://www.analyticsinsight.net/brief-outlook-ai-landscape-germany/#:~:text=The%20AI%20landscape%20in%20Germany%20is%20rapidly%20transforming,Daimler%2C%20and%20Volkswagen%20are%20steering%20the%20AI%20innovation.
[21] https://www.rolandberger.com/publications/publication_pdf/roland_berger_ai_strategy_for_european_startups.pdf
[22] https://www.appliedai.de/hub/2020-ai-german-startup-landscape
[23] https://www.appliedai.de/hub/2019-ai-german-startup-landscape
[24] https://www.linkedin.com/pulse/german-artificial-intelligence-landscape-fabian-j-g-westerheide/



		Overall	Australia	Canada	China	France	Germany	United Kingdom	United States
Maturity	Percentage that are "Seasoned" AI adopters	21%	17%	19%	11%	16%	22%	15%	24%
	Have a comprehensive, companywide AI strategy	35%	34%	27%	46%	28%	26%	41%	37%
Urgency	Believe AI is very or critically important to company's success now	63%	**56%**	58%	54%	49%	46%	61%	69%
	Achieve strong competitive advantage with AI	37%	22%	31%	55%	27%	47%	44%	37%
	Believe AI will transform their business within three years	56%	51%	51%	77%	63%	60%	55%	55%
Challenges	Major or extreme concern about AI risks	43%	49%	44%	16%	48%	29%	35%	46%
	Cybersecurity vulnerabilities of AI are a top-three concern	49%	46%	42%	54%	49%	51%	44%	50%
	Moderate-to-extreme AI skill gaps	68%	72%	72%	51%	57%	62%	73%	68%

Source: Deloitte State of AI in the Enterprise survey, 2nd Edition, 2018.

Deloitte Insights | deloitte.com/insights

Figure 4: AI Maturity and perception amongst early adopters
Source: Deloitte Insights State of AI in the Enterprise, 2nd Edition survey

Figure 4 above provides insight into how industry and the public view the importance of AI within the countries seen as early adopters of AI, including the UK and Germany.

AI maturity is still generally low in all the countries surveyed. Not even a quarter of the organisations involved in each country can be seen as seasoned adopters, with the United States coming top at 24%, Germany second at 22% and the UK fifth at 16%.

In response to the problem of AI maturity, the German AI Strategy, European Digital Sovereignty and the drive towards safe, secure and ethical AI, German industry joined with UnternehmerTUM,[25] Germany's leading innovation and start-up centre, to establish and substantially back the largest initiative for the application of AI technology in Germany, appliedAI. appliedAI's core mission is to support experimenters, business units and corporates reach a high level of AI maturity with the products they produce and the applications they deploy.

4.1 KI Bundesverband (Federal German AI Association)[26]

Representing more than 300 AI companies, KI Bundesverband (the Federal German AI Association) is the largest AI network in Germany, and its primary remit is to connect AI innovators to established business and government. The association's mission is threefold: to establish digital sovereignty in Europe by ensuring that AI is used in line with European and democratic values; to strengthen the AI ecosystems by supporting knowledge exchange through networking; and, to bring openness to AI innovations in European companies with the aim to create a greater awareness of these new technologies.

The association has established groups focused on regional challenges, with working groups dedicated to the specific challenges within the industries or area they represent. Members are provided with opportunities to network with other AI entrepreneurs to exchange ideas about these challenges, but also gain a political voice at the state level and provide input into the decision-making on aspects impacting the regional economy.

4.2 Bitkom[27]

Bitkom is Germany's digital technology association. Founded in 1999, it is the largest such body in Europe with over 2,700 members, including more than 1,000 SMEs and over 500

[25] https://www.unternehmertum.de/en/
[26] https://ki-verband.de/
[27] https://www.bitkom.org/EN/EN

start-ups. Bitkom aims to progress the digitisation of the German economy, across society at large and within the public administration. Key to realising this ambition are working group activities that enable the members to address digitisation challenges and support the advancement of innovation-friendly regulatory environments. Three AI-related working groups include AI deployment, AI research and AI policy.

In return, members gain access to a vast network of companies, experts, political representation and their peers from across Germany. Companies can also get support in bidding for public tenders and on issues around compliance with regulations such as data protection and information security. Bitkom also undertakes comprehensive market studies providing members with critical insight on market dynamics and opportunities.

Observations: Networking amongst founders, start-ups, R&D centres and across government play a significant role in building trust. Again, German sensitivities towards data sharing and privacy were highlighted as a significant blocker to the uptake of digital innovations, e.g. Germany's COVID track-and-trace app failed over these concerns. Similarities between the UK and Germany were observed in terms of the reluctance of many companies to embrace the opportunity of AI adoption; director buy-in and the concern of disruption to business-as-usual being cited as primary reasons. The importance of good case studies, exemplars of success and how-tos were highlighted as key tools to stimulate adoption as individual companies are often only impressed when they can directly see an impact in their industry. It was also noted how Germany felt it was behind the UK in AI adoption across retail and e-commerce sectors; the UK is seen as having a more "sophisticated" or mature market. Whilst this may seem like a good opportunity for UK SMEs to make inroads, examples of where AI has been successfully deployed in the German insurance sector would suggest that UK products should highlight "algorithmic fairness" and user benefit in order to overcome data exploitation and privacy concerns.

5. AI in the Regions - Berlin

5.1 Berlin Partner for Business and Technology [28]

A public-private partnership between the Berlin State Senate and an extensive business network, Berlin Partner for Business and Technology provides a range of business, technology and innovation support services. Key services include funding programmes through public loans, guarantees, venture capital and even direct grants; business innovation packages that provide access to experts and the tools to accelerate innovation; knowledge and technology transfer; and international business support packages.

5.2 BIFOLD - Berlin Institute for the Foundations of Learning and Data[29]

BIFOLD (the Berlin Institute for the Foundations of Learning and Data) was established as a "Lighthouse" project in response to the German National AI Strategy and brought together two significant competency centres located within the Technical University of Berlin; the Berlin Big Data Centre and the Berlin Centre for Machine Learning. With a mission to advance AI application development and increase its impact on society, the economy and science, BIFOLD's focus on Big Data and machine learning drives its research into responsible AI, foundations and methods, management of data science processes, architectures, technologies, systems and tools[30]

In line with the strategic priorities of the AI strategy, BIFOLD drives innovation through prototyping AI technologies, Big Data systems, data science tools, and supports knowledge and technology exchange into the sciences, humanities, companies and especially start-ups.

5.3 Flying Health[31]

Flying Health is a start-up incubator focusing on "next-generation healthcare", digital healthcare that is driven by technologies such as AI, VR, mobile and web technologies, as well as new sophisticated sensors. Their approach has been to create an extensive network of relevant industrial partners, e.g. AstraZeneca, Lilly and AXA, that not only helps to generate market pull for successful start-ups but also provides Flying Health with the intelligence needed to create bespoke support packages, keeping the start-ups on track and more likely to meet market need.

Additionally, Flying Health works with established businesses and corporates with ambitions to move into the healthcare sector by providing market insight, horizon scanning, business strategy development and networking.

5.4 Merantix – AI Venture Studio[32]

Merantix is an AI Venture Studio, supporting new AI ventures from ideation, through incubation to scale-up. As a founding member of KI Bundesverband and with strong links to the Berlin AI research community, Merantix is building a fast-growing international network of partners from the research community and industry that can take good ideas and turn them into sustainable AI companies.

Since it was founded in 2016, Merantix has successfully raised $37.5 million in funding capital and consequentially forms a critical role in the Berlin AI ecosystem.

[28] https://www.berlin-partner.de/en//
[29] https://bifold.berlin/
[30] https://bifold.berlin/research/
[31] https://www.flyinghealth.com/
[32] https://www.merantix.com/

Observations: The delegates were impressed by the significant resources being invested in AI research and support, which perhaps has helped establish Berlin as a prime location for AI start-ups in Germany (Berlin – 36.5%, Munich – 22.4% and Hamburg – 5.8%). The strength and size of the Mittelstand (99% of all German companies), the focus on ethical AI, data protection, responsible AI, AI sovereignty and the regulatory environment supporting this has had a significant impact on the relationships between start-ups and their target customers. The vast majority of AI start-ups look to B2B relationships as they address specific industry challenges. The delegates also noted that the venture capital community in Germany expected the level of start-up maturity to be higher than their equivalents in the UK before making an investment. Similarly, German industry places a significant burden on start-ups in their expectation of 100% proven technology before adoption; a burden that is both difficult to achieve and time-consuming for any start-up. **The delegates viewed significant opportunities for the UK, in collaboration with the practical application of AI ethics and in showcasing the maturity of UK AI start-ups to German industry.**

The delegation observed that a series of recent government initiatives had helped support a vibrant ecosystem in healthcare AI start-ups through policies to introduce a new electronic patient record system and legislation to enable health insurance reimbursement for apps that qualify as digital therapeutics. Whilst the UK and German healthcare systems are structurally significantly different, the innovation challenges faced by start-ups in this area are similar. An approach taken by many German healthcare start-ups is to use federated learning as a way to address data privacy and data sharing concerns; a similar approach could be taken in the UK. Both the UK and Germany could benefit from reciprocal access to each other's healthcare markets in order to accelerate scale-up of solutions, but there are considerable challenges in existing procurement and reimbursement systems that would need to be overcome.

The AI ecosystem in Berlin is active across several sectors with networks sharing AI expertise across different areas. Merantix was highlighted during the mission for playing a critical role. Since it was founded in 2016, Merantix has raised $37.5 million. There are significant similarities between Merantix and Team8 in Israel which also identifies the most promising use cases, validating them and spinning out companies to take them to market supported by the most promising entrepreneurs and CEOs. Team8 is integral to the Israeli technology start-up ecosystem. Since it was founded in 2014, Team8 has raised $56 million, incubated 11 successful start-ups and recently created a venture capital arm with $104 million under management. Team8's success does appear to provide strong validation for the future success of Merantix and its role in the Berlin and wider German ecosystem.

6. AI in the Regions - Bavaria

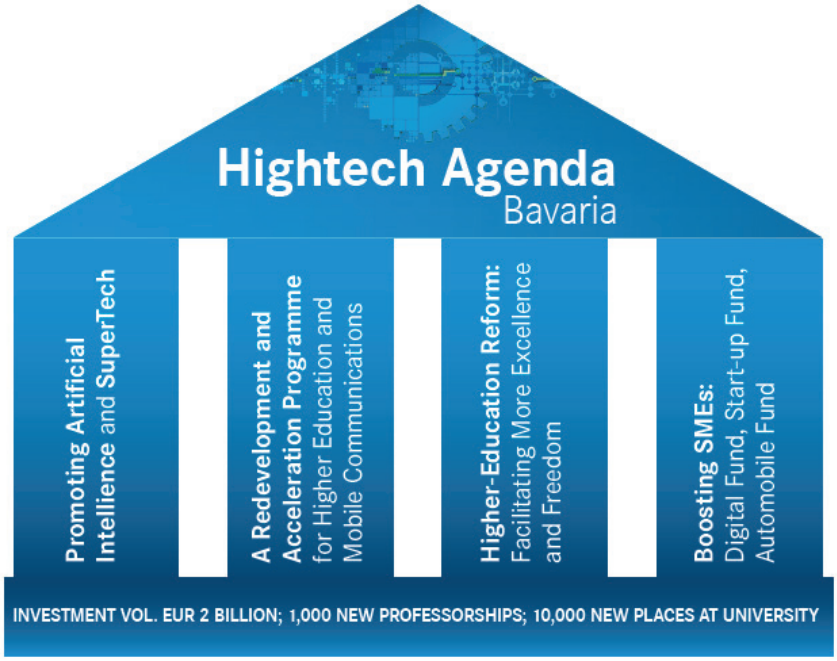


Figure 5: The Bavarian Hightech Agenda core activities
Source: Hightech Agenda Bavaria. Govt Policy Statement, 10 October, 2019

6.1 appliedAI[33]

appliedAI is the largest initiative for the application of AI technology in Germany, with the ambition of accelerating the adoption of AI across the whole country. Established by UnternehmerTUM, one of the largest innovation centres in Europe, appliedAI's international activities and services are largely driven by its founding partners, which include BMW, Google, Infineon, NVIDIA and Siemens. Funded by the Bavarian Government, corporate partners, and through customer projects, appliedAI's core mission is to help experimenters, business units and corporates reach a high level of AI maturity with the products they produce and the applications they deploy.

appliedAI takes a structured approach to developing AI maturity, viewing the process as a journey from the experimenter, an individual within an organisation taking the first steps with AI, through being practitioners and professionals to becoming a shaper or thought leader within an organisation driving forward an AI-first agenda. The services they offer reflect this structured approach in that they provide AI-related engineering, education strategy services[34] at each stage of the maturity scale. To date, they have supported 2,000 organisations in the adoption of AI, built 35 systems, defined 20 corporate AI strategies and helped 50 companies advance in their level of AI maturity.

6.2 Bavarian State Ministry for Digital Affairs (StMD)[35]

The Bavarian State Ministry for Digital Affairs (StMD) was founded in 2018 during the formation of the new Bavarian State Government. It is the think tank for digitisation in Bavaria and is responsible for digital policy, strategy and coordination. The Ministry for Digital Affairs is the first of its kind in Germany.
In 2019, the state government developed and committed €3.5 billion in funding to its Hightech Agenda. Four pillars cover the promotion of AI and SuperTech (cleantech, aerospace, quantum and 6G); a redevelopment and acceleration programme for higher education and mobile communications; higher education reform to facilitate greater research excellence and

[33] https://www.appliedai.de/
[34] https://www.appliedai.de/services
[35] https://www.stmd.bayern.de/

freedom; and, lastly, a package to boost SMEs.

From the Hightech Agenda, €360 million will be invested in AI, 20 world-leading AI research centres will be created within the state of Bavaria, and 100 new AI professorships will be funded. The Bavarian Government is driving forward an agenda that will grow the AI ecosystem and promote the development and application of AI in accordance with European values and the use of AI for the benefit of all. This also includes the responsible handling of data and the development of AI competence in society and companies.[36]

The Bavarian AI ecosystem is composed of several distinct strands, including:

- Higher education and talent – the development of the core skills needed to advance the development and use of AI.
- National and international collaboration – the drive to make Germany a world leader in AI and to develop AI based on the European values (European Digital Sovereignty).
- Fundamental and applied research – the provision of the framework, the funding, the capability and the policies to foster an environment where world-leading transformational research and development activities can flourish and bring about transformational change and impact.
- Enabling the regional economy and businesses – the development of policies, incentives and the provision of appropriate support to enhance the take-up of digital technologies including AI.

Different regions, or nodes, across the state focus their activities on enhancing different aspects of the ecosystem. Munich is seen to be at the centre of the ecosystem where the focus is on intelligent robotics, bringing together the research and teaching activities of two leading universities alongside the research institutes' activities and the significant activity from industry and start-ups in the region. At the forefront of this will be:

- The envisaged Bavarian AI Factory with robots that companies or employees can remotely control via the Internet, which would be unique.[37]
- The Bavarian Competence Network for Artificial Machine Intelligence (Fraunhofer IKS, TUM, Helmholtz Zentrum München).
- The ELLIS Institute Munich (TUM and Helmholtz Zentrum München) as part of the European Lab for Learning and Intelligent Systems.

Further strengthening the ecosystem is the recently established Bavarian AI Council,[38] with 21 interdisciplinary AI experts from across academia and industry. Delivering the recommendations and guidance of the council is the Bavarian AI Agency[39], additionally tasked with:

- Creating the brand "AI in Bavaria".
- Providing coordination and networking support for all activities in AI within the state.
- Technology and talent scouting both nationally and internationally.
- Support for accessing and attracting third-party funding and investment.

6.3 Fortiss Centre for AI (C4AI)[40]

The Fortiss Centre for AI (C4AI) is a joint undertaking by Fortiss, Bavaria's National Research Institute for software-intensive systems, and IBM. The joint venture has a strong focus on developing reliable, trustworthy, safe and secure AI technologies through the application of rigorous software and systems engineering but also through the application of AI itself, to improve both the software and development process. The centre, located at the IBM Watson Campus in Munich, focuses on AI engineering.

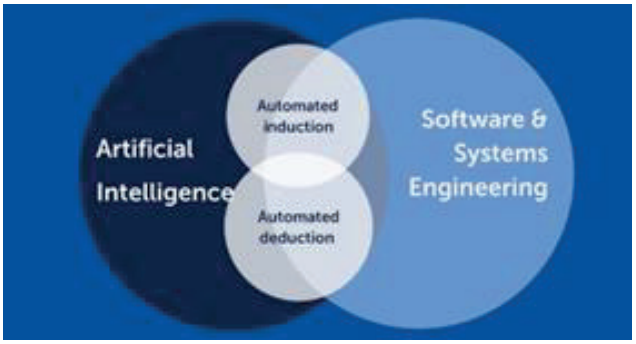


Figure 6: The interaction and intersection between AI and systems engineering
Source: Fortiss Centre for AI

[36] https://www.bayern.de/wp-content/uploads/2019/10/hightech_agenda_bayern.pdf
[37] https://themunicheye.com/two-billion-euro-program-for-innovation-in-bavaria-3747
[38] https://www.bayern.de/hochkartig-besetzter-ki-rat-bert-ab-sofort-bayerische-forschungseinrichtungen/
[39] https://badw.de/fileadmin/user_upload/Files/BADW/pressemitteilungen/2020/pm-40-20/40_LRZ_KI_Rat_.pdf
[40] https://www.fortiss.org/en/research/fields-of-research/detail/center-for-ai

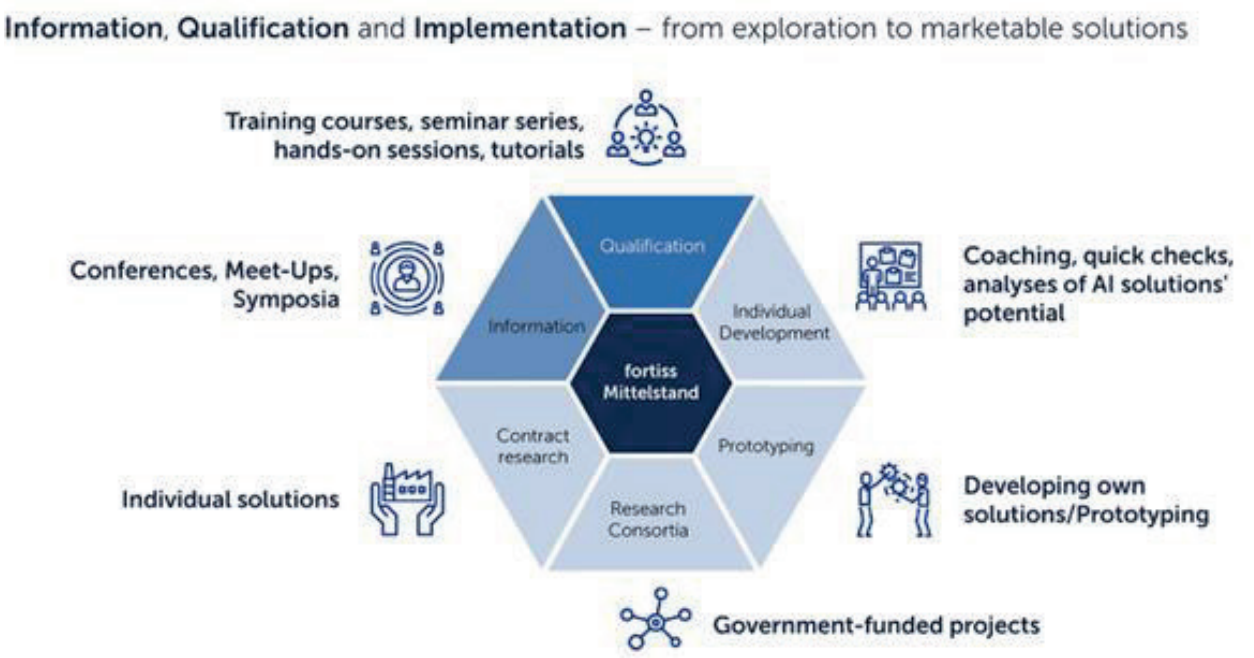


Figure 7: The service portfolio for SMEs
Source: Fortiss C4AI

Whilst the application for their research is steered heavily towards embedded AI with the context of enabling provably safe and secure cyber-physical systems and IoT, at a broader level, their research should have an impact on standards for safe and secure AI. This should inadvertently lead to new products and services that are based on certifiable embedded AI, an increased acceptance of AI-based technologies through explainable AI, and result in the creation of competitive advantage through more transparency in algorithms and their development.

The Fortiss Mittelstand[41] provides a central point of support for SMEs in Bavaria seeking to carry out digital transformation projects. They can act as a source of information, provide education and support with the implementation and deployment of enterprise solutions.

6.4 Fraunhofer Institute for Cognitive Systems (Fraunhofer IKS)[42]

The Fraunhofer Institute for Cognitive Systems (Fraunhofer IKS) sees itself as both a technology and knowledge transfer partner and an institution filling the void between university research and its commercial deployment in a business setting.

The focus within Fraunhofer IKS is on the engineering of safe intelligence; cognitive systems with assured resilience. Their research, therefore, focuses on certifiable AI, intelligent architectures and intelligent systems safety and reliability. The context for their research is given by the application areas of industry 4.0, autonomous systems, intelligent medical devices and smart agriculture.

Cognitive systems are complex; managing and ensuring the quality of such systems still poses a significant research challenge. Current approaches for self-estimation of the dependability of an AI system are still not mature enough to provide a reliable approach to this problem. This is one of the key challenges that the work of Fraunhofer IKS seeks to address.[43] There is significant interest in the problem of safety and standardisation for "autonomous intelligent systems", and Fraunhofer has an ongoing collaboration with the University of York in this area.[44]

[41] https://www.fortiss.org/en/about-fortiss/fortiss-mittelstand
[42] https://www.iks.fraunhofer.de/en.html
[43] https://www.iks.fraunhofer.de/en/services/dependable-artificial-intelligence.html
[44] https://www.york.ac.uk/safe-autonomy/ https://www.york.ac.uk/assuring-autonomy/

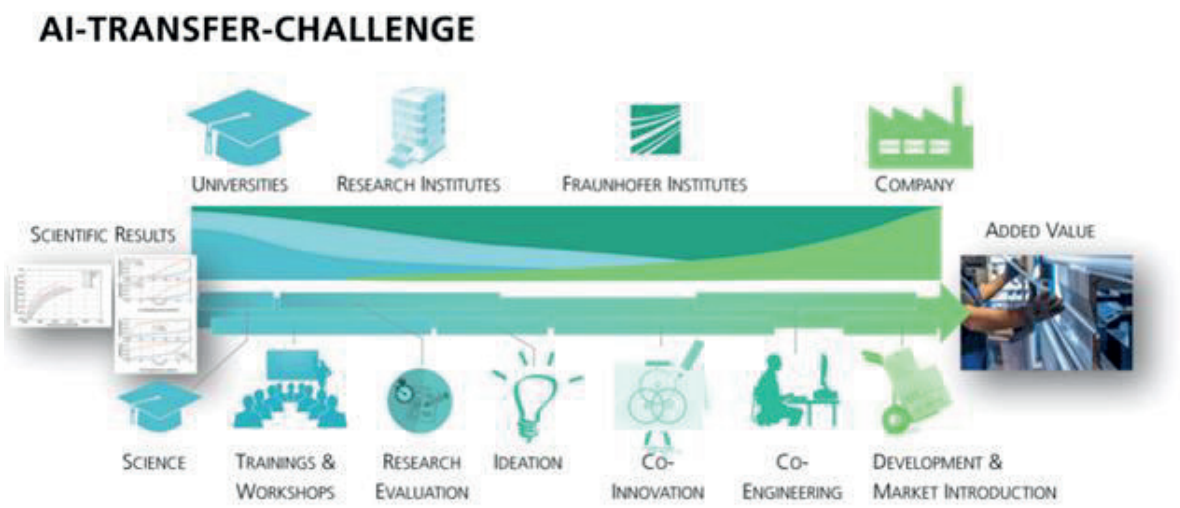


Figure 8: Stages in AI knowledge and technology transfer
Source: Fraunhofer IKS

Observations: The delegation noted that the Bavarian Government was investing heavily in AI research and innovation and saw ample opportunity in this area. They also noted a strong appetite and willingness to collaborate internationally. They saw the UK as a key ally in this space, particularly around safe, secure AI, data sharing, certification and standards, as well as opportunities around networking the two AI ecosystems through agencies like appliedAI.

The appliedAI initiative stood out for its holistic approach to raising AI maturity levels across industry, and a similar approach could benefit the UK. However, the UK market was noted for the maturity of its AI start-ups. The raising of AI maturity levels across industrial end-users faces similar challenges in Germany as we face in the UK; a limited understanding and lack of clarity of what AI is and how adopting AI could make a meaningful difference. There is little understanding of structural corporate changes required to scale AI from a proof-of-concept to full-scale industrial implementation. Also, a lack of perceived competitive pressure to adopt AI, and finally, a significant trust issue faced by start-ups compared to large established solution providers.

7. AI in the Regions – Baden-Württemberg

7.1 CC-KING Competence Centre AI Engineering[45]

CC-KING Competence Centre AI Engineering (CC-KING) is the national state competence centre for AI engineering and is a collaboration between:

- Fraunhofer Institute of Optronics, Systems Engineering and Image Exploitation (IOSB);[46]
- FZI Research Centre for Information Technology;[47] and
- The Karlsruhe Institute of Technology (KIT).

Funded by the Ministry of Economics, Labour and Housing of the State of Baden-Württemberg, CC-KING creates the critical link between AI research and engineering disciplines. Supporting the practical application of AI and machine learning, CC-KING engages in fundamental research and then develops tools to enable the use of AI and machine learning within business practices. Key areas of application include mobility and industrial production. Again, there is a strong focus on the application of sound engineering disciplines to drive the development of "robust" solutions. The centre additionally offers direct practical support to the private sector.[48]

7.2 Cyber Valley[49]

Cyber Valley is Europe's largest AI research consortium and was founded by the state of Baden-Württemberg with key research institutes such as the Max Planck Society and a significant number of industrial partners such as Bosch and Amazon. These industrial partnerships drive the research in AI to strengthen and enhance German industries, services, and products through machine learning, robotics and computer vision.

Cyber Valley is home to many of Germany's leading innovative companies. It incorporates five clusters of excellence and one university of excellence. The partnerships have led to a thriving, dynamic ecosystem between world leaders in science, research and industry with both Bosch and Amazon having established AI research centres in the region. The Stuttgart-Tübingen region further enhances its standing as a global leader in AI research through its public discourse activities which focus on areas such as ethics, philosophy and trust.

Cyber Valley has established a start-up network to build an ecosystem of entrepreneurs. They invite start-ups to events and meet-ups and encourage networking. Supporting this is the Cyber Valley Investor Network, with representation from Atlantic Labs (Berlin), IT-Farm (Tokyo/Palo Alto), BMWi Ventures (Mountain View/Munich), Grazia Equity (Stuttgart), and Gründermotor (Stuttgart). These members provide mentorship to researchers and help turn ideas into successful companies.

7.3 Research Collaboration Network - ELLIS [50]

The European Laboratory for Learning and Intelligent Systems (ELLIS) was established by the Tübingen AI Centre[51] and Cyber Valley. Drawing its inspiration from similar network collaboration models, in particular the Vector Institute in Toronto[52], the ELLIS network aims to foster European excellence in AI by providing the support to create and retain a critical mass of AI talent to rapidly advance research and innovation.

ELLIS has developed and is delivering on a three-pillar strategy to achieve this objective:

1. Through 11 Fellow Programmes, bringing the best European talent together to work on key challenges ranging from basic research in theory and algorithms to applications in health, climate sciences and human-centric elements of AI.
2. Through a PhD Programme, identifying and supporting the best PhD students in Europe working in AI.
3. Through a network of ELLIS Units that are already performing leading AI research across Europe. These are chosen through open calls and each unit is expected to fulfil a set of criteria to ensure research excellence and be internationally competitive. The University of Oxford, University of Cambridge[53] and University of Edinburgh[54] are already established units and a bid to join from University

[45] https://www.ki-engineering.eu/en.html
[46] https://www.iosb.fraunhofer.de/en.html
[47] https://www.fzi.de/en/home/
[48] https://www.ki-engineering.eu/en/about-cc-king.html
[49] https://www.cyber-valley.de/en
[50] https://ellis.eu/
[51] https://tuebingen.ai/
[52] https://vectorinstitute.ai
[53] https://ellis.eu/units/cambridge
[54] https://ellis.eu/units/edinburgh

College London[55] is currently being reviewed.[56]

7.4 Karlsruhe Institute of Technology (KIT)[57] and Interactive Systems Lab[58]

Karlsruhe Institute of Technology (KIT) is one of eleven universities of excellence in Germany. Sitting within the Helmholtz Association, KIT focuses on fundamental research and covers areas including humanoid robotics, natural language translation, algorithms and software engineering for AI.

The Interactive Systems Lab at Karlsruhe is a joint initiative between KIT and Carnegie Mellon University (CMU). The lab's focus is on technologies that enable the human experience, human mutual understanding and communication. Research topics include speech recognition, translation, speech synthesis, language, vision technologies, person tracking and recognition, multi-modal and cross-modal perceptual interfaces, smart rooms and pervasive computing. There is existing collaboration with the UK through the EU Funding Programmes with organisations such as Ocado and a strategic partnership with the University of Leeds where AI has been prioritised[59].

7.5 Digital Hub for Applied AI Karlsruhe[60]

The Digital Hub for Applied AI Karlsruhe is one of 12 hubs established through BMWi's Digital Hub Initiative. Each hub reflects the core competency within its region; Karlsruhe is seen as one of Germany's most important hotspots for AI. The hub is well connected to the region's AI ecosystem, being located close to the Karlsruhe Institute of Technology and the Fraunhofer Institute for Optronics, System Technology and Image Processing (IOSB), as well as having their efforts coordinated by the FZI Research Centre for Computer Science and CyberForum.

The Karlsruhe hub focuses on AI for energy, mobility and production, and similar to other hubs across Germany, it offers the following support services:

- Start-up Finder is a mechanism by which a company (corporate or medium-sized) or an investor can get access to over 450 start-ups via the digital hubs.
- Program Finder provides access to accelerators, incubators and other initiatives being run by the digital hubs.
- Workshops, seminars and networking events are all part of the activity undertaken to help companies gain awareness and understanding of AI and specific support for implementing AI.

Figure 9: Digital hub locations in Germany

7.6 CyberForum[61]

CyberForum is a high-tech business network with more than 1,200 members across the breadth of the digital ecosystem. As well as having a coordination role in the Digital Hub for Applied AI Karlsruhe, CyberForum provides a variety of support to all types of organisations, small to large, in both the public and private sectors. For SMEs they provide HR, business mentoring, access to funding and internationalisation support. Schools are supported through digital transformation activities, and start-ups are supported through a dedicated incubator. CyberForum doesn't take an equity position in these start-ups. Since 1997 approximately 5,000 founders have benefited from their services.

CyberForum runs an extensive programme of events and provides opportunities for apprentices and IT professionals to get placements within member organisations, an activity designed to retain talent within the Karlsruhe region. Additionally, CyberForum represents the interests of its members and the wider high-tech industry on both state and federal level.

[55] https://ellis.eu/units/london-ucl
[56] https://ellis.eu/ellis-position-paper
[57] KIT - Karlsruhe Institute of Technology
[58] https://isl.anthropomatik.kit.edu/english/index.php
[59] https://www.leeds.ac.uk/news/article/4389/leeds_develops_new_european_partnership
[60] https://www.de-hub.de/en/the-hubs/karlsruhe/
[61] https://www.cyberforum.de/en/about-us/

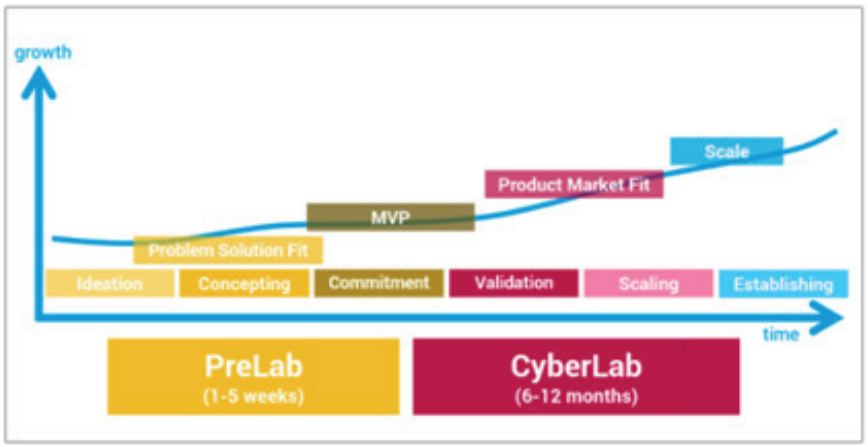


Figure 10: Support for start-ups at the different stages
Source: CyberLab

7.7 CyberLab[62]

CyberLab is an IT accelerator in Karlsruhe with access to the network of members and alumni in CyberForum. The infrastructure and support required by a start-up are provided within the lab. An initiative called Pre-Lab takes the form of a six-day intensive programme where mentors work with the start-up founders to analyse their business concept. The aim is to mitigate risks and uncertainties and help to sharpen their market proposition. The lab is connected to 250 angel investors and venture capitalists.

Approximately 50 teams have been supported in the pre-lab stages, and 15 teams have been incubated in CyberLab. Around 600 investor pitches have been screened, and 23 teams have gone on to raise pre-seed funding in excess of €200K.

7.8 FZI House of Living Labs[63]

FZI is a research institute founded by the University of Karlsruhe and the Ministry of Economy in Baden-Württemberg. The FZI House of Living Labs is a modern research environment focused on industry 4.0. It specifically targets SMEs that would like to conduct interdisciplinary research and development with the support and expertise of the FZI researchers and experts. The Living Labs environment makes it possible to test new research and innovations within real-world settings.
The interdisciplinary nature of the labs means that innovations can be identified across different research areas and subjects, and unique use cases are created for which innovations are developed. The House of Living Labs provides both an environment for the exchange and the generation of new ideas, but also for development, integration, investigation and testing.

Observations: The delegation overwhelmingly recognised the regional focus as the industrialisation of research through the technology and competence centres bridging the gap between academia and industry. It was clear that the region's strengths in AI-related technologies such as embodied intelligence, human-centred computing, spoken human-machine interaction and industrial robotics, resonated well with local and international industrial partners but that their approach to entrepreneurialism, start-ups generated from spinouts of these collaborations, could be more supportive to founders not yet part of this ecosystem. CyberLab stood out as a great example of how AI accelerators should function with the delegation not just impressed by the lab's position on equity, but also by their success rate in taking start-ups to pre-seed funding..

[62] https://www.cyberlab-karlsruhe.de/en/
[63] https://www.fzi.de/en/research/fzi-house-of-living-labs/

8. Collaboration

The collaboration between the UK and Germany has been a long-standing one based on their shared principles, values and rules emanating from membership of the European Union. European Research Programmes have been running since the mid-1980s, and collaboration in a multitude of guises has been at the heart of all the framework programmes.

UK industry, academia and research institutions have collaborated with their counterparts in Germany ever since on all aspects of scientific and technological research and development. This has included opportunities to collaborate on fundamental and applied research through the differing funding instruments supported by the framework programmes over the years. The UK's recent commitment to the European Framework Programme ensures that these relationships, established over years of collaboration, will be maintained and that new opportunities for collaboration can be fostered[64].

This mission highlighted the extent to which Germany is investing in AI initiatives. This investment and surge in activity should be seen as an opportunity for UK experts, researchers and innovators to forge new collaborations to not only further their work but also gain influence in the direction of how these activities in Germany and Europe progress going forward.

Both the public and private sector German organisations consulted recognise the benefits of collaboration and certainly wish to see it continue, but have questions as to how that might happen in the future.

[64] https://www.ukri.org/our-work/collaborating-internationally/working-on-eu-funded-projects/

9. Conclusion

Germany launched its AI Strategy in 2018, backed by a cumulative federal budget of €5 billion, to support the country's goal of becoming a world leader in AI and its desire for Digital Sovereignty through the initiatives and activities indicated in this report.

States like Bavaria and Baden-Württemberg, alongside national initiatives, have built significant ecosystems to accelerate the take up of AI in both research and start-up support. These ecosystems are complex and can be challenging to navigate for someone not familiar with the landscape.

A lot of progress appears to have been made in a short period. The significant investments made by both the public and private sectors alongside a very strong fundamental and applied research base has undoubtedly helped to accelerate the delivery of the National AI Strategy. This has been in part due to the clear long-term commitment of the German public and private sector.

There are strong collaborations between their research base through to labs for applied AI research and leading corporates like IBM, Amazon and Google. Initiatives like Cyber Valley have quickly gone on to become some of Europe's largest research collaborations to advance breakthroughs in AI.[65]

To date, there appears to be limited evidence of societal interdisciplinary and integrated approaches within the research activities around AI, perhaps as a result of the primary focus on and the formal structured approach taken to ensure robust engineering of AI solutions. This could be a key area for collaboration between Germany and UK, and could help expedite the adoption of AI by integrating the social sciences and the UK's leadership in AI ethics into the development of AI innovations.

Whilst Germany has some of the world's leading collegiate research institutions with a global footprint and recognition, it is still the case that a lot of the innovation is still struggling to get out of the research environment into industry as enterprise commercial solutions. This is a problem that isn't unique to Germany; however, the initiatives and ecosystems that are growing in Germany should have some impact, and the trajectory for Germany with respect to furthering their market position in AI certainly looks promising.

[65] https://www.dwih-newyork.org/en/current-focus-topics/artificial-intelligence/ai-research-takes-root-in-germany/

Annex 1

List of UK Participants

Alan Turing Institute
Assentian
Department for International Trade - British Consulate General Munich
Digital Catapult
Glamourous AI
Imagination Technologies
Innovate UK
KTN
Panakeia
The Floow
UK Government Office for AI
UK Science & Innovation Network - British Consulate General Munich

List of German Participants

appliedAI Initiative

Bavarian Ministry for Digital Affairs

Bayern Innovativ/Zentrum Digitalisierung.Bayern (ZD.B)

Berlin Partner for Business and Technology

Bitkom e.V.

CC-KING Competence Centre Artificial Intelligence Engineering

Cyber Valley

de:HUB for applied AI

DIZ Digital Innovation Centre and CyberForum (Coordinator of de:Hub for applied AI)

DLR-PT Project Management Agency

Flying Health Incubator

Fortiss Centre for AI with IBM

Forum Digital Technologies (FDT)

Fraunhofer IKS as part of the Bavarian Competence Network “Artificial Machine Intelligence”

Future Work Lab

FZI - House of Living Labs

FZI Research Centre for Computer Science (Coordinator of de:Hub for applied AI)

German Federal Ministry for Economic Affairs and Energy (BMWi)

German Research Institute for Artificial Intelligence (DFKI)

Karlsruhe Institute for Technology (KIT)

KI Bundesverband e.V.

Merantix

Mittelstand 4.0 Centre of Excellence

Steinbeis Europe Zentrum

The Berlin Institute for the Foundations of Learning and Data (BIFOLD)

Tübingen AI Centre

ktn