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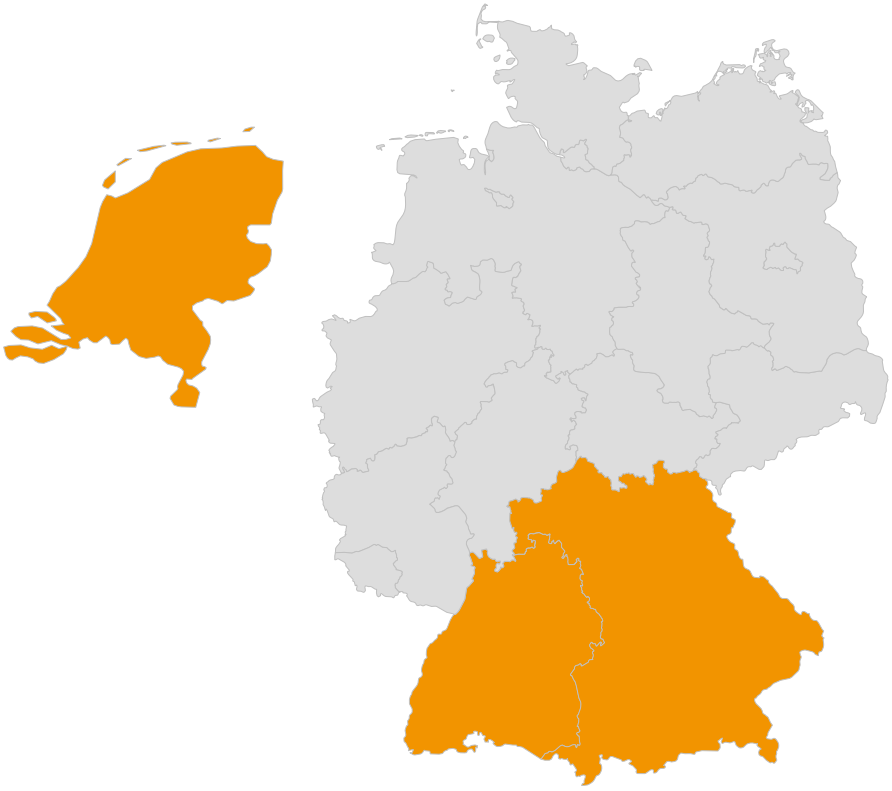
FRAUNHOFER INSTITUTE FOR CASTING, COMPOSITE AND PROCESSING TECHNOLOGY IGCV

ARTIFICIAL INTELLIGENCE IN SOUTHERN GERMANY

OPPORTUNITIES FOR DUTCH BUSINESSES IN THE INDUSTRIAL SECTOR

November, 2020



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Management Summary

Artificial intelligence (AI) offers new potential for German companies and for cooperation between Dutch and German companies. The market study conducted with southern German companies shows the current development from the context of digitization and Industry 4.0 towards data-driven companies that already use or plan to use AI applications such as Automated Quality Assurance, Predictive Maintenance, Autonomous Robotic Systems and Predictive Quality in their own companies. With regard to the state of AI adoption and the external skills required, a distinction must be made between medium-sized and large companies. It is also apparent that, in addition to the actual AI knowledge, criteria such as the ability to execute and domain knowledge play an at least as important role for German companies when deciding on a possible cooperation.

On the business side, platforms such as associations and AI-specific and sector-specific conferences are currently used for AI exchange, while many national AI initiatives also promote AI exchange and networking among businesses. There are also links to European AI initiatives.

Furthermore, the national legislations must be observed when implementing AI applications in Germany, whereby the cornerstones for new standards and directives in the coming years are being laid within the framework of the AI standardization roadmap. Based on the preliminary work in the context of Industry 4.0, standards for the cross-platform data exchange of machines will be further developed, which will also play an important role in the implementation of AI applications in the future.

Key findings

- Most of the surveyed medium-sized and larger manufacturing companies are already implementing AI use cases or plan to implement AI use cases in the near future
- Partnerships with Dutch/international companies are preferred over local companies if they have more experience in the considered area
- The main platforms to get in contact are associations and conferences (AI-specific or sector-specific)

Introduction

To get an overview of the potential for cooperation between Dutch and southern German companies in the field of Artificial Intelligence and Industry 4.0, Dutch experts were first interviewed about the current AI landscape in the Netherlands. Based on this, a survey was designed for German companies and telephone interviews were conducted with 11 medium-sized manufacturing companies (up to 499 employees) and 11 large companies (500 employees and more) from Baden-Württemberg and Bavaria. On the one hand, the current status of the companies with regard to the current use of artificial intelligence within their company was recorded and the relevant AI use cases and key drivers were included. In terms of possibilities for cooperation, the most wanted external skills and current problems were also discussed. Furthermore, an overview was created of how potential industrial partners are identified, which criteria are important in this context and which platforms are used for this purpose.
Besides that, a structured research on relevant topics concerning Dutch-German cooperation in the field of Artificial Intelligence was conducted. Existing AI initiatives in Southern Germany, which support local companies with the integration of Artificial Intelligence, also offer a possibility for Dutch companies to get in contact with German companies. Furthermore, existing legislations and standards should be considered when cooperating with German companies. European AI initiatives and programs also offer a possibility of international cooperation to establish a sustainable relationship between Dutch and German research institutes and companies.

Research Questions

Focus of interviews

Which **areas of AI** provide the greatest opportunities for cooperation in southern Germany in the context of Industry 4.0?

What AI related **external skills** are German companies looking for?

What **issues and obstacles** exist in relation to these AI domains within Industry 4.0?

Focus of research

What are the best **public-private initiatives** for promoting economic cooperation in the area of knowledge valorisation or southern German/German clusters which Dutch parties can join?

What **legislation, guidelines and standards** are important within this market?

Which **EU programs focussing on AI and Industry 4.0** can Dutch and German companies join together?

Market Study

With the focus of the study on Artificial Intelligence and Industry 4.0, manufacturing companies from sectors such as mechanical and plant engineering, metal processing, electrical appliances and medical technology were surveyed. Half of the surveyed companies can be assigned to the medium-sized companies (n=11) and the other half can be assigned to large companies (n=11), which are partly considered separately in the study due to the different initial situations (Figure 1). Among the surveyed companies, about 73 percent of the large companies have already implemented at least one AI use case (Implementation). While this is the case in 36 percent of the medium-sized companies, 27 percent of the companies here are in the process of implementing or planning AI use cases (Planning) and 36 percent have identified potential AI use cases (Identification) or have not yet dealt with the topic (None). With a share of 55 percent of companies with at least one implemented AI use case, the study correlates with results of a worldwide study conducted by McKinsey[1] (2019, n=2,360), with 58 percent at this level. In a study conducted in Germany by Bitkom[2] (2020, n=603), by contrast, only 6 percent of the companies said they already use AI and 22 percent planned to do so in the future. In a study by PwC[3] (2019, n=500), also conducted in Germany, the number of companies that already have AI applications in use or at least have already conducted initial test phases falls to 9 percent. The studies were not focused on the Industry 4.0 context and a broader industry spectrum was considered, but it can be stated that the degree of AI adoption of the companies surveyed in this study can be considered comparatively high.

The biggest users of AI in this study are above all the large companies and enterprises, which also use AI to expand their own offerings with new products and services (such as integrating AI in existing products like mechatronic devices).

[1] Global AI Survey: AI proves its worth, but few scale impact. McKinsey Analytics. 2019

[2] Künstliche Intelligenz - Einsatz und Forschung in Deutschland. Bitkom Research. 2020 (german)

[3] Künstliche Intelligenz in Unternehmen. PwC. 2019 (german)

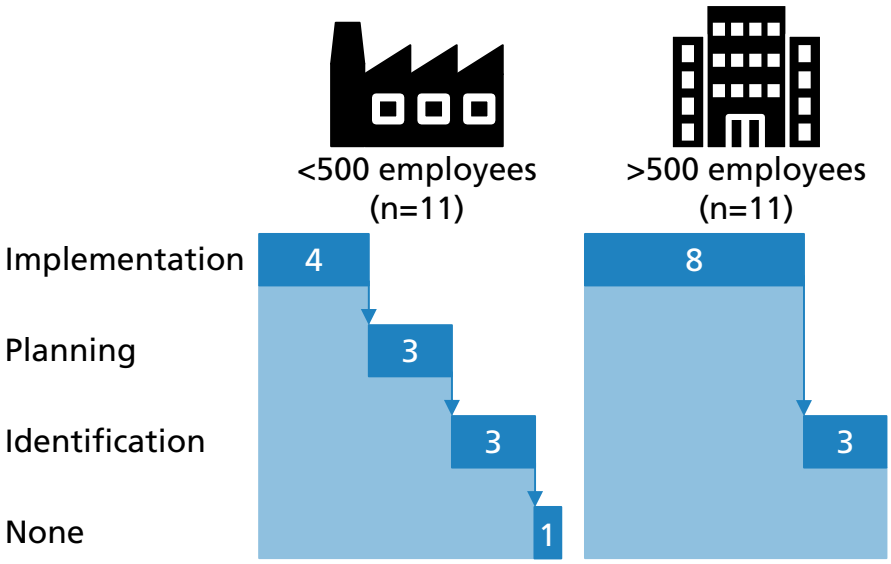

Figure 1: State of AI adoption in surveyed companies

The survey revealed four AI use cases to be particularly relevant:

- **Automated Quality Assurance**: The automated testing of components for defects. AI is mainly used for the identification of defects on the basis of image data of the products, building on previous successes in the field of image processing. However, other forms of sensor technology can also be used here.
- **Predictive Maintenance**: Machine data can be used to monitor the machine condition (e.g. degree of wear) and on the basis of this data a prediction of the remaining useful life can be made using AI methods. In this way, machine downtimes can be avoided and maintenance cycles can be optimized.
- **Autonomous Robotic Systems**: Autonomous robots are able to perceive their environment and thus perform their tasks even under varying conditions. Approaches from the field of computer vision can be used to detect objects, their positions etc. in the robot's environment. More recent approaches also deal with the use of Reinforcement Learning, a subcategory of machine learning, in which the behavior of the robot is also learned by itself.
- **Predictive Quality**: Machine data (e.g. environmental data, sensor data) can be used to predict whether the product currently being processed will be manufactured without

defects before it is tested in downstream processes. The aim is often to determine the factors influencing product quality on the basis of data and to use this knowledge to reduce scrap.

According to this survey (Figure 2), Automated Quality Assurance is already implemented in 8 companies and therefore the most widely used AI use case. Predictive maintenance was already identified by more than 60 percent of those surveyed as at least one current or future relevant use case. According to the survey, only few use autonomous robot systems, although these are considered relevant for the future, as it is hoped that they will be more robust and easier to implement in the future. Predictive quality is also considered a relevant use case by 36 percent of those surveyed.
Nevertheless, 68 percent of the participants stated that quality improvement is one of the drivers for the use of artificial intelligence and 55 percent said that the possibility of automation through artificial intelligence is an essential aspect. Furthermore, 41 percent of the respondents cited the increase in throughput or efficiency as well as the possibility of offering new products and services as a reason to deal with the topic of Artificial Intelligence.

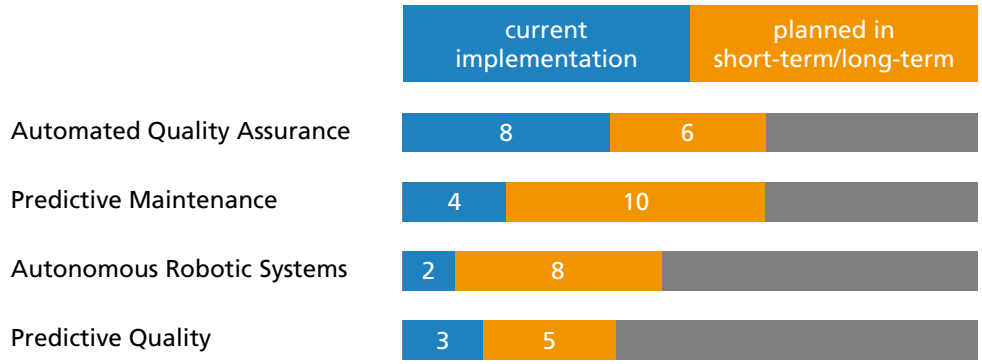

Figure 2: Most relevant AI use cases (n=22)

Before, during and after the implementation of AI applications, different types of skills are required. The companies were asked which of the following skill sets they would rather build up internally or outsource.

- **Data Scientist**: Implementation of the AI application based on machine learning methods
- **Data Architect**: Implementation of the IT infrastructure for data storage and making data available
- **MLOps**: Combination of the words DevOps (Development Operations) and machine learning. Even after an initial implementation, AI applications must be kept in operation. In the field of MLOps, the expertise of classical IT and data science is combined (e.g. for the maintenance of machine learning models)
- **Project Management**: Organization and planning of AI implementation projects
- **Strategy**: Identification of potential use cases and development of roadmaps together with company employees

The individual roles do not necessarily have to be assigned to individual persons. Thus, a data scientist with appropriate experience can also dedicate himself to areas of MLOps. The focus of the survey was to determine in which areas cooperation with other companies are possible or necessary (Figure 3).
Most large companies have already gained initial experience in the implementation of AI applications and are currently in the process of expanding their own expertise. The essential competences, which are necessary for the implementation and the operation of AI applications, are therefore tried to build up by further training and new hires. With regard to new approaches in the field of Artificial Intelligence and applications in which the company has not yet gained experience, however, specialized data scientists are in demand and cooperations are sought.
Medium-sized companies in Germany are characterized above all by a high degree of specialization in specific domains. In areas such as special-purpose machine construction and metal processing, it is often possible to draw on decades of previous experience, but

many of these companies are still in the start-up phase regarding digitization and Industry 4.0. In the area of Artificial Intelligence, potential is also seen here, but external partners are being sought who can independently implement and operate AI applications and are also available afterwards if required for further services.

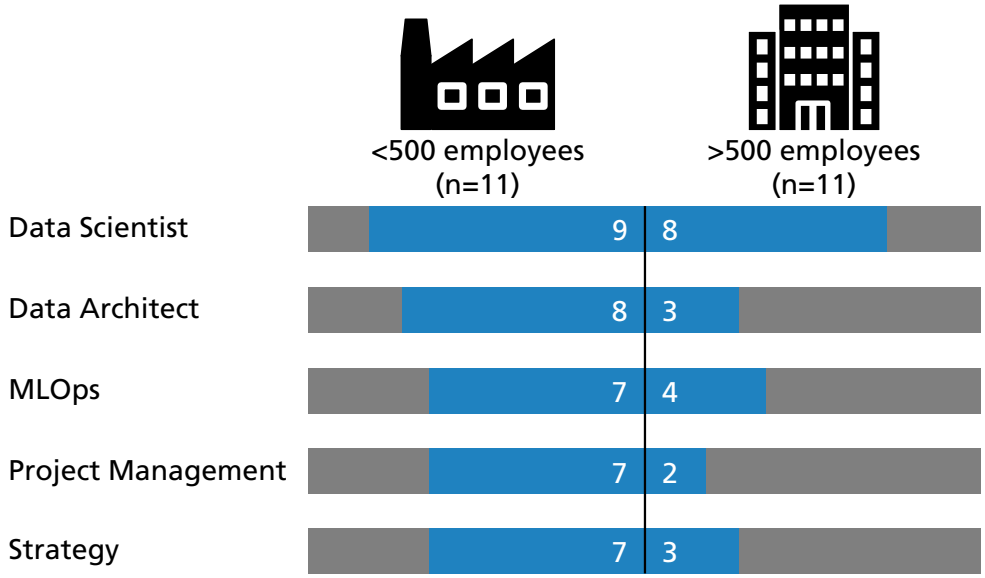

Figure 3: Most wanted external skills

With regard to the challenges in implementation, the respondents cited as a major hurdle that already when identifying potential AI use cases, it is difficult to estimate the effort and benefits (50 percent). This fact makes it difficult to convince decision-makers in the company. Other challenges cited were the quantity of available data (45 percent), the in-house knowledge of Artificial Intelligence (36 percent) and the lack of customized solutions (23 percent).

In addition to criteria such as cost and trustworthiness, there are three major criteria that German companies use when considering cooperation with potential new partners (Figure 4). Especially in the context of Artificial Intelligence the key decision criterion is the ability to execute, which means that the potential partners not only show that they have the necessary theoretical background knowledge, but are also capable to implement the AI application in the company. For this purpose, emphasis is placed on reference projects and the demonstration of the structured approach (e.g. in the context of data acquisition). It should also be proven that the experience is available to integrate the application into the existing infrastructure of the company (e.g. existing control

systems). A further criterion is the closeness of the potential partner and its reference projects to the considered business problem and the closeness to the domain of the company. Knowing the domain of the company avoids the time and effort required for AI practitioners from other fields to understand the focused problem and processes. The successful implementation of similar projects also increases the confidence in the feasibility of the considered application and reduces the risk for the investment. Especially in the field of Artificial Intelligence, the feasibility and benefits of AI applications often cannot be defined concretely at the beginning of the project.

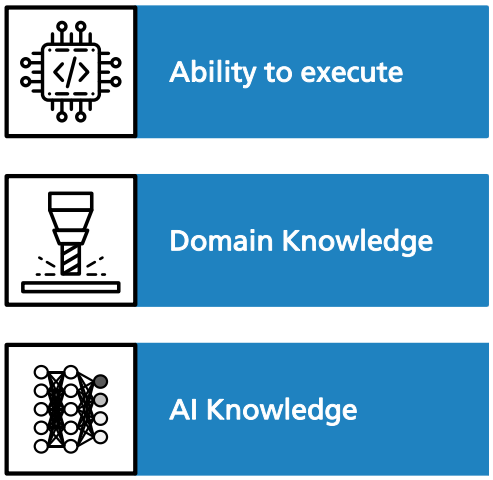

Figure 4: Criteria of potential partners

Half of the companies surveyed are already working with foreign system integrators and service providers. No company sees cooperation with foreign companies, such as from the Netherlands, as an obstacle, if, for example, reference projects can show that the criteria are better met than by a German company. The lack of international cooperation mainly originates from current ways of identifying potential partners through local resources like local networks and partners. Important platforms for identifying potential AI use cases and partners are associations like the Bavarian Employers' Associations for the Metalworking and Electrical Industries (bayme vbm), the Chamber of Commerce and Industry (IHK) or the Mechanical Engineering Industry Association (VDMA). Also, various conferences offer a platform, whereby in Southern Germany various AI conferences are used for exchange. Many southern German companies are looking for

potential AI applications at sector-specific or domain-specific conferences, since AI per se is often not the primary goal and the closeness to the own domain is given.

AI Initiatives in southern Germany

In Baden-Württemberg and Bavaria, there are various AI initiatives (Figure 5), which are funded by the German government or the respective federal states and are intended to support companies with the implementation of Artificial Intelligence. These companies are often being supported in the search for potential partners and tools for the implementation of Artificial Intelligence. Dutch companies can also get in touch with the initiatives and contribute to the range of services offered by the initiatives, for example through their own demonstrations and implementations. In general, however, objectivity must always be maintained, also with regard to potential competitors.

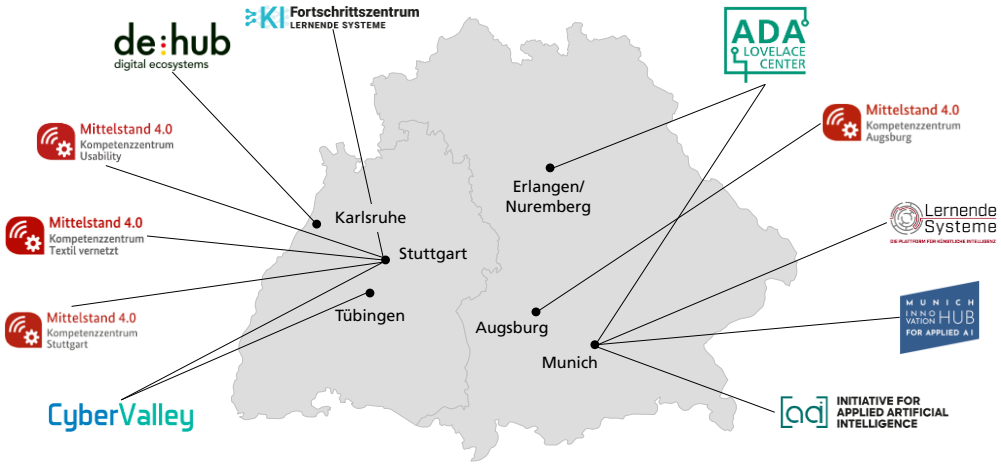

Figure 5: Overview of AI initiatives in southern Germany

- **Mittelstand-Digital** (Funded by the Federal Ministry for Economic Affairs and Energy)

Mittelstand 4.0 Competence Center Augsburg	
Organizations	Fraunhofer IGCV (Augsburg)
Homepage	https://kompetenzzentrum-augsburg-digital.de/ (german)

Mittelstand 4.0 Competence Center Stuttgart	
Organizations	Fraunhofer IPA (Stuttgart), Fraunhofer IAO (Stuttgart)
Homepage	https://digitales-kompetenzzentrum-stuttgart.de/ (german)

Mittelstand 4.0 Competence Center Usability	
Organizations	Hochschule der Medien (Stuttgart)
Homepage	https://www.kompetenzzentrum-usability.digital/ (german)

Mittelstand 4.0 Competence Center Textil-vernetzt (networked textiles)	
Organizations	Hahn-Schickard-Gesellschaft für angewandte Forschung e.V. (Stuttgart), DITF Denkendorf (Denkendorf)
Homepage	https://www.kompetenzzentrum-textil-vernetzt.digital/ (german)

- **AI4Germany** (Funded by respective federal states)

AppliedAI	
Organizations	UnternehmerTUM (Munich)
Homepage	https://www.appliedai.de/ (english)

DE HUB	
Organizations	Digitales Innovationszentrum (Karlsruhe)
Homepage	https://www.de-hub.de/en/the-hubs/karlsruhe/ (english)

KI-Fortschrittszentrum „Lernende Systeme“	
Organization	Fraunhofer IPA (Stuttgart), Fraunhofer IAO (Stuttgart)
Homepage	https://www.ki-fortschrittszentrum.de/ (english)

- **Individual initiatives**

Plattform Lernende Systeme	
Organizations	Acatech (Munich)
Homepage	https://www.plattform-lernende-systeme.de/home-en.html (english)

ADA Lovelace Center for Analytics, Data and Applications	
Organizations	Fraunhofer SCS (Nuremberg)
Homepage	https://www.scs.fraunhofer.de/en/focus-projects/ada-center.html (english)

Munich Innovation Hub for Applied AI	
Organizations	Fortiss (Munich), UnternehmerTUM (Munich), Munich School of Robotics and Machine Intelligence (Munich)
Homepage	https://www.fortiss.org/en/about-fortiss/fortiss-mittelstand/munich-innovation-hub-for-applied-ai (english)

CyberValley	
Organizations	Max Planck Institute for Intelligent Systems (Tübingen, Stuttgart), University of Stuttgart (Stuttgart), University of Tübingen (Tübingen)
Homepage	https://www.cyber-valley.de/en (english)

European initiatives and programs

European initiatives also provide an opportunity for cooperation between the Netherlands and Germany. For example, the *Munich Innovation Hub for Applied AI* is a cooperating partner with the European network *AI DIH Network*. The initiatives within *AI4Germany* are also in close exchange with the European initiative *AI4EU*, which was established as the central AI information infrastructure of the EU. European initiatives are listed below (some initiatives were part of former European funding programs with unclear continuation).

Public-private initiatives

- AI4EU[1]
- SPARC[1]
- CERN for AI[1]
- Electronic Components and Systems Joint Undertaking
- European High-Performance Computing Joint Undertaking[1]
- European Lab for Learning and Intelligent Systems
- Confederation of Laboratories for Artificial Intelligence Research in Europe (CLAIRE) [1]
- Digital Innovation Hubs (DIH) [1]
- GAIA-X (federated data infrastructure for europe)[2]

European programs:

- Horizon Europe (starting 2021)
- Digital Europe (starting 2021)
- High-Level Expert Group on Artificial Intelligence (AI HLEG)
- Connecting Europe Facility (CEF)

[1] A survey of the European Union's artificial intelligence ecosystem, University of Cambridge, 2019
[2] https://www.bmwi.de/Redaktion/EN/Dossier/gaia-x.html

Legislations, guidelines and standards

In recent years, German and international standardization committees have increasingly addressed the topics of artificial intelligence. In particular, the German Institute for Standardization (DIN), together with around 300 experts from industry and research, has launched the conceptualization of a standardization roadmap for AI in October 2019 with a publication date of the final results at the end of November 2020[1]. The development of the standardization roadmap was carried out by a central coordination and orchestration of seven working groups with different main topics[2]:

- **Foundations** - What foundations must be laid in order to embed AI-based systems in the market?
- **Ethics/Responsible AI** - How are ethical aspects considered when using artificial intelligence in autonomous machines?
- **Quality/Conformity/Certification** - How can learning systems be tested and certified?
- **IT Security for AI systems** - How can AI-based systems be secured against cyber attacks?
- **Industrial Automation** - What rules must AI-based procedures and processes in the manufacturing industry be subject to?
- **Mobility & Logistics** - What conditions must be created for automated driving and intermodality?
- **Medicine** - What can AI do in medicine and how does it handle sensitive medical data?

Within the kick-off event, the first workshops were already held within the individual working groups, which in the following year worked independently on the contents and questions of the individual topic areas and focused these in individual sub-working groups. The collected requirements, challenges and the resulting standardization needs were then consolidated for the standardization roadmap for AI.

[1] http://www.din.de/go/normungsroadmapki (german)
[2] https://www.din.de/de/forschung-und-innovation/themen/kuenstliche-intelligenz/aktuelles/praesentation-der-normungsroadmap-ki--771532 (german)

Relevant existing national and international standards and guidelines are outlined below:

National

- DIN SPEC 92001-1: Artificial Intelligence - Life Cycle Processes and Quality Requirements - Part 1: Quality Meta Model
- DIN SPEC 92001-2: Artificial Intelligence - Life Cycle Processes and Quality Requirements - Part 1: Robustness
- DIN SPEC 13266: Guideline for the development of deep learning image recognition systems
- DIN SPEC 91426: Quality requirements for video-based methods of personnel selection
- DIN SPEC 2343: Transmission of language-based data between artificial intelligences - Specification of parameters and format
- VDI/VDE/VDMA 2632: Machine vision (requirements specification, acceptance)
- VDE-AR-E 2842-61-1: Development and trustworthiness of autonomous/cognitive systems - Part 61-1: Terms and concepts
- VDE-AR-E 2842-61-6: Development and trustworthiness of autonomous/cognitive systems - Part 61-6: After release of the solution

International

- ISO/IEC 20546: Information technology – Big Data – Overview and vocabulary
- ISO/IEC TR 20547-2: Use Cases and derived technical considerations
- ISO/IEC FDIS 20547-3: Reference architecture
- ISO/IEC TR 20547-5: Standards roadmap
- ISO/IEC NP 4213: Information technology —Artificial Intelligence —Assessment of classification performance for machine learning models
- ISO/IEC 24029-2: Artificial Intelligence (AI) —Assessment of the robustness of neural networks — Part 2: Formal methods methodology

In Germany, the **General Data Protection Regulation (GDPR)** applicable in the EU has been extended by the **Bundesdatenschutzgesetz (national federal data protection act, BDSG)**, the current version of which has been in force since 2018. In Germany, special attention must be paid to the handling of personal data, if such data is to be used for the implementation of AI applications. Examples include first names, surnames, pseudonyms, addresses, photos, video recordings, sound recordings, movement data, gender, age and weight of individuals.

In the context of Industry 4.0, standards have recently been established in Germany, which provide uniform interfaces for different equipment manufacturers. In future, these should greatly simplify the integration of new technologies such as AI applications into existing infrastructures. For example, **OPC Unified Architecture (OPC UA)** is being developed and implemented in industry as a standard for platform-independent and service-oriented data exchange. A focus is placed on the self-description of devices, whereby the necessary semantics are defined in various committees for specific contents (e.g. robotics, food processing technology). **Message Queuing Telemetry Transport (MQTT)** represents another relevant standard for machine-to-machine communication (M2M). Work is also currently underway on the combination of data standards such as OPC UA and **Time-Sensitive Networking (TSN)**, with a focus on real-time communication.