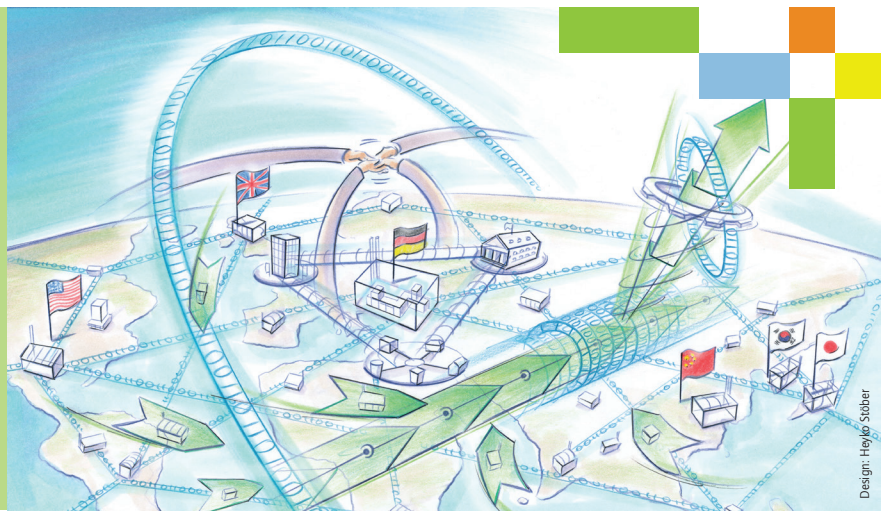


Industrie 4.0 in a Global Context

Strategies for Cooperating with International Partners

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The transformation of the economy being brought about by Industrie 4.0 means that, in the future, business processes such as supply, manufacturing, maintenance, delivery and customer service will all be connected via the Internet. The resulting highly flexible value networks will require new forms of cooperation between companies, both nationally and globally. There is still considerable uncertainty regarding the areas in which German businesses should engage in this kind of cooperation – despite the potential synergies and competitive advantages there is also concern about the possible loss of know-how and value-added. This study analyses the opportunities and challenges of international cooperation in the field of Industrie 4.0. It is based on more than 150 interviews and discussions with experts from Germany, China, Japan, South Korea, the UK and the US. The latter

five countries are set to become important future suppliers of Industrie 4.0 solutions and are therefore potentially attractive cooperation partners for Germany.

Opportunities and threats of Industrie 4.0

The experts interviewed in the study considered the **holistic conceptual basis** of the term Industrie 4.0 to be its key strength. It serves as an important model to global operating companies for the vertical integration of smart machines, products and production resources into flexible manufacturing systems and their horizontal integration into cross-industry value networks. Accordingly, all the countries included networking and digitalisation as the priority themes for Industrie 4.0.

At a glance

- Experts from the leading industrialised nations see Industrie 4.0 as a major opportunity in terms of competitiveness, domestic manufacturing and new business.
- International norms and standards are an essential requirement to ensure interoperability between different systems.
- Their development will require close international cooperation between businesses and institutions.
- German companies are sought-after partners for Industrie 4.0. Flexible cooperation with global pioneers will enable them to enhance their know-how, take advantage of business opportunities and play their part in shaping the dynamic Industrie 4.0 market.
- Germany is currently lagging behind with regard to data-driven business models and the development of large platform ecosystems.

Against this background, the six countries all agreed that the greatest economic opportunities of Industrie 4.0 lie in **production optimisation**. The experts from all the focus countries expected the resulting productivity gains to significantly increase their **global competitiveness** and strengthen manufacturing industry in their respective nations.

However, there are differences in terms of how they rated the other opportunities associated with Industrie 4.0. In Germany in particular, the focus is on integrating information, communication and manufacturing technologies in smart, self-organising factories. In the US and increasingly also China, on the other hand, Industrie 4.0 is strongly associated with smart products, Internet platforms and the **new business models** that are based on them.

In the US, Silicon Valley Internet companies, innovative start-ups and financially strong, globally networked venture capital providers have all understood the significant business opportunities provided by the emerging **platform economies**. They are making targeted inroads into the global markets for Industrie



4.0 solutions and are shaping the future of these markets. In China, the government initiatives *Made in China 2025* and *InternetPlus* establish a contextual link between networking, integration and the accompanying new business models. The size of China's domestic market and the fact that it is relatively closed to the outside world provides Chinese platform operators with a favourable environment to rapidly grow their domestic market in order to generate the critical mass of customers and complementary products needed to fuel a subsequent global expansion.

As a result, German companies are encountering emerging **digital ecosystems** around Industrie 4.0 platforms, as well as **network and lock-in effects**. These are some of the key challenges facing Germany as it strives to secure a long-term position as one of the leading global players in the emerging Industrie 4.0 platform economies. Furthermore, the strong competition from the US and increasingly also China is focusing attention on the **size of Germany's domestic market** as an institutional influence on the ability of platform operators to expand globally.

At the same time, the experts from Germany and the US – the two countries that are currently the leading suppliers of Industrie 4.0 solutions – highlighted the **risk of developing products that lack market relevance**. In addition, all the countries in the survey were concerned about **data security** and **data sovereignty**. If Germany wishes both to lead the way in actively shaping the future of Industrie 4.0 and to enable early adoption in businesses, it will need to work internationally to promote norms and standardisation so that a common international infrastructure can be created.

The benefits of standardisation

The standardisation of architectures, data exchange formats, semantics, vocabularies, taxonomies, ontologies and interfaces is key to creating interoperability between the different technologies involved in a complex and extremely heterogeneous field like Industrie 4.0. The experts who took part in the study did not focus on any one particular standard. What matters is for whichever standards are settled on to be adopted on a widespread basis in order to enable the creation of **interoperable systems that can be flexibly integrated**.

The experts from all the countries in the survey agreed that because it is such a complex field **there will not be one single**

Industrie 4.0 standard. Instead, the next few years will see the emergence of numerous standards, some of them highly specialised, enabling interoperability in and between all manner of different systems.

One focus of German and international standardisation initiatives should therefore be on semantic interoperability and standard data formats, as well as metadata, vocabularies and domain models. The experts from Germany and Japan also considered reference models to be important, whereas the Chinese experts regarded the introduction of a standard Industrie 4.0 vocabulary as a top priority.

In this context, two of the key issues that need to be addressed by standardisation are **interoperable interfaces** between solutions from different manufacturers and the establishment of **open standards**. The experts felt that these are essential for the emergence of open, flexible and successful ecosystems spanning not only different manufacturers but also different countries and continents.

According to the experts, if the appropriate solutions are not developed there is a danger that isolated, proprietary stand-alone or silo solutions could emerge. This would expose purchasers of Industrie 4.0 solutions to the **risk of technological lock-in**, resulting in technological dependence and high costs if they wished to switch to a different solution. For small and medium-sized Industrie 4.0 suppliers that do not control the market, open standards increase its potential both in terms of the number of customers for their products and the demand for complementary products. Open systems are thus of particular importance to **small and medium-sized enterprises** whose relatively limited influence makes them more reliant on the existence of interoperable systems for accessing what is potentially a very large market.

These standards are developed by organisations that work closely with industry in order to efficiently address and close the technology gaps and requirements that it identifies. German standardisation organisations should engage more closely with the **international consortia** that play a key role in this area. The Industrial Internet Consortium (IIC) and the associated Object Management Group (OMG) occupy a prominent global position in the dynamic and diverse international standardisation organisation landscape. Germany has an excellent international reputation thanks to the developments and



initiatives that it has already undertaken in the field of Industrie 4.0, such as Bitkom, DIN, DKE/VDE, VDMA and ZVEI. It is thus very well placed to engage in further international cooperation in the area of standardisation.

In view of the race that is currently underway to establish international norms and standards as quickly as possible, many of the experts in the survey – particularly those from Germany and South Korea – believed that standardisation work is currently progressing too slowly. However, they also stressed the fact that the highly complex nature of Industrie 4.0 and the need for extensive committee work have a strong impact on the **speed at which standardisation progresses**. The experts felt that closer international cooperation between companies, associations and policymakers is required in order to give current standardisation activities greater impetus.

The meaning of cooperation in Industrie 4.0

The international competition with regard to the establishment of norms and standards for Industrie 4.0 means that close cooperation is required between businesses and institutions. The experts from all the countries in the survey identified networking and digitalisation as the key technology areas where a need for cooperation exists. They attached particular importance to data acquisition/transmission, networking, data processing/analysis and interfaces. The experts identified different ways of cooperating in order to drive norms and standardisation and develop innovative Industrie 4.0 solutions in these areas: industry-specific and cross-industry cooperation, cooperation with suppliers and with competitors and cooperation with global corporations and innovative startups.

The experts considered the most effective instruments to be **testbeds** for the development of prototypes and the pragmatic implementation of new solutions, together with industry-specific integration platforms for facilitating the widespread adoption of solutions. Both Germany and in particular the US place greater emphasis on testbeds, while China, Japan and South Korea additionally focus on industry-specific integration platforms.

However, the main difference in focus is not so much between individual countries as between large, global **corporations and SMEs**. Because of the extensive resources at their disposal, large corporations are able to participate in a variety of

international standardisation organisations and networks. Testbeds are thus a good way for them to cooperate with other large corporations, SMEs and start-ups. They allow Industrie 4.0 innovations to be **rapidly and pragmatically** transformed into commercially viable solutions. The corporations then disseminate the technical standards established in the testbeds across their extensive networks of suppliers and customers. Consequently, it is important to ensure that German corporations engage in the latest international standardisation debates from an early stage.

As well as testbeds, industry-specific platform solutions can help SMEs in particular to reduce **investment risks**, benefit from synergies in the establishment of standards and successfully communicate standards to their customers. Academic organisations and the relevant associations can play a valuable role in orchestrating cooperation on industry-specific integration platforms.

Overall, the experts who took part in the survey expected cooperation to **enhance know-how**, especially with regard to data security and business models, reduce development times and prevent redundant solutions. Germany and Japan were particularly keen on the idea of an international dialogue on data-based business models, not least because of the threat of US and Chinese platform providers dominating the market in the medium term. China, South Korea and Japan also identified a need for cooperation in the areas of R&D and training and professional development. On the whole, the respondents from the US and the UK rated government cooperation initiatives as less important.

The experts cited **data security** and a potential loss of know-how as the greatest threats to the establishment of integrated systems. On the whole, however, the potential risks are not enough to prevent most companies from engaging in cooperation. In particular, cooperation is seen as an important way of preventing Internet companies from stealing a march on traditional manufacturing industry in the Industrie 4.0 transformation.

In order to stay abreast of the dynamic developments in this area, many companies – especially large corporations – are currently actively involved in a variety of Industrie 4.0 organisations and initiatives. The main benefits that they hope to achieve through this involvement relate to **interoperability and innovation**.



According to the experts, the most important requirements for engaging in cooperation are **contracts** and the formulation of **ground rules**. Moreover, they believe that cooperation should take place in simple, international company networks. Academic institutions and the relevant associations should also be included so that they can contribute their expertise and views. A well-coordinated approach with separate responsibilities for each partner is seen as important for building trust among the different companies and countries whilst at the same time providing them with the freedom to decide how they go about addressing the technical, business and organisational challenges of a highly dynamic field like Industrie 4.0.

Status quo of Industrie 4.0 in different countries

Germany



In Germany, the term Industrie 4.0 describes a strong, technology-based vision of the future. The focus is on optimising production processes in terms of quality, price and flexibility and delivering better financial returns overall. The strategic goal is to maintain Germany's traditionally strong position in manufacturing and mechanical engineering throughout the digital transformation. The development of new business models and smart products is considered to be less important.

Because of its strength in the fields of automation and factory equipment, German industry has taken on a key role in the development of Industrie 4.0 – not only through its large corporations, but particularly through its globally successful SMEs. Germany's excellent international reputation in this field means that it is well placed to engage in ongoing international cooperation initiatives, several of which are already up and running. In general, it is recommended that cooperation should focus on Japanese and US firms from the information and communication (ICT) industry with particular expertise in Internet technologies. Meanwhile, South Korea and China are

both promising markets for German products owing to their high demand for manufacturing technology.

A top-down approach to standardisation predominates in Germany, led by government, pioneering companies and academia. Companies collaborate closely with the research community and their activities are coordinated by organisations such as the Plattform Industrie 4.0 with the aim of achieving a dialogue-based consensus. However, if this process takes too long, there is a danger that Germany could fall behind its global competitors over the medium term. Overall, the speed of standardisation is rated much more negatively in Germany than in other countries, while the expectations regarding reference architectures and standard programming interfaces (APIs) are significantly higher.¹

General dos & don'ts

- **Build on the strong Industrie 4.0 brand:** Continue to strengthen the international dimension of German Industrie 4.0 activities in order to benefit more from the high interest shown by countries around the world in German-made Industrie 4.0 solutions.
- **Use international standardisation as a catalyst for cooperation:** German industry should become more involved in the leading international standardisation organisations and seek to take on an active leadership role.
- **Create stronger links between innovation centres:** Promote collaboration between innovation centres in order to facilitate cooperation between businesses and researchers from different countries.
- **Make sure that the benefits of Industrie 4.0 do not seem too abstract:** Pursue a dual approach that pushes ahead with the development of an integrated Industrie 4.0 strategy whilst at the same time developing pragmatic, high-profile solutions.

1 | The conclusions were formulated from a German perspective.



China



The Chinese manufacturing landscape currently is extremely heterogeneous in nature. On the one hand, there are a handful of major global corporations (e.g. Huawei, Sany and Haier) that possess advanced and in some cases highly automated factories. On the other hand, there are large numbers of SMEs in which almost no automation or digitalisation has occurred – indeed, many of them are still only just starting to introduce computer-integrated manufacturing. The Chinese government recently adopted the *Made in China 2025* strategy with the aim of fully modernising the country's manufacturing industry. Industrie 4.0 is seen as a key enabler of these efforts to catch up with other nations. Industrie 4.0 is therefore being heavily promoted and China has explicitly expressed its desire to engage in cooperation, particularly with Germany.

There are numerous opportunities for Germany in the short to medium term. China is a promising market for upgrade technologies such as industry software and automation technology. Moreover, the Chinese market's high implementation speed can be used by German organisations to develop their own Industrie 4.0 solutions and promote the widespread adoption of the associated norms and standards. Over the longer term, however, the planned transformation of the Chinese economy is also set to turn China into a serious competitor.

Dos & Don'ts for China

- **Use China as a multiplier for German standards:** Implement German beta standards in Sino-German cooperation initiatives in order to improve their chances of being adopted worldwide.
- **Supply China with automation equipment:** Take advantage of the opportunities to sell Industrie 4.0 solutions to the Chinese market.
- **Make the most of the opportunities in the sustainable technologies market:** Promote environmentally sustainable Industrie 4.0 solutions in order to make the most of the Chinese government's green manufacturing initiative.
- **Approach Beijing via the provinces:** Take account of the high regional diversity and extensive

political powers of the provincial governments and seek to enter the Chinese market via selected provinces.

- **Enter with strong partners:** SMEs should enter the market in partnership with established companies and take advantage of their local infrastructure.
- **Weigh up the investment risks:** Be aware of the fragile regulatory framework and ensure that investment decisions are accompanied by an exit strategy.

Japan



Industrie 4.0 is already very advanced in Japan. As in Germany, manufacturing industry has a long-standing tradition in the Japanese economy. Industrie 4.0 is thus both an opportunity for Japan and a challenge in terms of how the digitalisation of industry is managed. A modular technology stack² and the relevant standardisation of Internet technologies are regarded as important, particularly for new business models. As far as existing business models are concerned, standardisation is explicitly ruled out in some areas. The Japanese government and various private business initiatives are driving standardisation in the field of Industrie 4.0, even though they have different views on these aspects.

Dos & Don'ts for Japan

- **Develop integration solutions for the Japanese market:** Gain an overview of the system landscape at the different levels of the value-added process and discuss integration solutions down to the sub-supplier level.
- **Integrate robotics with human factors and ergonomics:** Promote cooperation in the fields of robotics and human factors and ergonomics and take advantage of Japanese expertise in data-focused technologies.
- **Drive cooperation on data-based process optimisation:** Engage in pilot projects with

2 | In this context, "technology stack" refers to a group of technologies that, while separate from each other, are nonetheless developed in close coordination. One example is the web technology stack that incorporates e.g. coordinated protocols for exchanging (HTTP) and representing (HTML) information.



relevant partners in order to take advantage of Japanese expertise in the field of process optimisation.

- **Cooperate flexibly in initiatives:** Bearing in mind the complex Industrie 4.0 landscape in Japan, avoid creating bottlenecks and ensure that cooperation initiatives with Germany are decentralised.
- **Implement the sensei principle in technology solutions:** Develop a thorough understanding of the role of the sensei (teacher/master) and integrate this approach into the German Teaching & Learning Factory concept.

South Korea



South Korea's economy is characterised by global, hierarchically structured conglomerates ("chaebols") in the high-tech and mechanical engineering sectors (e.g. Samsung, Hyundai and LG). Many SMEs are highly dependent on these conglomerates. The benefits of Industrie 4.0 are widely recognised in South Korea. The government has launched a nationwide project primarily aimed at helping SMEs to boost their production capacity through the use of smart factory technologies. The goal is to establish up to 10,000 more productive factories by 2020 through partnerships between business, the relevant organisations and government. These measures are a response to the growing pressure on the South Korean economy due to the improving quality of Chinese manufacturing.

As well as productivity gains, South Korea also believes that Industrie 4.0 can deliver economic benefits through new, data-driven business models, e.g. in the field of smart cities where it is already a global leader. As far as standardisation is concerned, the government is keen to engage in international cooperation and to involve the private sector. South Korean industry is calling for rapid standardisation solutions to enable interoperability. The pronounced focus on increasing productivity and the established tradition of cooperation with Germany mean that there is an opportunity for German businesses to target South Korea more strongly as a market for their Industrie 4.0 solutions. Cooperation with the large conglomerates should facilitate access to the South Korean SMEs, enabling the widespread establishment of standards across several different industries.

Dos & Don'ts for South Korea

- **Use the chaebols as a route into the market:** Seek to cooperate with global conglomerates that bring together several value chains and suppliers under one roof.
- **Recognise SMEs as an important target market:** Identify relevant SME customers that are investing heavily in Industrie 4.0 solutions under the government's *Smart Factory Initiative*.
- **Transfer know-how from the consumer sector:** Take advantage of South Korean companies' strengths in data-driven business models and establish joint cooperation projects on smart services.
- **Establish cooperation structures for German and South Korean start-ups:** Use South Korea's highly developed innovation centres as a point of contact for accessing the local start-up scene network.
- **Recognise the opportunity for IT security projects provided by South Korea's foreign policy environment:** Draw on the established tradition of cooperation between Germany and South Korea to develop Industrie 4.0 security solutions in conjunction with partner companies.

United States



In the US, Industrie 4.0 is generally included under terms such as the Internet of Things, smart production or the Industrial Internet. Consequently, it is understood to have a much wider meaning than in Germany, encompassing not only the technological dimension but also the development of the new business models (smart services) that are coming about as a result of Industrie 4.0 (e.g. in the field of big data analytics). Silicon Valley firms in particular are hopeful that the transition to a network economy will provide export opportunities for sensor and wireless technologies. Overall, the US rates the opportunities associated with Industrie 4.0 as far more significant than the possible risks.

Industrie 4.0 is being driven by private sector consortia, chief among them the Industrial Internet Consortium (IIC) founded by General Electric (GE). The IIC coordinates initiatives to create ecosystems connecting physical objects with people, processes



and data. It aims to guarantee interoperability through reference architectures, frameworks and open standards. Rather than regarding each other as competitors, the various consortia that exist in the US see Industrie 4.0 as a collective endeavour. Companies domiciled outside of the US already account for the majority of their members. The risk for Germany is that these US consortia could rapidly establish “quasi-standards” and steal a march on German companies in the field of standardisation. Germany has an excellent reputation in the US as a potential cooperation partner.

Dos & Don'ts for the US

- **Continue to strengthen trade relations in the field of Industrie 4.0:** Make the most of the traditionally strong trade relations between Germany and the US and capitalise on the reindustrialisation of the American economy.
- **Don't lose control over Industrie 4.0 business models:** Ensure that future business models form an integral part of long-term corporate strategies and that control over them is not lost when cooperating with software firms.
- **Focus on Industrie 4.0 platforms:** Create a level playing field for cooperation with the large US Internet companies by establishing industry-specific platforms for SMEs.
- **Actively manage ideas and talent:** Engage in active ideas and talent management through strategic partnerships with US companies and applied research institutions.

United Kingdom



British companies recognise the potential of Industrie 4.0. The government is promoting reindustrialisation in order to rebalance the British economy and reduce its dependence on volatile financial markets. Although there is still no coherent national innovation plan, individual programmes are already up and running. The current strategy is centred on innovation centres in a variety of different fields, known as “Catapults”. The Catapults provide a dedicated environment where businesses and researchers can work together to develop innovative commercial Industrie 4.0 solutions.

Dos & Don'ts for the UK

- **Get involved with innovation centres (Catapults):** Use the Catapults as testbeds for innovative Industrie 4.0 solutions and for cooperating with other businesses and research institutions in the UK.
- **Observe non-manufacturing sectors with a view to know-how transfer:** Identify technologies and business models in highly-developed British sectors such as smart education and smart infrastructure in order to benefit from know-how transfer.
- **Use British services expertise to develop smart services:** Take advantage of the UK's large service sector and British e-commerce expertise by cooperating with companies and research organisations to develop smart services.



Outlook for Industrie 4.0

The vision of Industrie 4.0 has had a dynamic impact on innovation policy both in Germany and in other countries around the world. Close cooperation between businesses, the trade unions, the relevant associations, academia and government has increasingly allowed the vision to be conceptualised, refined and implemented. In the past few years, several companies in Germany have established new factories and a competence centre network modelled on Industrie 4.0 projects such as the smart factory and learning factory. As a result, Germany is currently around two to three years ahead of other countries in the field of Industrie 4.0. Assuming that the relevant actors work together, it should be possible to achieve the targets for 2030 set out in the *INBENZHAP* project which describes the probable scenario of an Industrie 4.0 economy that strikes the right balance between people and technology and in which government engages effectively. Thanks to its good digital infrastructure, its know-how in the key technology areas and its holistic understanding of value creation, Germany is a leading global player in this field. However, companies from other countries around the world are taking rapid action to close the gap. Consequently, specific measures are required to ensure the long-term success of Industrie 4.0 in Germany:

Large, predominantly multinational **corporations** should resist the temptation to promote silo solutions for Industrie 4.0. The financial returns of universal products such as analytics tools for the large volumes of data generated in industrial processes can be increased if these products provide open interfaces that allow integration with solutions from different providers. Corporations would therefore do better to focus on interoperability and on actively supporting international standardisation efforts.

This approach also makes it easier for **SMEs** to enter the market – universal modular products with open interfaces allow them to integrate their own solutions. This benefits both the large corporations by providing them with a wide user base and the SMEs by allowing them to market specialised modules in specific areas. When developing new technologies, it is important to

ensure right from the outset that the relevant business models are developed in tandem, as well as to facilitate global expansion through the targeted development of strategic networks.

Associations play an important role in technology development – both large corporations and SMEs need to be more active on this front. It is important to clearly define which technology areas should be standardised and which are explicitly regarded as proprietary intellectual property by the companies involved. Furthermore, close, long-term and agile cooperation between **business, academia, government and the relevant associations** is essential – both nationally and globally – in order to keep up with the rapid pace of developments in the field of Industrie 4.0. Organisations, trade unions and the relevant associations can also employ showrooms and use cases to provide a targeted demonstration of the technological, organisational and commercial implications of Industrie 4.0 for SMEs. Moreover, cross-industry dialogue formats can be used to enable closer networking across different industries.

Government has a vital role in implementing the recommendations described above. It should use structures such as the Plattform Industrie 4.0 to try and prevent buyer lock-in and encourage these organisations to participate in national and international standardisation activities. Government should also facilitate networking between the relevant associations and promote targeted initiatives involving multiple associations. In addition, it must drive the nationwide expansion of high-performance, high-speed networks (e.g. G5), the expansion of smart networks and the digitalisation of analogue infrastructure. Government also needs to create a binding legal framework that takes account of the right to information and data sovereignty whilst at the same time providing the necessary freedom for the commercial implementation of data-driven business models.

If Germany manages to actively address these challenges and implement the relevant policy measures, it will be able to extend its current lead over other countries and ensure that Industrie 4.0 becomes a lasting success for the German economy and society as a whole.



Study methodology

The acatech STUDY Industrie 4.0 in a Global Context was funded by the Federal Ministry for Economic Affairs and Energy (BMWi). It is based on over 150 interviews with experts from Germany, China, Japan, South Korea, the US and the UK conducted between September 2015 and June 2016. The results were discussed in depth with representatives of government, business, academia and other organisations at a technical workshop. The workshop participants assessed the opportunities and threats of Industrie 4.0 for German industry and drew a number of preliminary conclusions. Current government and private sector initiatives and the opinions of academia and standardisation organisations were also studied in parallel.

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