

# Guideline Industrie 4.0

Guiding principles for the implementation of  
Industrie 4.0 in small and medium sized businesses



Excerpt

in cooperation with



## Editorial



Hartmut Rauen

Innovations, problem-solving expertise and highest quality are key characteristics of the German mechanical engineering industry. That is also what Industrie 4.0 stands for. It is about combining information technologies with production engineering and creating new innovative products and solutions. Without doubt, there are numerous challenges linked to it: data security, technical standards as well as necessary legal frameworks. In addition, there are investments in research, education and training to be made and a strong demand for new business models to be satisfied. As international competition around Industrie 4.0 will increase, we have to face these challenges. There can be no doubt about it.

The German mechanical engineering industry as a provider and user of Industrie 4.0 technologies plays a vital role in this endeavor. It integrates the latest technologies into products and processes and hence asserts its leading position as an enabler. At the same time, it represents a data source for Industrie 4.0: It collects data, interprets it, uses it for innovation and develops new business models. But Industrie 4.0 shall not only be of interest to large companies. It must also be economically viable and beneficial for small and medium sized businesses.

Against this background, the Industrie 4.0 guideline from the VDMA (German Engineering Federation) regards itself as a practical tool for the identification and implementation of company-specific approaches to Industrie 4.0. The VDMA guideline shall also encourage and arouse curiosity to see Industrie 4.0 as an opportunity for the own company.

Many other activities of the VDMA forum Industrie 4.0 also pursue this aim, for example the "Lab Touren I40" that take the visitor on a journey to innovation sites at German universities or the "Forschungskreis I40" which initiates cross-industry research projects in the interest of the VDMA members as part of the Industrial Collective Research (IGF).

Speaking of research and science: Special thanks are due to Prof. Dr.-Ing. Reiner Aderl of Darmstadt University of Technology and Prof. Dr.-Ing. Jürgen Fleischer of the Karlsruhe Institute of Technology as well as to their research assistants for editing this guideline scientifically. In addition, I would like to express my gratitude to the involved VDMA members for their commitment as pilot companies.

The VDMA guideline Industrie 4.0 can therefore also be seen as an example for excellent cooperation and networking of German machine and plant manufacturers.

I wish you all an interesting and inspiring read.



**Hartmut Rauen**

Deputy Executive Director  
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# Guideline Industrie 4.0 – Guidance for German small and medium sized companies



Reiner Anderl

With Industrie 4.0, the fourth industrial revolution has started. Modern information and communication technologies are merging with production technologies to form a new stage of value creation. The availability of information in real time through networking of all partners involved in the entire value-adding process leads to dynamic, real-time optimizing and self-organizing, cross-company value-adding networks.



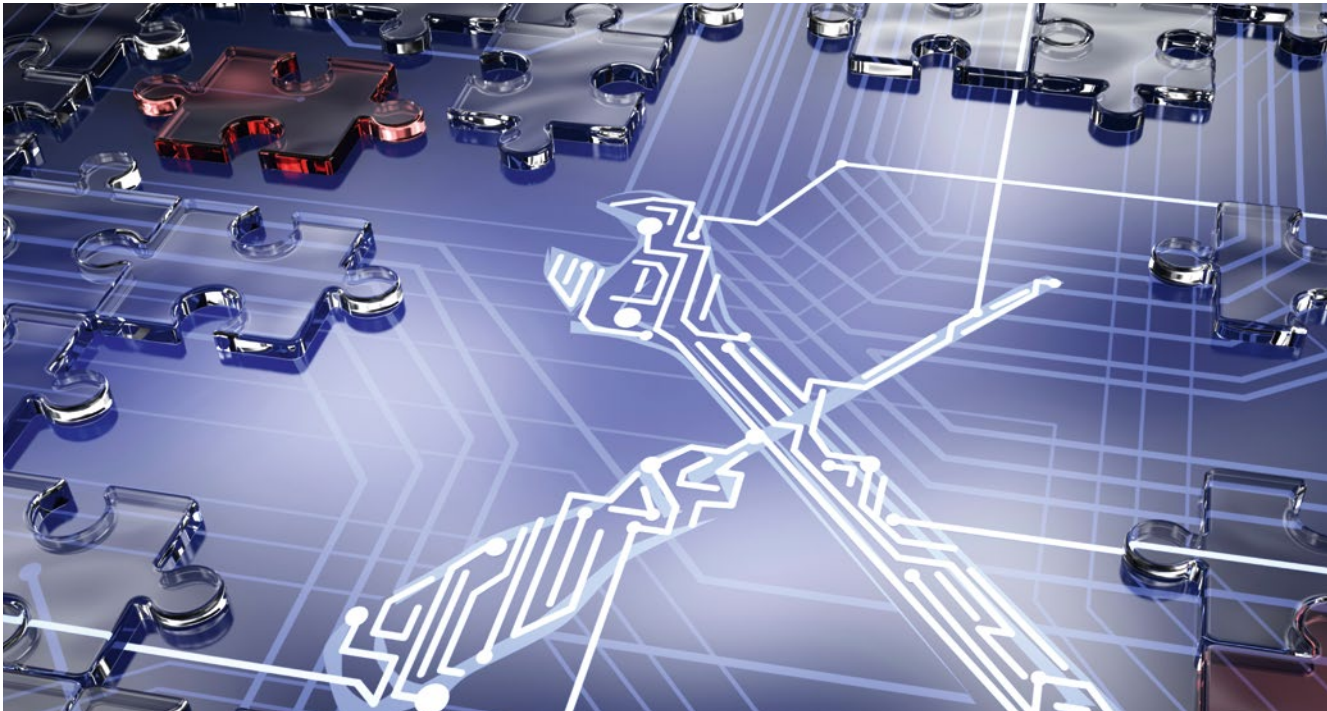
Jürgen Fleischer

The small and medium sized companies in the German mechanical engineering industry are the backbone of German industry. They guarantee growth and prosperity in our society. According to a study of the Commerzbank [1], the majority of companies (86 percent) has recognized the opportunities offered by Industrie 4.0. Nevertheless many of them are still reluctant to introduce solutions.

They are reluctant despite the opportunity that the introduction of Industrie 4.0 solution approaches offers them to respond to the changing conditions of global markets. Ever shorter product and innovation cycles and the increasing predatory competition are only some examples of the challenges that small and medium businesses have to face today. In practical terms, the introduction of Industrie 4.0 means to these companies that they can adapt more individually to the needs of their customers and that they can offer a high variant diversity down to a batch size of 1 at prices close to mass production prices. The approaches of Industrie 4.0 allow to build production networks that produce efficiently and effectively at low costs.

But other sectors are aware of the potential of Industrie 4.0 as well. Companies from the field of information technology are pushing onto markets characterized by production technology. In order to become an innovation and market leader on the global market or to continue to remain it, time is becoming a decisive factor for the introduction of Industrie 4.0.

This guideline should support small and medium-sized businesses of the German mechanical engineering industry in rapidly introducing business models for Industrie 4.0. For this purpose, the guideline describes a procedure model that takes into account the visions around Industrie 4.0 and reduces them to viable



stages of development. The application of these development stages in one's own company helps in finding ideas for new business models, innovative products and improved production. The conception of business models will be carried out in workshops within the company. The guideline presents the structure and the procedure of such a workshop.

This way, the guideline offers guidance to the small and medium businesses of the German mechanical engineering industry to find their own definition of Industrie 4.0, to see the benefit for their company and to be able to specify it in monetary terms.

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## Management Summary

**Many companies regard Industrie 4.0 more as a challenge rather than a chance or an enabler for new business models. Concrete solutions lie as much in the dark as the question what Industrie 4.0 actually stands for. The diversity in the business landscape of the German mechanical engineering industry, however, means that every company has to create its own view of Industrie 4.0 and to develop its own ideas for using the new potentials.**

Therefore, the aim of this guideline Industrie 4.0 is to provide small and medium sized machine and plant builders with a tool for developing their own Industrie 4.0 business models and thus support them in their own Industrie 4.0 implementations. For this reason, the guide does not represent a ready-made strategy for implementing Industrie 4.0 in one's own company. It rather shows tools and procedures for the individual further development of one's own strengths and expertise.

The guideline is divided into five sections: preparation, phase of analysis and creativity, evaluation and implementation of the developed business models. The core forms the realization of an in-house workshop. Its proceeding and methods are presented in detail in this guideline. The practicability of this guideline was tested in four workshops in the pilot companies ARBURG GmbH & Co KG, HAWE Hydraulik SE, SCHUNK GmbH & Co. KG and SMS Group. The experiences gained in these workshops were then again included in this guideline.

The objective of the workshop concept for the companies is to develop their own approaches of business models in the context of Industrie 4.0 with the help of creativity techniques. Core elements are an analysis of the company's initial situation in relation to Industrie 4.0 and the so called "Toolbox Industrie 4.0". The toolbox illustrates different application levels of Industrie 4.0 approaches and breaks them down into single realizable development stages. To support generating ideas in the company, the toolbox is divided into the parts "Products" and "Production".

The workshop concept sees the use of the toolbox in connection with established creativity techniques for generating ideas and business models. Interdisciplinary teams from the respective company develop their own ideas around Industrie 4.0 in individual and group work, assess these and further develop them to create company-specific concepts for business models. It concludes with the transfer of these concepts to projects which can be worked on as part of an individual Industrie 4.0 strategy.

The workshops carried out in the four pilot companies brought up innovative ideas for business models. It was shown that the procedure model can be used successfully for elaborating ideas for business models in the context of Industrie 4.0. Therefore, the guideline offers companies a suitable basis for developing their own concepts within the Industrie 4.0 setting.

## Small and medium businesses turn towards Industrie 4.0

German machine and plant manufacturers are facing the challenge of Industrie 4.0. Numerous companies are not able to see the objectives and the specific benefit of the solution approaches provided by or around Industrie 4.0. They are reluctant to introduce Industrie 4.0 technologies to their own business. However, the solution approaches of Industrie 4.0 offer the very potential to establish new business models through digitalization and cross-linking of products and production. The challenge for small and medium businesses of the German mechanical engineering industry lies in the task of reducing the visions of Industrie 4.0 to viable development stages that show tangible benefits for their own company and are also monetarily quantifiable.

The time factor is decisive when implementing Industrie 4.0 solution approaches. Because information and communication technology is used in production, companies based on information technology are increasingly penetrating the production technology characterized markets. By introducing the Industrie 4.0 solution approaches, German machine and plant builders have a suitable instrument at hand to assert their market position or to expand it even further.

**The time factor plays a decisive role in shaping the fourth industrial revolution.**

### How can Industrie 4.0 be used to earn money?

Industrie 4.0 in itself does not represent any value. The solution approaches of Industrie 4.0 are rather paving the way for new product innovations, product-related services and improved

production processes. This way, on the one hand, Industrie 4.0 can help companies to reduce costs of their own production. And on the other hand, an increase in sales can be achieved through the enhanced usefulness and value of their own products.

### How can the vision of Industrie 4.0 become reality?

Many technologies for the Industrie 4.0 solution approaches are already available. But the benefits of Industrie 4.0 will only unfold with a clever combination of these technologies. Still, many companies are unaware of the road leading to the identification and successful combination of Industrie 4.0 solution approaches. The vision of Industrie 4.0 must be turned into reality.

**The benefit of Industrie 4.0 unfolds with a clever combination of already existing technologies.**

### The guideline will aid orientation

It is for this reason, that this guideline for introducing Industrie 4.0 to small and medium businesses has been developed. It equips companies with a procedure model that helps them to successfully develop innovations in the context of Industrie 4.0 and launch them in their companies.

The guideline primarily addresses the decision makers in small and medium businesses of the German mechanical engineering industry. With this guide they are given a tool that will accompany them step by step in finding their own concepts based on the Industrie 4.0 vision.

## What are the contents of this guideline?

**Industrie 4.0 means change: German small and medium businesses are given the chance to actively participate in shaping this change. This may be achieved by launching new, innovative products but also by improving processes within the company, especially within their own production. Ahead of the introduction of these innovations goes a process that needs to be actively shaped and that takes into account the potentials and peculiarities of the company. The aim is to develop new products, processes, services or business models in general.**

### **Objective of this guideline**

This guideline supports small and medium sized companies of the German mechanical engineering industry in identifying potentials for products and production with a systematic process in relation to Industrie 4.0 and in developing their own specific ideas in this respect. In doing so, the guide describes a suitable procedure for direct application in the company.

**The introduction of Industrie 4.0 starts with a commitment of the senior management.**

### **What is needed for the implementation?**

Industrie 4.0 affects all business units of a company from development and production all the way to service and disposal. Therefore, the commitment to the implementation of Industrie 4.0 needs to be expressed by the top management prior to applying the procedure of the guideline.

The solution approaches of Industrie 4.0 may involve fundamental changes in the production or in designing business models. It is therefore necessary that the decision for implementing Industrie 4.0 solution approaches within the company is taken at the management level and that the projects are staffed accordingly.

The first implementation step is the forming of a suitable project team. The interdisciplinary project team should consist of employees from production and information technology as well as from the development division. This is especially vital when generating ideas around Industrie 4.0 that require close networking between information technology and engineering sciences.

### **The Toolbox Industrie 4.0**

A key element of the guideline is the Toolbox Industrie 4.0 (pages 11 to 16). This toolbox combines the different application levels of Industrie 4.0 in reference to product innovations and production-related technical applications. The application levels are each broken down into five technological and sequential development stages. The Toolbox Industrie 4.0 becomes the starting point for classifying the fields of expertise offered by the company and thus serves as a basis for new ideas in the course of an Industrie 4.0 implementation process.

### **How is this guideline structured?**

This guideline is to be understood as a chronologically arranged procedure model. To check its practicability the procedure was tested in four workshops in the following pilot companies: ARBURG GmbH & Co KG, HAWE Hydraulik SE, SCHUNK GmbH & Co. KG and SMS group. The experience gathered was included in the further development of this guide.

Toolbox Industrie 4.0		Industrie 4.0				
Products						
Integration of sensors / actuators						
	No use of sensors/actuators	Sensors / actuators are integrated	Sensor readings are processed by the product	Data is evaluated for analyses by the product	The product independently responds based on the gained data	
Communication / Connectivity						
	The product has no interfaces	The product sends or receives I/O signals	The product has field bus interfaces	The product has Industrial Ethernet interfaces	The product has access to the internet	
Functionalities for data storage and information exchange						
	No functionalities	Possibility of individual identification	Product has a passive data store	Product with data storage for autonomous information exchange	Data and information exchange as integral part	
Monitoring						
	No monitoring by the product	Detection of failures	Recording of operating condition for diagnostic purposes	Prognosis of its own functional condition	Independently adopted control measures	
Product-related IT services						
	No services	Services via online portals	Service execution directly via the product	Independently performed services	Complete integration into an infrastructure of IT services	
Business models around the product						
	Gaining profits from selling standardized products	Sales and consulting regarding the product	Sales, consulting and adaption of the product to meet customer specifications	Additional sale of product-related services	Sale of product functions	

Toolbox Industrie 4.0		Industrie 4.0				
Production						
Data processing in the production						
	No processing of data	Storage of data for documentation	Analyzing data for process monitoring	Evaluation for process planning / control	Automatic process planning / control	
Machine-to-machine Communication (M2M)						
	No communication	Field bus interfaces	Industrial ethernet interfaces	Machines have access to internet	Web services (M2M software)	
Company-wide networking with the production						
	No networking of production with other business units	Information exchange via mail / telecommunication	Uniform data formats and rules for data exchange	Uniform Data formats and inter-divisionally linked data servers	Inter-divisional, fully networked IT solutions	
ICT infrastructure in production						
	Information exchange via mail / telecommunication	Central data servers in production	Internet-based portals with data sharing	Automated information exchange (e.g. order tracking)	Suppliers / customers are fully integrated into the process design	
Man-machine interfaces						
	No information exchange between user and machine	Use of local user interfaces	Centralized / decentralized production monitoring / control	Use of mobile user interfaces	Augmented and assisted reality	
Efficiency with small batches						
	Rigid production systems and a small proportion of identical parts	Use of flexible production systems and identical parts	Flexible production systems and modular designs for the products	Component-driven, flexible production of modular products within the company	Component-driven, modular production in value-adding networks	

Figure 1: Toolbox Industrie 4.0

The procedure in this guide is divided into five process steps. These process steps have to be accompanied by a project team that is also responsible for the preparatory work and organization of the workshop. The procedure illustrated in figure 2 starts with a period of preparation. In this preparation phase, a suitable starting basis for companies to develop their own ideas in the Industrie 4.0 setting is created. Building on that, in a subsequent analysis phase the company's fields of expertise are identified and presented in a comprehensible way. Based on this analysis and the development potentials derived therefrom, in the following creativity phase ideas relating to products and production are generated in an in-house workshop. The workshop has to be perceived as a key element of this guide's procedure model. It helps to

elaborate and assess the ideas for introducing Industrie 4.0. To this end, the participants are informed about the results of the analysis phase and brought up to the same level of knowledge during the workshop. Afterwards they purposefully develop concepts for business models. In the following evaluation phase, the participants evaluate these concepts in terms of their market potential and the necessary resources for their implementation.

The approach of the guideline will be presented in detail in the following sections.



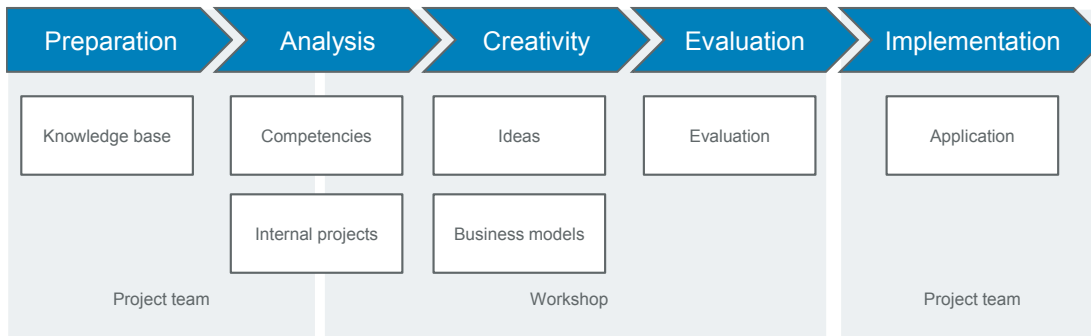


Figure 2: Structure of the guideline

### Preparation phase

An in-depth knowledge of the relevant market or of one's own production respectively is the starting point for elaborating product ideas and improving production. A solid knowledge base of all participants of the workshop in the matters related to Industrie 4.0 will also support the later development of ideas. It is therefore the objective of the project team to create a common understanding of the subject Industrie 4.0 within the company.

**The workshop brings together the know-how of different departments and specialist areas. It is the key element for a creative elaboration of concepts for business models.**

### Analysis phase

The analysis phase aims at identifying the expertise available in the company concerning Industrie 4.0 technologies. For this purpose, the market position of the company and the company's own expertise regarding Industrie 4.0 are ranked in this phase. This ranking is confronted with the outside image of the company.

The analysis of the competencies or fields of expertise in this respect is carried out for the products as well as for the production. It is inspired by the application levels and development stages of the Industrie 4.0 toolbox. The result is a first starting basis for the later idea generation.

### Creativity phase

The aim of the creativity phase is the generation of new ideas and the subsequent elaboration of concepts for business models. The implementation will be realized on the basis of the fundamentals created in the analysis phase in a process consisting of two stages. In the first part of the process, the participants of the workshop identify and collect initial ideas. These ideas will then be discussed and further developed in the second part. At the end of this period, business models related to Industrie 4.0 have been developed into concepts.

### Evaluation phase

The objective of this phase is the assessment of the previously elaborated concepts for business models. For this purpose, the participants classify the concepts for business models elaborated in the workshop according to their market potential or to their potential for production respectively as well as according to the required resources for implementation. The aim is to identify business models with a high potential and a low resource input or a valuable utilization of the company's strengths.

### Implementation phase

Finally, the project team draws up the generated proposals and prepares them for further examination or for presenting them to the company management. This way the results of the workshop can be transferred to suitable projects for practical implementation.

## Industrie 4.0 in the VDMA

The VDMA Forum Industrie 4.0 consists of an interdisciplinary team of VDMA experts that regard themselves as partners and service providers. They support the member companies in the fields of action relevant to Industrie 4.0.

### Politics & Networks

On the road to becoming a leading market and leading supplier of Industrie 4.0, essential conditions need to be agreed upon with political and societal representatives. In order to lead Germany as an industrial location into the future, high requirements in the fields of research and development, education and qualification, norms and standards, legal and IT security need to be complied with.

### Production & Business Models

Industrie 4.0 places high value on networking in production by using modern internet technologies. The objective is to facilitate communication between the operating equipment, products and its components to guarantee efficient and customer-specific production processes. Automation and products of batch size 1 will no longer be mutually exclusive. The potential for networking and customer-specific production resides in innovative business models covering the entire product life cycle – from conception to disposal.

### Research & Innovation

When implementing Industrie 4.0, the success in international competition and the competitiveness of industrial Germany mainly rests upon the research findings. Particularly important are reliable funding tools in the research area of production and ICT as well as the consideration of the requirements of the sector machinery and plant engineering mainly operated by small and medium sized companies. Major factors of success lie in the networking of all players and quickly transferring the research findings to all partners active in industrial operations.

### Norms & Standards

Industrie 4.0 allows cross-company networking and integration of various value-added networks. For this purpose, norms and standards are of fundamental importance since they define the mechanisms of cooperation and the information to be exchanged. It is thus essential to take part in the process of standardization and the shaping of open standards for the purpose of building a reference architecture and to engage all players in an active dialogue.

### IT Security & Legal Affairs

In the context of Industrie 4.0, IT security is imperative for the secure operation of cross-company manufacturing processes. Automated data exchange of networked systems must be secure and reliable. It is crucial to control the identification of the process players and to protect the know-how of products, machines and plants.

In the field of Industrie 4.0, legal repercussions can already be detected. Consequently, existing legislations need to be further developed and newly interpreted. This endeavor will constitute a central task when it comes to implementing Industrie 4.0 and incorporating it into the daily business of companies.

### People & Work

Industrie 4.0 will fundamentally change work and processes. In the future, the factory employees will have to take on more responsibility when it comes to coordinating processes, steering communication and taking autonomous decisions. The tasks will be more challenging, technologically as well as organizationally, and interdisciplinary competences will gain in importance. The authorities, educational establishments and companies will have to adjust to these challenges.

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