Industry 4.0 – a revolution in work organization

How automation and digitization will change production

Client
Ingenics AG

Compiled by
Fraunhofer Institute for Industrial Engineering IAO, Stuttgart
PUBLISHING INFORMATION

This study was carried out by the Fraunhofer Institute for Industrial Engineering IAO

Published by: Ingenics AG
Headquarters
Schillerstrasse 1/15
89077 Ulm, Germany
Tel.: +49 731 93680-0
kontakt@ingenics.de
www.ingenics.com

Director: Professor Dr.-Ing. Wilhelm Bauer

Authors: Dr. Sebastian Schlund, Moritz Hämmerle, Tobias Strölin

Contact: Fraunhofer Institute for Industrial Engineering IAO,
Nobelstrasse 12, 70569 Stuttgart, Germany
www.fraunhofer.de/lang-en/

Dr.-Ing. Sebastian Schlund
Tel. +49 711 970-2065, Fax -2099
sebastian.schlund@iao.fraunhofer.de

Copyright: Ingenics AG and Fraunhofer IAO, 2014

Cover image: © Alexandra Ignatyeva/shutterstock.com

This document and all its component parts are protected by copyright. Any use beyond the narrow limits of the German Copyright Act is not permitted without the written permission of the authors and may be punished.

Note: In cases where the text refers to people, the wording used is intended to include both sexes, even if for the sake of readability only the masculine form is mentioned.
## CONTENTS

1. Preface ................................................................................................................................. 4
2. Summary ............................................................................................................................... 5
3. Starting point and motivation of the study ........................................................................... 8
4. Implementing Industry 4.0: a challenge for companies, data quality and employees ........... 10
5. High expectations of automation and digitization in order processing ............................... 14
6. Impact on work organization .............................................................................................. 18
7. Impact on qualification and skills development .................................................................... 24
8. Industry 4.0 – background and objectives .......................................................................... 26
9. Conclusion and outlook ...................................................................................................... 28
10. References ......................................................................................................................... 29
1 Preface

Digitization will change the way we work!

Digitization has already changed the way we work in the area of information management – and in the production area things are set to change profoundly. Lightweight robots, tablet PCs, transponders, sensors and memory are now more affordable than ever before. At least in Germany, “Industry 4.0” seems to have become a generic term that encapsulates these expectations. Although the number and scope of industrial solutions implemented to date do not quite stand up to the promise of a fourth industrial revolution, we can see how people on all sides are working full speed to develop new applications, products and solutions.

Since nobody today believes that such developments will ultimately lead to factories without people, it is time to organize the way we work in line with Industry 4.0. Actual gains in productivity can only be achieved if work processes are adapted and employees at all levels are able to put new technology into use. Action is needed today to qualify the employees of tomorrow and to develop their skills. To this end, we need a picture of future developments based on the very successful current situation of the German manufacturing industry.

The present study provides an outlook on how Industry 4.0 will impact the world of work. It is the result of a survey involving 518 managers in the manufacturing sector. An examination of the results reveals one thing above all else: digitization and automation look set to change the foundation of the world of work as we know it – from issues concerning regulations of flexibility to competence training, management and salary system.

Several important issues concerning job design and work organization must be addressed over the coming years in order to deal with the anticipated changes in a way that German industrial companies will remain suppliers to the world. Together we can do it!

Professor Oliver Herkommer
Chief Executive Officer
Ingenics AG

Professor Dr.-Ing. Wilhelm Bauer
Director of Fraunhofer IAO and
IAT University of Stuttgart
2 Summary

The digitization of the value chain has arrived in German industrial companies. This concept is currently operating under the name of “Industry 4.0” in Germany and it focuses on self-organizing systems with real-time capability. It can be seen in the form of networked production equipment, the higher pervasiveness of IT systems, intelligent work pieces, tools, transport equipment and the use of mobile communication technology.

Together with a new level of automation, people expect improved productivity to the extent that we might talk of a fourth industrial revolution. This is made possible by the lower price of industry-related hardware and software: lightweight robots, tablet PCs, RFID tags and transponders – but also affordable sensor technology and readily available memory in the form of cloud technology, to name one example.

Although such technology may appear very attractive, a truly relevant increase in productivity will only happen if the use of technology translates into more effective and efficient production processes.

Based on a survey of 518 production managers, this study sketches a picture of the extent to which “Industry 4.0” has been implemented in German industrial companies. A central focus is the anticipated impact on job design and work organization.

Here is a summary of the main findings from the study.

Expectations and requirements:

› For production in Germany, **advances in automation** are expected in the coming years. Especially for intra logistics, manufacturing and indirect areas, respondents expect the level of automation to increase greatly over the next five years.

› The topic of “Industry 4.0” goes hand in hand with high expectations. Those surveyed perceive greater added value in **increased supply chain efficiency** (78 %), **order processing** (77 %), **machine networking** (72 %) and the **digitization of shopfloor management** (72 %).
Many companies are already developing the necessary infrastructure for pervasive digitization in production. There is already **reliable wireless Internet coverage in production areas** at 45% of companies and 41% have a broadband connection.

**Extent of implementation in companies:**

- In terms of implementation, “Industry 4.0” has **not yet arrived across the board**. Only 6% of those surveyed believed their company was fully ready for Industry 4.0, whereas 55% of respondents stated work to prepare for Industry 4.0 was not yet under way.
- An Industry 4.0 strategy exists in only 29% of the companies surveyed. In such cases, the company directors are usually responsible for the strategy (53%).
- The main barriers to implementing IT innovations in production are considered to be a lack of ability to change within the organization and insufficient technology. Almost as important for successful implementation are dealings with staff representatives, the protection of employee data and a consideration of the age structure within the company.
- Before the potential of Industry 4.0 can be leveraged, massive investments must be made to secure the already available standard of data quality. Nearly three-quarters of respondents (72%) agree with this statement.

**Job design and qualification:**

- **Industry 4.0 will change jobs in production.** More than half of respondents (51%) expect the introduction of Industry 4.0 to reduce the volume of simple manual work. An increase in the proportion of employees involved in indirect planning and control roles is predicted by 54% of respondents.
- Qualification and skills training for the introduction of Industry 4.0 are considered to be very important by a large number of managers. Especially necessary in this regard are the readiness for lifelong learning (86%), stronger interdisciplinary thinking and behavior (77%) and greater IT skills (76%).
- Companies are already developing **IT skills in production** on a massive scale – especially in the indirect areas (80%), (intra) logistics (75%) and manufacturing (67%).
- With respect to the remuneration system for different skills profiles, 55% of respondents anticipate a more individual form of compensation in the future.
Work organization and participation:

› Employee participation is becoming more dynamic. Exactly half of respondents believe that employee participation will become more difficult due to the levels of freedom on the one hand, but also that it will be made easier by the use of new technology.

› The increasing digitization of work processes makes work results more transparent. Half of respondents expect that employees will nevertheless actively participate in this development while rejecting aspects of individualized performance measurement.

› As a consequence of introducing Industry 4.0 in companies, 63% of those surveyed expect more flexible working time model.

Although it is difficult to predict today which of the dominant concepts and solutions of Industry 4.0 will prevail in practice, all the signs indicate that digitization will have a profound effect on the industrial value chain, just as it did in the area of information management.

In many cases, the basic technical requirements are already met or are currently being implemented by companies. They are fully aware of the need to develop qualifications – both professional and otherwise.

In addition to the implementation of new, efficient solutions, there are major challenges in the area of work organization. Industry 4.0 will change work processes. The ways in which it is allowed to affect flexibility, pay, employee participation and work roles will decide how quickly and to what extent it is implemented – and thus the success or failure of the fourth industrial revolution.
3 Starting point and motivation of the study

Industry 4.0 – this term is associated with expectations of profound changes in industrial production on par with an industrial revolution. For many, the intelligent networking of production systems implied by the term is nothing more than the next logical step in the evolutionary (yet very dynamic) digitization of our economy, our knowledge and our community.

For the present study entitled “Industry 4.0 – a revolution in work organization” the Fraunhofer Institute for Industrial Engineering IAO in Stuttgart interviewed a total of 518 industrial companies in Germany on behalf of management consulting company Ingenics.

The survey took place between July 15 and September 30, 2014, in the form of a questionnaire that was sent by mail and e-mail to production managers and company directors.

The focus was on companies in the automotive industry and in mechanical and plant engineering, who collectively represented just over half of the participants.

In what sector is your company mainly active?

Sample = 518
A third of those surveyed (33 %) work for companies with fewer than 250 employees (SMEs), while 60 % work for a large companies.

Respondents represented businesses of every size and with every degree of automation – from manual to highly automated production. Broadly speaking, the participants were equally divided into groups with manual and primarily manual production (30 %), hybrid production (34 %) and automated or highly automated production (26 %).
4 Implementing Industry 4.0: a challenge for companies, data quality and employees

It will not be possible to achieve the potential level of productivity without changes and investment. In order to meet the expectations associated with Industry 4.0, it is necessary to prepare companies for the developments that lie ahead, to involve those affected and to set up projects geared toward greater automation and digitization in direct and indirect business processes.

4.1 The ability for Industry 4.0 in German companies has to be developed

Today, only 6% of those surveyed believe their company is fully ready for Industry 4.0. In contrast, a 55% majority of companies have yet to begin work to prepare for Industry 4.0.

An explicit Industry 4.0 strategy already exists in only 29% of the companies surveyed. In such cases, the company directors are usually responsible for the strategy (53%). Only 22% of companies have a separate budget dedicated to the issue of Industry 4.0 (ranging from 0.01% to 20% of annual sales).
The limited penetration of Industry 4.0 is surprising given both the extensive media coverage of the subject and the expectations people have concerning its impact in terms of improved efficiency in order processing and supply chain management. It is fair to assume that companies are following other initiatives and using different “headlines” for their involvement and projects when it comes to the intelligent networking of people, machines and objects with real-time capability due to the vague nature of “Industry 4.0” as a term.

4.2 The ability to change within a company is the main obstacle to implementation

The main barriers to implementing IT innovations in production are considered to be a lack of ability to change within the organization and insufficient technology. Almost a third of companies agree with this statement. Equally important for successful implementation are dealings with staff representatives (28 %), the protection of employee data (26 %) and a consideration of the age structure within the company (26 %).
Contrary to expectations, respondents believe that organizational barriers to the implementation of innovative IT solutions in production are as critical as the technical restrictions, or even more so.

4.3 Massive investments are necessary for data quality

Industry 4.0 applications must always be based on up-to-date data that is both accurate and reliable. However, this is not yet available in most cases. Of those surveyed, 72% agree that massive investments must be made to secure the already available standard of data quality before the potential of Industry 4.0 can be leveraged. Some of the challenges in data quality today concern the accuracy, completeness and timeliness of the available master data in ERP and MES systems. Most of these are used offline at present to initiate, monitor and evaluate planning and optimization processes. When it comes to the actual management of production, companies use proven self-regulating systems, such as kanban control cycles. In the future, it is expected that near-real-time planning and control will be performed much more directly by IT systems as a result of increased connectivity. Furthermore,
systems do not yet contain the necessary data that would allow the improved control of business processes, for example information about the exact position of mobile objects, such as tools, work pieces and containers.

**Before the potential of Industry 4.0 can be leveraged, massive investments must be made to secure the already available standard of data quality.**

With regard to the technical requirements, almost half of companies already have reliable broadband and wireless Internet connectivity (45% and 41%). These figures are consistent with the high expectations of policy initiatives in the area of Internet development, especially for industrial companies (Digital Agenda and the German National Broadband Strategy). Companies reveal a somewhat limited infrastructure when it comes to other useful requirements, such as IP-enabled machines (22%), intuitive user interfaces (10%) and indoor positioning systems (7%).

**What basic requirements are already met in your department with respect to the technical infrastructure?**

*The basis for Industry 4.0 in the form of seamless broadband connectivity and available data networks already exists or will be established in the near future. This also applies to production!*
5 High expectations of automation and digitization in order processing

5.1 Automation in production will continue to advance

The automation and digitization of industrial production are closely related to the goal of intelligent networking in Industry 4.0.

With respect to key production processes, more than 70 % of companies anticipate a greater degree of automation in (intra) logistics and production, while 56 % expect increased automation in assembly. Only in the area of quality assurance do fewer than half of the respondents foresee a higher level of automation. It is striking that 69 % assume there will be greater automation in the indirect areas, especially in production planning and control.

This view is shared across all industry segments and company sizes. On the whole, small and medium-sized enterprises with fewer than 250 employees expect an even greater increase in the level of automation in manufacturing and quality assurance as well as in the indirect areas. In contrast, they see slightly less potential for automation in assembly and logistics.
5.2 Quality will remain the key goal for German companies

Alongside the expectations of increased productivity associated with greater levels of automation, quality will continue to play a central role as a key target for German companies. Of those surveyed, 73% believe that the importance of quality-related issues and testing will continue to grow.

Many more respondents expect a higher level of automation in quality assurance than a constantly increasing level of automation in quality assurance (73% versus 49%). One explanation for this statistic is that the processes concerned are either automated already or the relevant quality parameters cannot be thought of in terms of further automation (e.g. visual inspections and haptic tests).
5.3 Automation will increase the proportion of fixed assets

The expected increase in automation is also reflected in assumptions that the proportion of fixed assets in annual sales will grow over the next five years. Of those surveyed, 51% of companies expect an increase in fixed assets. In contrast, 20% predict that the proportion of fixed assets will fall. These views are almost identical for the subgroup of SMEs. Here, too, 51% of companies anticipate an increase in fixed assets.

As a consequence of the expected level of automation, there will probably be more opportunities for suppliers of machines and equipment to establish flexible automation concepts and new forms of machine utilization (e.g. operator models).

5.4 From shopfloor to supply chain – high efficiency gains expected all round

Companies have high expectations of Industry 4.0. Of those surveyed, 78% expect efficiency gains in the supply chain. More efficient order processing is anticipated by 77%.

A high level of potential efficiency is also perceived in the areas of machine networking (72%) and the digitization of shopfloor management (72%). Surprisingly, less potential is seen with respect to more efficient product creation. Only 46% of respondents believe that Industry 4.0 provides significant added value here.
There are high expectations of digitization and automation in industrial production. Companies see significant efficiency potential in this area, especially as regards the horizontal integration of order processing and the entire supply chain.
6 Impact on work organization

6.1 Basic jobs will continue to decline

Industry 4.0 will reduce the amount of simple manual work. This expectation is shared by 51% of those surveyed. At the same time, 54% of respondents predict the number of indirect employees to rise. This is generally consistent with the results of recent studies into the impact of leaps in technology on labor and employment [9], [10], [11]. It is not surprising that the results overlap because expected gains in productivity are usually achieved by replacing manual work [12], [13]. For example, a significant reduction in manual coordination and clarification processes would be expected as a result of intelligent networking in production. [12]

![The implementation of Industry 4.0 will reduce the amount of simple manual work.](chart)

However, the results do point to a contradiction insofar as a high degree of automation in the indirect areas is expected at the same time (Section 4). If there are similar efficiency gains in the direct and indirect areas of production, there is no reason why the proportion of indirect employees in the total workforce should increase dramatically when Industry 4.0 is implemented.

![What will happen to the proportion of indirect employees following the implementation of Industry 4.0?](chart)

With regard to the impact on jobs and work, the production companies surveyed expect a number of positive effects in addition to a reduction in the number of employees performing simple manual labor.
If the expected level of productivity offered by Industry 4.0 can be achieved, today’s factories and value chains will require fewer employees in the future – yet they will operate at the same capacity. This could affect both low-skilled jobs, where simple routine tasks such as inserting and loading objects may become automated and in the area of planning and control, where intelligent networked control systems may take over routine decisions. On the other hand, greater process efficiency could make it possible to manufacture products more competitively. If companies can satisfy higher levels of demand, this would allow them to maintain existing jobs and even to take on additional employees as they grow. There are clearly two sides to the argument that the productivity-enhancing technology of Industry 4.0 will threaten jobs. Indeed, a refusal to adopt Industry 4.0 in Germany may jeopardize jobs to a much greater extent if competitors from abroad have the upper hand and begin to occupy leading roles in German production companies.

6.2 Management will become more important – but not necessarily more direct

The issue of management is growing in importance in the light of Industry 4.0. The expected effects of digitization and automation are one indication of this. It will be necessary to make decisions more quickly and with more momentum in the future. At the same time, the consequences of decisions will be more far-reaching if the integration of value chains continues to gather pace. Some aspects of decision-making will also be transferred to intelligent systems.

How will the span of control develop in your area of the company?

<table>
<thead>
<tr>
<th></th>
<th>Expand</th>
<th>No change</th>
<th>Shrink</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage</td>
<td>26%</td>
<td>55%</td>
<td>20%</td>
</tr>
</tbody>
</table>
Self-organization and decentralized decision-making will become more important [14]. Relevant studies point out that “Management 4.0” will have to leave its comfort zone and focus again more closely on the point of value creation [15]. However, only 20% expect that the span of control – the number of employees directly led by a manager – will shrink. In contrast, 26% of respondents anticipate that the span of control will grow in scale.

The introduction of Industry 4.0 will result in level hierarchies.

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>26%</td>
<td>74%</td>
</tr>
</tbody>
</table>

A similar result can be seen in response to the question about a more level hierarchy. Of those surveyed, 74% do not expect hierarchies to disappear with the introduction of Industry 4.0.

› This is a surprising result considering that insufficient readiness for organizational change is cited as the main barrier to implementing Industry 4.0. At the same time, respondents do not expect that spans of control will shrink or that hierarchies will disappear. There may be great expectations concerning the future development of this issue, but it is already clear that the indirect management of dispersed teams is rapidly growing in importance, for instance via mobile devices and social media.

### 6.3 Employee participation will become easier and harder at the same time

Especially in German industry, a stable and functioning social partnership is a guarantee of success. Against the background of changing work roles due to automation and digitization and the emergence of new opportunities thanks to Industry 4.0, it is to be expected that employee participation will be different. However, the actual forms that it will take remain open at present. Half of those surveyed expect that employee participation will change. Initial approaches to this issue already exist and are being tested in companies [16]. Participation is easier thanks to new networking options and means of participation, but it is also made more difficult due to the degree of freedom offered by pervasive networking. In short, employee
participation in the future will not be easier or more difficult, but it will be different compared to today.

6.4 The limits of individualized performance measurement will be redrawn

If automation and digitization are to prevail in German companies, this requires the involvement of employees.
Systems with real-time capability and the more dynamic utilization of production data allow work results that are more transparent, all the way down to the employee level. At the same time, new possibilities make it possible to individualize the work environment. Of those surveyed, 53% of companies expect employees to contribute toward the implementation of Industry 4.0 in this area, but they also anticipate that they will reject certain aspects of individualized performance measurement (such as measures to determine their position and the use of this data). In contrast, 28% of respondents believe that any kind of individualized performance measurement would be rejected, while 19% are of the view that employees would proactively help to develop such a scheme.

Individual performance measurement is not rejected by employees outright, but they are very critical of certain aspects. Generally speaking, it is assumed that employees will actively participate in developing future work environments. That being said, it is necessary to implement and control digital tools and to train employees how to use them. The way in which a change process is introduced within the company will thus play a decisive role. The same can be expected for the participatory involvement of employees.

6.5 Work will become more time-flexible – and more individually remunerated

Due to the introduction of new technologies, the use of near-real-time decision-making processes and increasing levels of self-organization, more flexible working models are expected. As a consequence of introducing Industry 4.0 in companies, 63% of those surveyed foresee even more flexible working models.

**Do you expect working times to become more flexible in your company as a result of Industry 4.0?**

![Chart showing 63% Yes and 37% No](chart.png)
Greater working time flexibility following more individual patterns together with different job profiles for employees will also present challenges with respect to existing remuneration schemes. Although it is assumed on the whole that staff will have more qualifications, only 38% of those surveyed believe that jobs will be categorized at a higher level. The same number of respondents (38%) expect existing classification models to remain in place. Many more (55%) anticipate that greater skills in the future will translate into a different (more individual) form of compensation.

What do new and possibly greater requirements of staff mean for company remuneration schemes?

- Greater skills must be matched by a different (more individual) form of compensation.
  - Agree (completely): 55%
  - Agree in part: 31%
  - Do not agree (at all): 14%
  - N = 312

- The classification of production employees will increase in line with their adapted job profile.
  - Agree (completely): 38%
  - Agree in part: 27%
  - Do not agree (at all): 35%
  - N = 315

- Despite an adapted job profile, the classification of production employees will remain the same.
  - Agree (completely): 38%
  - Agree in part: 27%
  - Do not agree (at all): 34%
  - N = 328

An increase in more individualized forms of compensation (for each employee) requires that targets be taken into account where employees have some level of influence. Criteria such as productivity and turnaround time as well as the individual flexibility of staff members require a basis for comparison and accepted structures. Future work systems will have to accommodate differences in individual employee performance. Concerning this point, the pressure to change resulting from digitization will be heightened by demographic change. In the area of work organization, solutions have to be found to integrate employees who deliver different levels of performance. This applies to production systems and working time arrangements as well as remuneration schemes.
7 Impact on qualification and skills development

7.1 Development of IT skills planned in all areas of production

The issue of qualification is expected to play a central role in the path toward implementing Industry 4.0. In many cases, the qualifications of staff are already specialized in specific areas of technology – mechanical engineering, electronics and IT. In production, the necessary level of implementation expertise is often missing when it comes to information and communication technology. Alternatively, responsibility is located in other parts of the company (IT department) or skills in this area simply do not match today’s technical possibilities.

In what areas will you develop or expand IT expertise?

<table>
<thead>
<tr>
<th>Area</th>
<th>Extensive development</th>
<th>No Change</th>
<th>Extensive Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indirect areas</td>
<td>80%</td>
<td>19%</td>
<td>1%</td>
</tr>
<tr>
<td>Quality assurance</td>
<td>60%</td>
<td>39%</td>
<td>1%</td>
</tr>
<tr>
<td>Logistics</td>
<td>75%</td>
<td>24%</td>
<td>1%</td>
</tr>
<tr>
<td>Assembly</td>
<td>60%</td>
<td>39%</td>
<td>1%</td>
</tr>
<tr>
<td>Production</td>
<td>67%</td>
<td>32%</td>
<td>1%</td>
</tr>
</tbody>
</table>

The survey results indicate that companies are already planning to establish and develop IT skills on a massive scale. This concerns first and foremost indirect areas such as work scheduling, production planning and control (80%). Companies will also continue to develop IT skills in the areas of (intra) logistics (75%), manufacturing (67%), quality assurance (60%) and assembly (60%).
7.2 Decision-making, responsibility and technical knowledge required in equal measure

With regard to the specific skills required in the production, respondents cite the readiness for lifelong learning (86 %) and stronger interdisciplinary thinking and behavior (77 %) before greater IT skills (76 %). On the whole, an examination of the results reveals that respondents place particular importance on skills that are geared toward increasing staff confidence and proactive process optimization.

Apart from greater IT skills, the most important qualification as regards areas of activity is the ability to take responsibility for processes, to develop this responsibility and to think and act in terms of integrated processes that take place in multiple domains. Developing these skills in all areas of production and implementing a practical system of qualification is a challenge that all of those concerned must face today.
8 Industry 4.0 – background and objectives

At present, there is no generally applicable definition of the term “Industry 4.0” that is binding.

Although everyone is talking about it at the moment, people have very a different understanding of the term depending on their perspective and interests. It can refer to an economic program to strengthen Germany or Europe as a base of industry [5] or the implementation of certain aspects of digitization and automation in industrial production [6]. So far, there has been no coordinated effort to establish a limit to the definition. The most widely used meaning is the working definition of the Industry 4.0 Platform (see [3]):

The term Industry 4.0 stands for the fourth industrial revolution – a new stage in the organization and control of the entire value chain throughout the product life cycle. This cycle is geared toward the increasingly individual nature of customer preferences and extends from conception and order placement to development, production, product supply to the end customer and even recycling, including all the associated services. It is based on the availability of relevant information in real time thanks to the networking of all the parties involved at the point of value creation and the ability to determine the optimal value creation flow at any time using this data. The integration and connectivity of people, objects and systems results in dynamic, self-organizing value creation networks that are optimized in real time across all areas of the company and that can be further improved depending on a range of criteria, such as costs, availability and the use of resources.

The present study assumes an essential understanding of Industry 4.0 as “the intelligent networking of people, machines and objects with real-time capability to manage systems in industrial production” (based on [8]).

Industry 4.0 is closely associated with many different strategic goals. Within the framework of the defined “dual strategy,” [2] it is intended to develop products and product-related services and thus to position domestic industry as a leading provider of intelligent networked products. At the same time, the second part of the strategy sets out to ensure that German companies incorporate innovative Industry 4.0 technology in key processes along the value chain, creating an exemplary market for the industrial use of new solutions. The recommendations of advisory committee Forschungsunion cover three main directions:

› Horizontal integration across value creation networks
› Transparency of engineering along the entire value chain
› Vertical integration and integrated production systems
Industry 4.0 can be seen in the form of networked production systems, the higher pervasiveness of IT systems, intelligent work pieces, tools, transport equipment and the use of mobile communication technology. As a result of this development, completely new business models are expected with respect to products and production. Together with a new level of automation, people anticipate improved levels of productivity on par with a fourth industrial revolution. This is made possible by the lower price of industry-related hardware and software: lightweight robots, tablet PCs, RFID tags and transponders as well as sensor technology and memory. Nowadays, such technology is both affordable and easy to obtain. Another factor is the widespread use of the Internet as a data exchange platform in B2C and B2B activities. However, a truly relevant increase in productivity will only happen if the use of technology translates into more effective and efficient production processes.

In addition to the implementation of the technical concepts in individual areas of application, it is expected that the introduction of Industry 4.0 will have a profound effect on the world of industrial work. Greater levels of self-organization and the existence of near-real-time status information call for a new approach to job design and work organization. Additionally, the anticipated advances in automation will expand and shift employee roles, areas of activity and the necessary skills in both direct and indirect parts of the company. Initial studies suggest a drastic shift in employment due to the automation of knowledge management and mobile robot technology [9], [10], [11].

The term “Industry 4.0” was first presented to the general public in 2011 [1]. Much has happened since. Especially since the Hannover Messe used the phrase as a motto in 2013 and 2014, the intelligent networking of production has become a key issue for the future in science, industry and politics. Activities in this area were given a further boost by the recommendations for implementation presented in 2013 as part of the “Industry 4.0” project of the future [2] and the subsequent development of the Industry 4.0 Platform [3], which is jointly supported by industry associations VDMA, ZVEI and BITKOM. Additional momentum came from the first examples of implementation in practice as well as activities at a national and international level with research funding and the central role of the issue in the Digital Agenda [4].
9 Conclusion and outlook

Industry 4.0 is coming and it will stay. Even if the concept and the current level of media hype associated with it eventually run out of steam, automation and digitization will continue to drive innovation in industrial production for a long time to come. Companies expect nothing less than a fundamental change in production and work processes as a result.

Although it is difficult to predict today which of the dominant concepts and solutions of Industry 4.0 will prevail in practice, in many cases the basic technical requirements are already met or are currently being implemented by the first wave of companies. They are also fully aware of the need to develop qualifications – both professional and otherwise.

In addition to the implementation of new, efficient solutions, there are major challenges in the area of work organization. Industry 4.0 will change work processes. The ways in which it is allowed to affect flexibility, salary system, employee participation and work roles will determine how quickly and to what extent it is implemented – and thus decide the success or failure of the fourth industrial revolution.

Industry 4.0 will be successful if it encompasses more than the utilization of technology. It is essential to develop better work processes with new technology. People, or rather employees, will be at the center of this development – competent process-optimizers, qualified decision-makers and flexible participants who help to shape Industry 4.0. Measures to ensure the necessary qualifications and to develop future skills must be worked out today.
10 References


[2] Forschungsunion: Recommendations for implementation concerning the “Industry 4.0” project of the future, concluding report by the Industry 4.0 research group, Berlin, April 2013


