



Federal Ministry
for Economic Affairs
and Energy

Federal Ministry
of Labour and Social Affairs

Working in the digital world

People | Organisation | Technology



Imprint

Issued by

Federal Ministry for
Economic Affairs and Energy (BMWi)
Public Relations
11019 Berlin
www.bmwi.de

Design

PRpetuum GmbH, München

Production

LoeschHundLiepold Kommunikation GmbH, Berlin

Status

June 2016

Print

N. N.

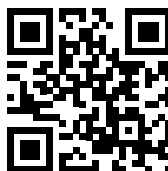
Photos courtesy of

Autonomik/Małgorzata Pakuła (Titel), BMWi/Maurice Weiss
(p. 2), BMAS/Knoll (p. 3), Fraunhofer IPA (p. 11), HYVE Innovation
Community GmbH (p. 14), Hochschule Esslingen/KD Busch
(p. 20), Industrieblick – Fotolia (p. 22), Juice Images – Fotolia (p. 26),
Schunk GmbH & Co. KG (p. 28)

This brochure is published as part of public relations work by the Federal Ministry for Economic Affairs and Technology. It is distributed free of charge and is not intended for sale. Distribution of this brochure at election campaign events or at information booths run by political parties is prohibited, and political party-related information or advertising shall not be inserted in, printed on, or affixed to this publication.



Federal Ministry for Economic Affairs and Energy (BMWi) has been awarded the berufundfamilie® audit certificate for its family-friendly HR policy. The certificate is granted by berufundfamilie gGmbH, an initiative of the Hertie Foundation.



This and other brochures are available from:

Federal Ministry for Economic Affairs and Energy
Public Relations
E-mail: publikationen@bundesregierung.de
www.bmwi.de

Central procurement service:

Telephone: 030 182 722 72
Order fax: 030 181 027 227 21

Contents

Introduction: Working in the digital world	4
SoMaLi: Social Manufacturing and Logistics.....	6
Management and process organisation	10
Application example I: ReApp – Reusable robotic applications for flexible robot systems.....	11
Application example II: MANUSERV – Practical impact of industrial service robots: the example of small-parts assembly	12
Application example III: InnoCyFer – Humans and their interaction with autonomous planning, design and control systems for cyber-physical production systems	14
Application example IV: ELIAS – Engineering and mainstreaming of industrial learning management systems for Industry 4.0	15
Application examples of Industry 4.0 Platform.....	17
New workplace models	19
Application example I: motionEAP – Motivating assistive system for production environments at companies based on motion recognition and projection.....	20
Application example II: APPsist – Assistance and knowledge transfer: the example of installation and maintenance activities	21
Application example III: InSA – Integrated protection and safety concepts for human robot interaction in cyber- physical environments	22
Application example IV: Soziotex – Sociotechnical assistive systems for production in the textiles industry.....	23
Projects at European level.....	24
Work 4.0	26
Autonomik für Industrie 4.0	28

Introduction: Working in the digital world

The dawn of the Industrial Revolution in the 19th century was not the starting point for passionate debate regarding technology-induced changes in the world of labour and for the veritable battle between the different parties with their conflicting interests. In the late 18th century, weavers had already fought their desperate fight against the introduction of technically modernised looms, with luddites protesting against the consequences of the Industrial Revolution, such as lower incomes and poorer working conditions.

Today, controversial views regarding technical progress are exchanged in a spirit of social partnership. The „Working in the Digital World“ conference aims to reconcile the view of what is desirable from a technological and economic perspective with the principles of reasonable social and labour policy. Experts no longer question the critical repercussions of the accelerated pace of the digitisation of products, processes and services on work processes, organisation structures and jobs. However, the resultant scenarios can be influenced using scientific knowledge and considering economic and social goals.

Technological advances and, more specifically, combinations of such advances, such as increasingly powerful, highly miniaturised service robots, 3D printing (additive manufacturing) and 3D visualisation, big data analytics and cloud-based services, open up a host of starting points for new, future-orientated business models. One development that will have a significant impact on industrial production in the coming years will be systems that act autonomously and co-operate in teams in order to independently manage even complex tasks. This will affect changes in processes and organisation structures, especially at workplaces. New forms of interaction between humans and machines, new tasks and related qualification profiles as well as occupational health and safety requirements and data protection standards will fundamentally transform the sociotechnical system. These challenges will have to be taken up, communicated and made transparent and, in a joint effort by all stakeholders, converted to a future perspective with new opportunities for both enterprises and workforces.

The discussion aimed at at the „Working in the digital world“ conference is to focus on the „AUTONOMIK für Industrie 4.0“ (in English „AUTONOMICS for Industry 4.0“) research and development programme by the Federal Ministry for Economic Affairs and Energy (BMWi) and the „Work 4.0“ dialogue of the Federal Ministry of Labour and Social Affairs (BMAS).

With the „**Work 4.0**“ dialogue, BMAS has created a framework for dialogue on the future of work with all its facets that goes beyond the boundaries of the new technology worlds of Industry 4.0. Certain key aspects of the dialogue, such as quality of work, new forms of interaction between humans and machines, mobile work without boundaries, occupational safety, labour law and data sovereignty, will be addressed at „Work in the digital world“ conference. The „Work 4.0“ Green Paper by BMAS takes a look at the world of work today, tomorrow and beyond. The Green Paper serves as a basis for broad-based dialogue on how we will work and live in the future. It does so by highlighting trends that will change our working environment, defining fields of action and identifying key questions and issues for dialogue. The aim is to open a dialogue with practitioners in enterprises, social partners, citizens and scientists in order to identify design opportunities and develop options for concrete action. Issues in this context will include life phase-orientated working time models, measures to protect new forms of gainful income, a new culture of continuing professional development, employee rights in the digital world of labour as well as new ways to compromise on flexibility.

Along with application-near scenarios, the conference will set the frame for fleshing out and substantiating dialogue on the future of the working society. Based on the „good work“ concept, the social conditions and rules in the digital working world are to be explored in more detailed specifically with a view to the production world of Industry 4.0.

With its „**AUTONOMIK für Industrie 4.0**“ technology programme, BMWi is providing vital support for the implementation of the Industry 4.0 future project adopted by the German government as part of its high-tech strategy. The research and development projects supported are to identify new industrial applications for digital technologies which can serve as a basis for the development of new products, services and viable business models. Feasibility and economic benefit are to be demonstrated in the projects. The results of the projects show the radical change that can be expected especially in planning, designing and managing production processes as well as in networking of in-house and company-spanning functional areas of the value chain. Cyber-physical systems, for instance, support and enable completely new forms of engineering, simulation and forecasting of real processes as well as new forms of assistance and learning at the workplace. Besides aspects of economy, organisation and management structures

as well as future workplace design, issues related to civil, liability and labour law as well as functional safety and data security, including data privacy will be addressed.

BMAS and BMWi have designed the conference as a framework for integrating the results of scientific assistance and discourse by various initiatives, most notably the Industry 4.0 platform (working group 5 „Work, training and further education“) and the „Digital working world“ platform. The discussion with representatives of these initiatives should offer an opportunity to jointly draw conclusions and to identify next concrete steps for proactive action at companies and by the social partners.

However, the debate is already underway. The results of scientific assistance on the „Future of work in Industry 4.0“ as part of BMWi's „Autonomik für Industrie 4.0“ (e-book, Springer) should be mentioned here since these findings address many of the above-mentioned topics. One of the authors' key points of interest is interaction between social needs, economic challenges and technological developments.

Another ongoing BMWi research project titled „Social Manufacturing and Logistics“ (SoMaLi) currently outlines a human-centric concept of working in digitised (production) environments with reference to the technological, organisational and social challenges of Industry 4.0.

Scientific assistance for the “AUTONOMIK für Industrie 4.0” technology programme commissioned by BMWi will evaluate the results of the above-mentioned research, the implementation projects, the various initiatives and, first and foremost, of today's conference. These results will then be edited and published in due time as part of further research on the „Future of work“.

„Social Manufacturing and Logistics“ – work in digitised production

Hartmut Hirsch-Kreinsen, Michael ten Hompel

Development perspectives for work in Industry 4.0

Many authors suggest that the growing use of digital technologies will lead to a sustainable change in work in almost all sectors and with a view to all of its relevant dimensions. In industry, this concerns not only shopfloor activities, but also indirect production planning and management activities right through to product development, along with significant changes in the demands placed on company management at executive level. Furthermore, external work processes and value chains beyond company limits are likely to undergo fundamental reorganisation. However, the answers to the question as to how work will change are currently very different. Some answers are sceptical, emphasising risks, such as the loss of large numbers of jobs, the danger of dequalification, new burdens and growing social uncertainty. Other experts voice optimism, expecting more jobs and more demanding work as well as a general increase in appreciation of activities and qualifications.

This optimistic perspective and the opportunities for growing appreciation of work are also discussed within the scope of Industry 4.0 discourse in Germany. One example of this is the position of the scientific advisory board of the Industry 4.0 platform. As part of its propositions published in 2014, this board claims that Industry 4.0 “opens up many options for human-centric design of work organisation”. It goes without saying that this development trajectory is in the broadest sense extremely desirable from the perspective of social and industrial policy.

Since human-centric forms of work will by no means emerge automatically, a holistic and strategy-based design approach and implementation measures along these lines will be needed. The term “social manufacturing and logistics” is intended to underline this in several ways. It refers to the functionalities of social media in terms of communication and networking between objects, machines and humans which are already commonplace in the private sphere and which are now becoming increasingly popular in production and logistics. This term also reflects the fact that the implementation of Industry 4.0 systems must always consider the socially orientated overall context of an industrial process.

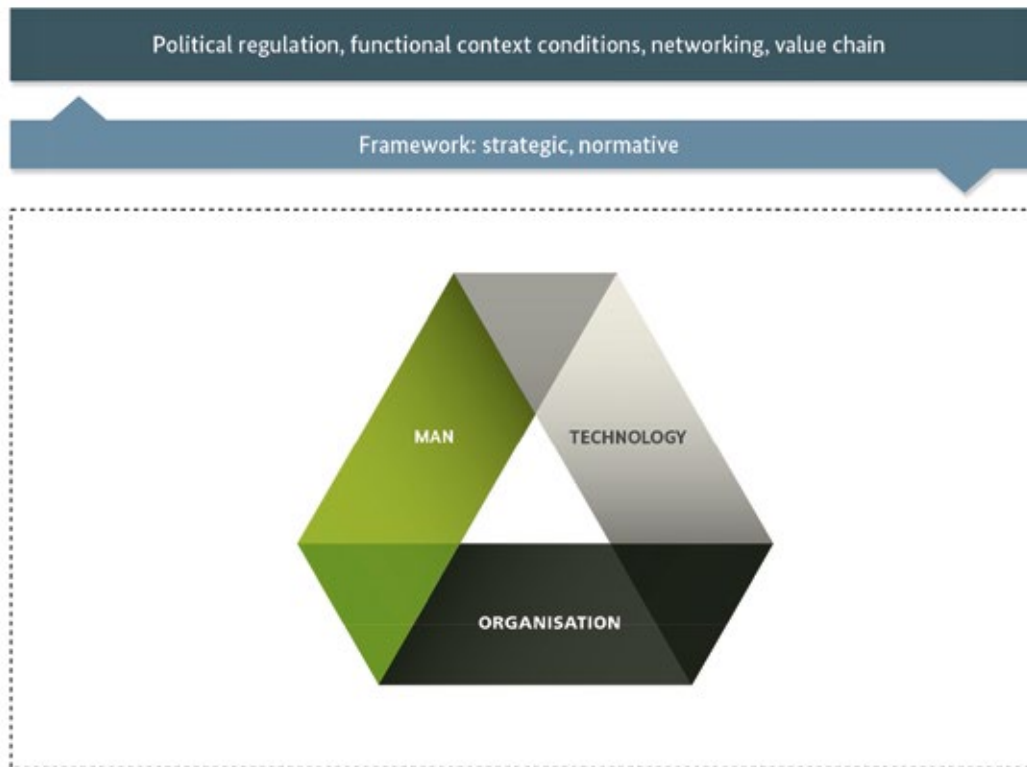
The design approach of the sociotechnical system

The concept of the sociotechnical system lends itself as a suitable basis for an analytical and design approach. This concept is the basis for the ongoing BMWi-sponsored “Social Manufacturing and Logistics (SoMaLi)” research project which is underway at TU Dortmund as a collaboration project of the Industry and Work Research (FIA) unit and the chair for Transport and Warehouse Logistics (FLW). The project aims to identify the social, organisational and technological challenges of Industry 4.0 in interviews with experts from industry and associations.

The concept of the sociotechnical system is not a question of a juxtaposition between humans and technology but has its sights set on a harmonised design of the sociotechnical system as a whole. Needless to say that the overall system design must consider the structural and economic requirements of the respective application and the different knowledge domains of Industry 4.0. The guiding criterion should always be to make optimum use of the potential of a human-centric design of work.

With this concept, the analysis focuses on the overall context of a production process with its technology, organisation and human sub-systems. Rather than looking into the details of the principles of operation and transformation processes of the sub-systems, their mutual interdependencies are emphasised. The concrete aim of the analysis are the functional relationships and interfaces between technology, humans and organisation. The current state of research into the human-centric design of Industry 4.0 systems and the conclusions from the interviews conducted in the ongoing SoMaLi project suggest the following fundamental challenges:

Fig. 1: Sociotechnical systema



Source: TU Dortmund

The technology/human interface

Under the conditions of Industry 4.0, it is not just the familiar criteria of action-orientated dialogue design that are addressed here; instead, the fundamental issue is “distributed actorship” between technological sub-systems and human work activities. The **distribution of functions** between machines and humans must be considered to be one of the fundamental challenges for the design of work in Industry 4.0. The aim here is to achieve an interface design where human work is given or retains **control of the production** processes and is supported by **intelligent assistive systems**. The work situation is characterised here by a range of tasks supported and supplemented by social media functions as well as by new requirements for qualified work and thereby encompasses key features of human-centric system design.

The technology/human interface: Industry 4.0 user in the logistics sector

An industrial services provider uses transport robots in the incoming goods area in order to transport goods to the warehouse. The robots move autonomously and safely between their human colleagues. The transport robots relieve workers from non-value adding activities who then have more time to inspect incoming goods. The company’s motivation is user-friendliness rather than rationalisation: Smart technology is not designed to replace workers, but to optimise and simplify certain process steps. Substituting physically demanding work is specifically designed to ensure sustainable employment opportunities for older workers.

The organisation/human interface

The central challenges include the question regarding the extent to which the design of an organisation can provide human work to the maximum extent possible with **complete tasks**, options for action as well as learning and qualification possibilities. After all, the organisation ultimately determines the contents of tasks and the related **qualification requirements**. The given organisational freedom can be used here to fundamentally upgrade all activities and qualifications. This enables work situations with special qualification requirements and potentially **considerable freedom**, the polyvalent use of employees and many options for learning on the job.

The organisation/human interface: Changing tasks in networked production

Digital product technology is very relevant for an electronics company. Based on highly automated and networked production logistics, requirements in customer orders are identified and assessed with a view to production, stocks and final assembly. Digital automation will lead to changes in workforce and organisation. On the one hand, previously manual operations will be automated even though human problem-solving competencies are still needed. However, employees will also face new challenges, such as functional maintenance and trouble-shooting, skilful use of digital devices as well as communication competence when it comes to setting up machines. At the same time, work will become more diverse due to repeated changes between different places of work and products. At the interface between organisation and workers, this opens up ways to completely change the work organisation and to bundle the resultant tasks to form new, holistic activities.

Fit for 4.0 – meeting the requirements of tomorrow with assistance in production!

Adjunct Prof. (Clemson Univ.) Dr.-Ing. Yves-Simon Gloy

The technology/organisation interface

This interface poses various challenges for the design of work: On the one hand, the degree of automation of the “technology” sub-system determines the functions which are (still) available for organisational design. Furthermore, Industry 4.0 systems with their high degree of temporal and functional decoupling between technology and work offer many options for **alternative organisational forms**. Under the conditions of networked systems, organisational design must additionally encompass not only the horizontal shopfloor level, but also the **vertical and/or hierarchical dimension** of the organisation as well as logistics. That’s because the social media functionalities and hence changed forms of communication have a major impact on both indirect areas – such as planning, management and engineering – and management functions. The new conditions of individualised production (“batch size 1”) based on **autonomous systems** deserve special mention in this context as they imply distributed control and intelligence even from an organisational perspective. This means a move towards far-reaching decentralisation and elimination of hierarchical levels with a view to a human-centric organisation design in its entirety.

The technology/organisation interface Development of sensor systems for autonomous systems

An electronics company develops new sensor technologies which are set to change traditional production processes. Machines fitted with smart sensors are to form distributed autonomous systems and exploit the potential of Industry 4.0. This is also in line with the company’s customer expectations, i.e. all-encompassing solutions rather than large numbers of individual sensors. Besides changing their customers’ operations, the electronics company itself is also transformed from a technology supplier to its customers’ “problem solver”. This will lead to new forms of co-operation within the workforce: beyond traditional department and company boundaries and in temporary project teams (forming global networks).

The outlines of a model for digitised work

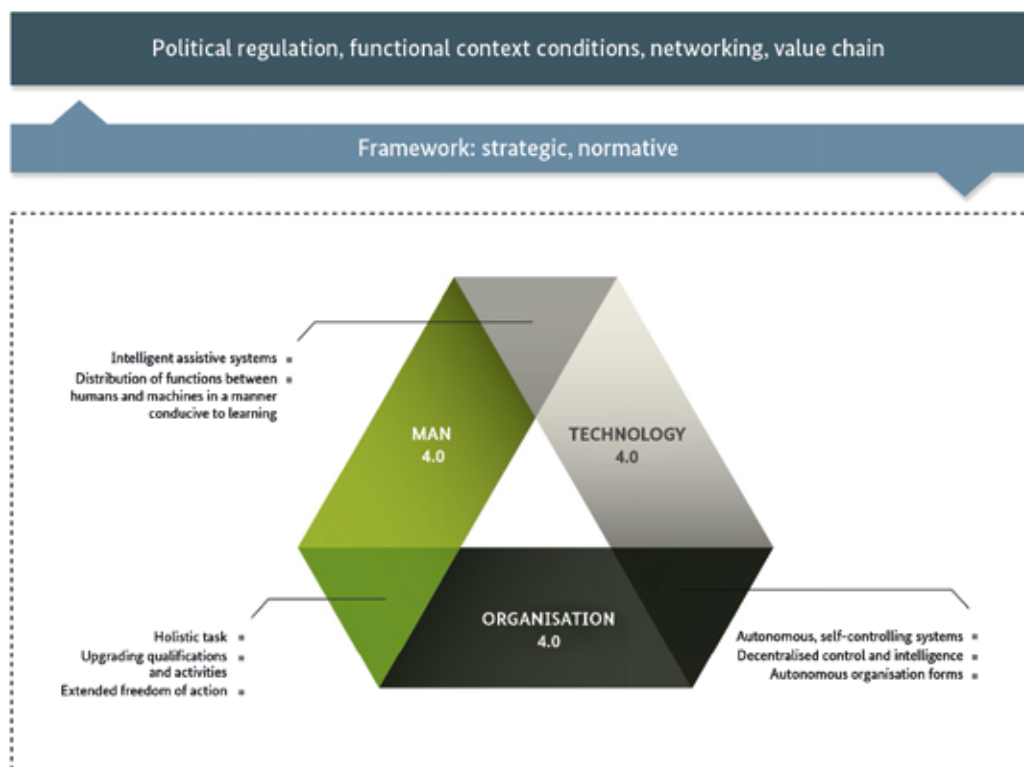
The outlines of a model for social manufacturing and logistics are becoming visible in this way. Following the above-mentioned criteria of technology, humans and organisation as well as their interdependencies, the conditions of Industry 4.0 facilitate forms of work that are determined by the respective design of their interfaces. The criteria for a human-centric development perspective for work would be far-reaching control options and intelligent assistive systems, complete full-scale tasks, a supportive approach to learning and significant freedom of action as well as new forms of self-organisation with distributed control.

Following the results of work and digitisation research, this then addresses the social and organisational preconditions for a high degree of system transparency for the workforce,

the possibility to master complex system processes and hence to ensure the optimum functionality of the system as a whole. The illustration shows an example of starting points for a human-centric system design in Industry 4.0. What's more, a human-centric development perspective of Industry 4.0 is also the optimum precondition for an industrial work design that meets the needs of an ageing workforce and which even the young generation will once again see as an attractive, interesting, less strenuous and self-organised "high-tech" activity.

Stakeholders from the fields of business, academia and politics should hence make use of the opportunities offered by ongoing and planned development and design projects to explore the human-centric design potential of Industry 4.0 as well as the social and organisational prerequisites and to combine these in an integrative sociotechnical perspective.

Fig. 2: Starting points for a human-centric system design



Source: TU Dortmund

Management and process organisation

The progress of automation in the working world, from production and service right through to the science sector, drives forms of work with an increasingly flexible and interactive structure independent of a particular place or point in time. This changes value processes, and the division of labour and tasks must be reorganised. Highly flexible production of individualised, digitally upgraded products and services now follows the paradigm of distributed and augmented organisations. It is unlikely that the trend towards low-cost individualisation will be economically or technically possible with traditionally planned and controlled production processes. In future, new, innovative digital technologies in production, manufacturing and logistics will enable companies to produce more and more products even in high-wage countries like Germany. In the coming decades, flexible, low-cost and smart robot systems in conjunction with additive manufacturing processes will be able to perform manufacturing steps which were previously only possible as manual activities and were therefore relocated to low-wage countries for cost reasons.

The digital transformation calls for a fundamental cultural change: On the one hand, digital competence will become a key qualification for the future. Moreover, companies will have to integrate new technologies strategically into their processes, build agile work organisations and open up their innovation processes. Networks of this kind will be the only basis for the agile and dynamic development of new solutions, business models and production systems. If a society takes on a pioneering role in the digital transformation, this will not only eliminate existing jobs, but also create new ones.

Prof. Dr. Wilhelm Bauer, Director, Fraunhofer IAO and IAT University of Stuttgart

This leads to the general question as to how the traditional view of industrial work systems in production can be developed to a new perspective for value systems for industry and services. Innovation capability as a concept of innovation policy has a key role to play in this context. Although it is a historical fact that the use of robots and automation solutions leads to an increase in average productivity, the scatter of the measurable effects is very substantial from one company to the next. This means that state-of-the-art manufacturing technology alone is not the key to competitive strength and innovative capability. Work organisation and work system design have an equally important role to play with a view to the companies' structure and human capital.

Key issues in this context include workplaces conducive to learning, lean and flexible production as well as optimised energy, material and personnel flows. The new technical systems currently emerging in the context of Industry 4.0 and the related fundamental changes in production, manufacturing and logistics offer the exciting possibility to increasingly shift the focus towards work-orientated learning when it comes to planning and designing new, automation-based work systems.

Conduciveness to learning is an important feature of an innovation-friendly work and company organisation. Two important aspects should be distinguished here. The complexity of tasks reflects the extent to which the work calls for different and demanding skills on the one hand and to which this also generates new demand for learning and learning opportunities on the other. One important aspect of conduciveness to learning is the possibility to take part in the design of one's own work and hence to define possible freedom of action.

The use cases described below illustrate the new automation potential and therefore the possibility of greater added value with flexible production requirements. They also show new ways of mastering increased demands on future qualification and competence developments through new work-integrated and demand-driven forms of learning.

The complexity of today's production systems increasingly calls for smart assistive systems in order to master the growing flow of information in the future.

Dr. Holger Flatt, Fraunhofer Application Center Industrial Automation (IOSB-INA)

ReApp – Reusable robot applications for flexible robot systems

The challenge

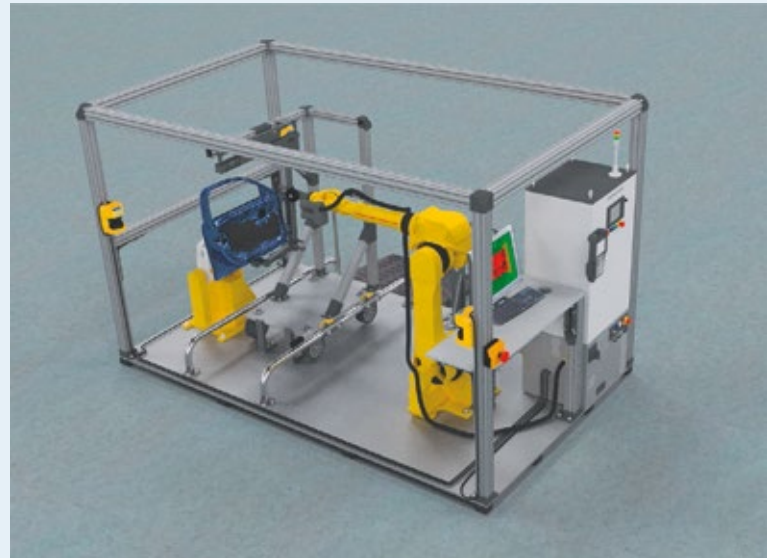
Robot-supported automation systems are becoming increasingly complex. The time and money needed to program these systems, their integration, maintenance and adaptation are much higher than the actual cost of the components. This means that the use of robot-based automation systems in small numbers, as is often the case at SMEs, is often not economically feasible. Today, the obstacles to reusable software are primarily due to the highly heterogeneous landscape of robotics and automation components, different robot programming languages and the lack of interface standards.

The ReApp project

BMW's ReApp project aims to use reusable software modules in order to boost the efficiency of the process of developing robot systems. ReApp is to create tools and models for the development of reusable software modules (apps) for robots with capabilities, for instance, for the identification, detection and seizing of workpieces right through to the automated execution of complete processes. Another result is a development environment where these apps can be modelled and easily integrated into and set up on the robot systems. The apps can be tested and simulated before the robot system is installed. The advantage: Thanks to the apps, robot-based applications can be developed faster and more efficiently than before. Automation therefore becomes economical even for small batch sizes. Three demonstrators are specified for the validation of ReApp which handle different end user applications.

Impact on processes and solution concepts

Thanks to ReApp, robot-based automation solutions are becoming increasingly suitable even for small batch sizes and therefore for small and medium-sized enterprises. Programming and set-up are much easier, and end users will be able to perform these tasks themselves. These automation systems will have consequences for workforce structures: Robots will increasingly carry out repetitive processes which call for a high degree of precision or reliability. This means that the number of unskilled workers will be reduced whilst staff with automation systems qualifications (such as robot programmers) will be increasingly in demand. But the ReApp application demonstrator for "automated soldering" shows that the opposite case is also possible: The use of a robot-based soldering station means that highly skilled manual soldering experts can be replaced



with "robot operators" with lower qualifications. However, the robot-based soldering station must be easy to program in this example: If re-programming requires special skills or if the set-up process takes too long, this could mean that the use of robots is no longer economical. Rather than being programmed in manufacturer-specific robot programming languages, robots will be programmed in future using software tools that combine and configure reusable program modules. The tasks of system integrators will therefore increasingly change from pure robot programming to system expert tasks that require knowledge, for instance, in the field of human/robot co-operation, image recognition and other more demanding functionalities.

Conference topics impacted

Work system design	1	
Quality of work	2	
Qualification issues	2	
Industrial safety	1	
Occupational health and safety	1	
Data sovereignty	2	(1 = very high 6 = low)



For more information about ReApp, please visit:
www.reapp-projekt.de

MANUSERV – Practical impact of industrial service robots: the example of small-parts assembly

The challenge

Industrial service robots support human activities in industrial environments. This division of labour can lead to greater product quality and process stability. Furthermore, workers can be relieved of monotonous and physically strenuous activities so that the design of work can become more conducive to health. Despite this far-reaching potential, the use of service robot systems in real production systems is at present still limited. One possible reason for this is uncertainty with regard to the application scenarios and process steps for which such robot systems are in fact suitable and the benefits that can be derived from this.

The MANUSERV project

In BMWi's MANUSERV project, a web-based planning and design environment is now being developed which proposes (partially) automated design solutions for using service robots as well as the corresponding process sequences to

Although man will always remain the most important success factor of production, more demanding requirements and the rapid pace of technological change mean that we will have to develop new approaches for training and developing our workforce and engineers in order to meet these challenges.

Dr. Eberhard Veit, DEO, Festo AG

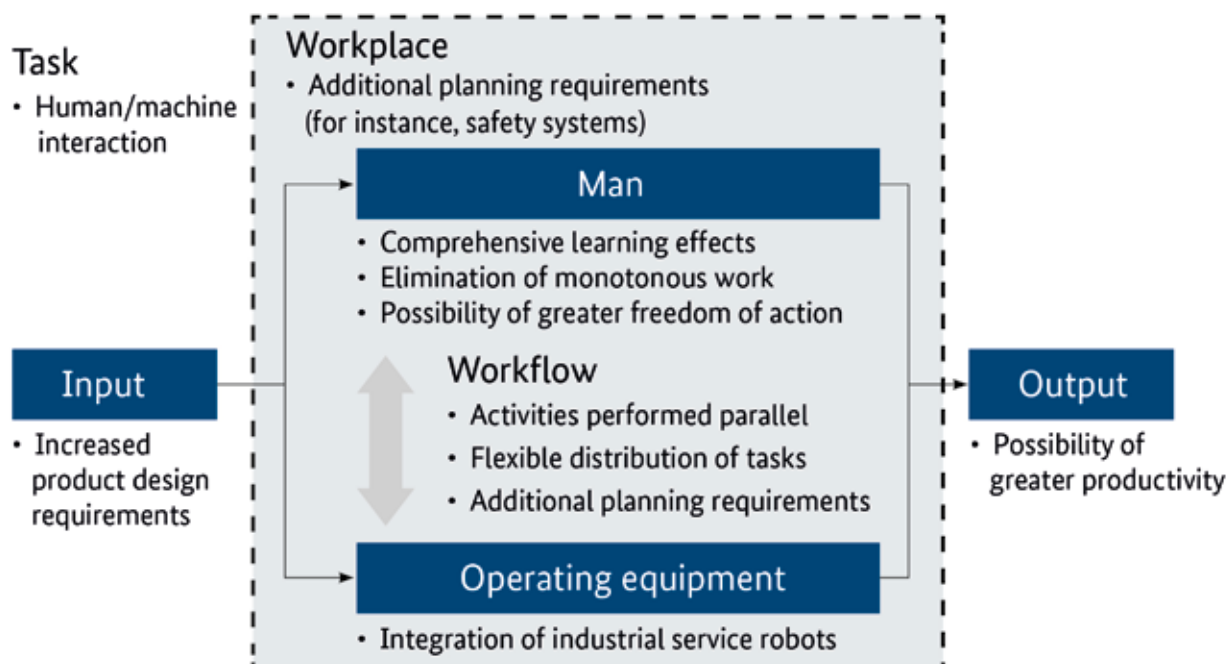
industrial users of existing work systems. In order to ensure maximum industrial applicability, the concept and its software-based implementation will be validated on the basis of three real manual work processes from different fields of application (installation/systems engineering, mechanical engineering and agriculture).

Impact on the work environment

The possible effects of such a hybrid system on the roles in a company were examined for a manual assembly process in the context of electrical installation engineering. It was found that the implementation of the service robot can lead to significant effects and changes both in production – especially for fitters, foremen and maintenance staff – and

for planners and designers.

Summary of effects



Assembly process



1. Assembly of “control module” including functional testing



2. Assembly of “power supply unit”, “loudspeaker”, packaging

Source: MANUSERV

Research demand

A host of different research and development approaches can be pursued in order to support the more wide-spread establishment of (partially) automated systems and the integration of industrial service robots in industrial application scenarios even further. One central starting point is the development of individual assistive systems that can be adapted to the respective demands and specific performance capabilities of individual employees. Restrictions which may be due to age, injury or illness are currently not sufficiently considered in the design of hybrid work systems. This means that the specific performance capability of each and every employee must be identified in detail and presented to the robot in a format that the robot can understand. Depending on an employee's specific need for support and with the help of new planning and design tools (such as individual digital human models), solutions for direct human/robot collaboration can be implemented in order to compensate for restricted physical performance and to ensure maximum productivity.

The digitisation of work does not necessarily improve working conditions or upgrade activities and qualifications. Instead, very different development trajectories for work have to be taken into account. It goes without saying that there is a strategic and political opportunity to use the introduction of new technologies in order to implement new forms of human-centric work. This does, however, call for a sociotechnical understanding of the current digitisation process.

Prof. Dr. Hartmut Hirsch-Kreinsen, business and industrial sociologist, TU Dortmund

Conference topics impacted

Work system design	1
Quality of work	2
Qualification issues	3
Industrial safety	3
Occupational health and safety	3
Data sovereignty	4
	(1 = very high 6 = low)



For more information about MANUSERV, please visit:
www.manuserv.de



InnoCyFer – Humans and their interaction with autonomous planning, design and control systems for cyber-physical production systems

The challenge

Companies are increasingly focusing on their customers' demands for customised products. The trend here is from customised to customer-innovated products. This means that customers are involved as designers and/or developers in the product emergence process and can design their specific products rather than choosing from pre-configured options. The manufacture of such customer-innovated products calls for novel production concepts and processes that must feature an extraordinarily high degree of flexibility and autonomy. This is achieved by digitising the entire production process which leads to new ways of planning and controlling production on the one hand and to changes in shopfloor work on the other.

The InnoCyFer project

BMW's InnoCyFer project is developing a web-based open-innovation platform which provides customers with a toolkit that allows them to design technically viable products individually and according to their own ideas without the need for specific skills. The highlight of this project are ways to plan and manage autonomous manufacturing and assembly. An optimisation algorithm (scheduler) which simulates the behaviour of ants enables autonomous machine utilisation scheduling for incoming jobs. The human production planner – who continues to be part of the production process – interacts with the scheduler by receiving information regarding planning proposals or control decisions and by intervening when necessary. Compared to today's production, this will change the way in which production planners or foremen work.

Impact on the work environment

Although increasingly autonomous systems relieve operators in certain areas, such as monotonous daily job scheduling operations, the volume of complex tasks is also increasing. This means greater demand for willingness to learn via assistive systems or further qualification programmes in order to keep pace with these requirements. All employees involved in the production process must increasingly adopt interdisciplinary forms of work because co-operation is required especially with IT. Moreover, demand is likely to shift from foremen to IT specialists.

Solution approaches

In BMW's InnoCyFer project, three solution concepts were developed for successful interaction between humans and autonomous systems. Besides a system for early identification of staff qualification measures and the adaptation of assistive systems to every employee's specific needs, this also includes a concept for handling and using large amounts of data.

Conference topics impacted

Work system design	1	
Quality of work	2	
Qualification issues	1	
Industrial safety	3	
Occupational health and safety	3	
Data sovereignty	2	(1 = very high 6 = low)



For more information about InnoCyFer, please visit:
www.innocyfer.de

ELIAS – Engineering and mainstreaming of industrial learning management systems for Industry 4.0

The challenge

The digitisation of production and service processes also involves fundamental changes in the working world. Increasingly complex, realtime-controlled work and production systems will change work contents and processes as well as the requirements for workforce skills and competencies. This will have a significant impact on qualification demands and competence development processes. Companies are therefore called upon to plan and design work and production systems in such a manner that they support labour-integrated and demand-driven forms of learning. Besides this potential, however, early action is also necessary with a view to issues like IT security, data protection and work organisation, for instance, by developing uniform norms and standards.

The time has come not just to talk about education and qualification for Industry 4.0 in Germany, but to do it.

Professor Dr. habil. Christoph Igel, German Research Center for Artificial Intelligence (DFKI)

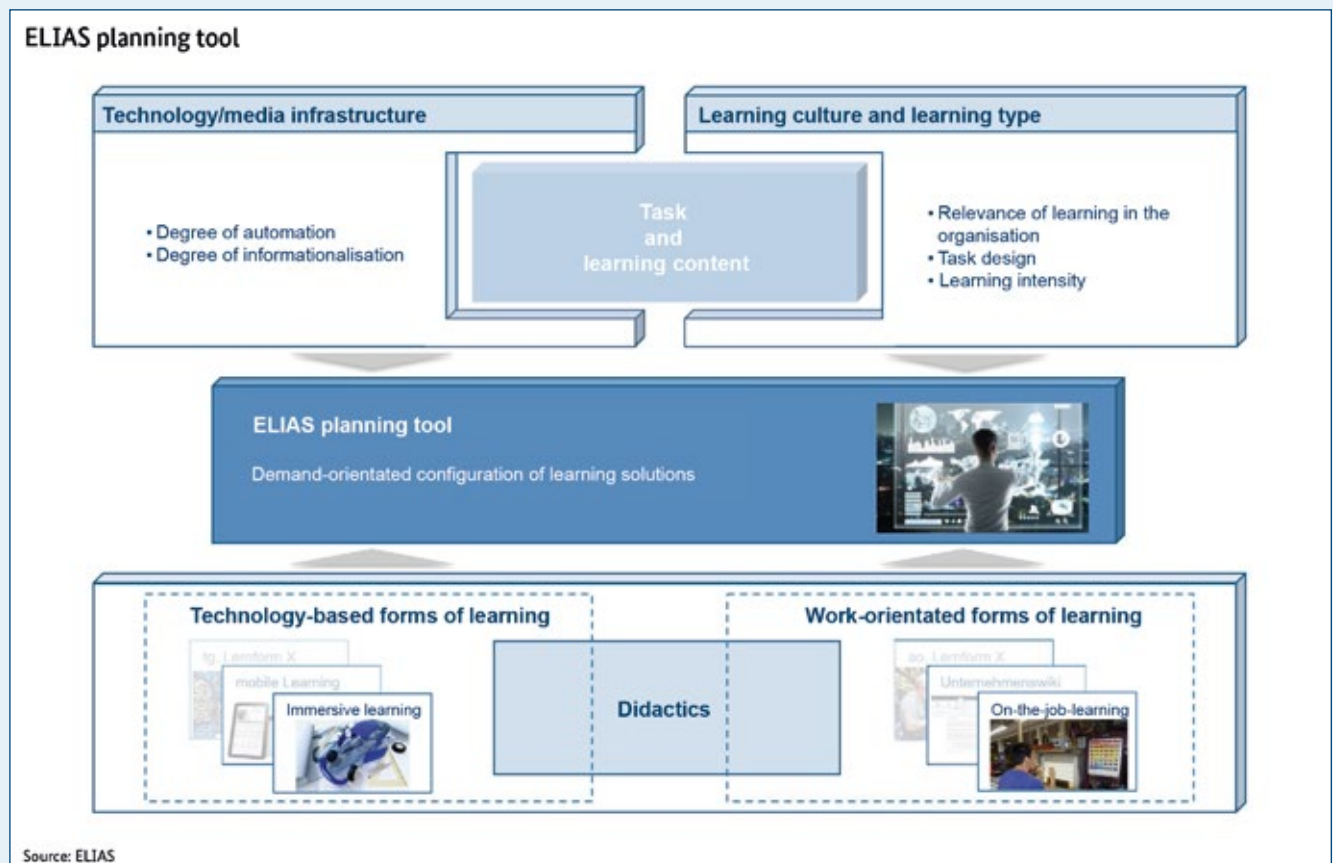
The ELIAS project

BMBF's ELIAS project is therefore developing new approaches for the design of work and production systems. The aim is a concept to integrate learning in the work process as a basic design component into existing or future work systems. The project aims to develop a planning tool with the principles of operation shown in the illustration below.

Industry 4.0 enables target-group-compliant and real-time-near information processing so that employees become informed decision-makers capable of mastering complex systems and of quickly responding to problems.

Prof. Dr.-Ing. Gisela Lanza, Karlsruhe Institute of Technology

On the basis of this analysis of boundary conditions, the planning tool provides service providers and manufacturing companies with a sensible range of learning solutions in order to integrate conduciveness to learning into their future and present work and production systems. The suitability of the ELIAS concept for industrial applications was tested and developed further on the basis of the use cases of the industry partners and by developing demonstrators.



Impact on the work environment

As different as the use cases may be, certain fundamental commonalities can also be identified in the procedures and solution concepts chosen: The digital tools used serve to assist the performance of tasks and address both individual and organisational learning. The organisation or work changes because the contents of activities are shifted and new job profiles are created. Furthermore, qualification processes take place and new personnel employment and development concepts emerge.

Digitisation will create new jobs.

Thorsten Dirks, President of Bundesverband Informationswirtschaft, Telekommunikation und neue Medien e.V. (BITKOM)

Solution approaches

Man, technology and organisation (MTO) are the underlying and interconnected elements of the solution of the cases. This commonality also enables certain common patterns to be identified in the way companies act. Digital tools are either developed by the companies supported by the expertise of various stakeholders and a prototyping process where users are also involved in development and testing. Suitable digital tools are not available as ready-made off-the-shelf solutions, but are developed internally with a clear focus on the contents of activities as well as knowledge and expertise available within the company. Adequate concept development, work analysis and participation management competence is therefore required. Some of these must be developed and acquired during the process itself. Further-

more, competence building and organisational learning take place in the form of work-near and work-integrated concepts. Ultimately, these two cases show that the informatisation and automation of the working world do not necessarily mean the elimination of low-qualification labour.

A sociotechnical perspective on digital work implies that work organisation, further qualification activities as well as technical and software architectures must be developed in close mutual coordination. This can lead to competitive advantages which will be hard to copy if companies manage to internally develop the required design competencies.

Dr. Thomas Mühlbradt, Deutsche MTM Vereinigung e. V.

Conference topics impacted

Work system design	1	(1 = very high 6 = low)
Quality of work	2	
Qualification issues	2	
Industrial safety	6	
Occupational health and safety	4	
Data sovereignty	3	



For more information about ELIAS,
please visit:
www.projekt-elias.de

Application examples of the Industry 4.0 Platform

The Industry 4.0 Platform has compiled more than 200 practical application examples on its website. In the context of “working in the digital world”, three projects will be presented as examples from this compilation. Detailed information about the project compilation of the Industry 4.0 Platform can be found at:

<http://www.plattform-i40.de/I40/Landkarte>

The KapaflexCy project

Self-organised capacity flexibility for Industry 4.0

Lean production that keeps pace with customer requirements calls for flexible and timely personnel deployment. Practical approaches, however, are often still based on manual operations and therefore extremely costly and inefficient: Team leaders and shift foremen coordinate the presence and absence times of workers. They do this by communicating verbally, usually on a daily basis, with workers, supervisors and other team leaders.

BMBF's KapaflexCy project has developed a self-organised capacity management concept that allows companies to manage their production capacities with the direct involvement of workers in a flexible, short-term and company-spanning manner. Even with fluctuating workloads and unstable markets, companies can respond faster, avoid unproductive times and reduce capacity management costs. Employees experience transparent personnel planning and coordinate their working times with each other.

What measures were used to develop the solution?

This was made possible through the use of mobile devices and the digitisation of production. These devices provide realtime information about the production environment, learn typical requirement situations as well as the appropriate capacity profiles and combine them with communication functions for the employees. This serves as a basis for developing a capacity coordination platform. Employees can use the platform in order to autonomously adapt their working time to demand. For this purpose, capacity assessment, deployment generation and mobile deployment coordination methods are designed and implemented in prototypes. The new method is being evaluated in three pilot applications.

The Floor Care Zukunft project

Kärcher: Future-enabled assembly system for scrubber driers

At the company headquarters in Winnenden, Germany, Kärcher manufactures a particular scrubber drier type for which 40,000 different variants are possible depending on customer specifications. This complexity as well as continuously growing orders and production quantities call for production optimisation: With a host of new technical features and Industry 4.0 elements, the line is much more functional and flexible than the previous system.

There is no master plan for Industry 4.0. But one thing is certain: Without a design for Work 4.0, Industry 4.0 will fail. This requires more qualification, more co-determination and supporting labour market policy. The central orientation must be: Digitisation will only succeed with employees, not against them. What is needed is reliability in change, fair and equitable change and more co-determination.

Jörg Hofmann, President of the IG Metall union

The solution is based on the identification of workpiece carriers using RFID communication, realtime analysis of possible problems as well as process optimisation tools. An SAP interface ensures transparent data and information.

The application enables more efficient and transparent execution of manufacturing jobs. Thanks to the new system, the 40,000 machine variants can be handled on a batch-size-1 basis. The workers receive job-specific information, with assembly information contributing towards a better quality level.

What measures were used to develop the solution?

Before manufacture of a new machine starts, a QR code is generated through which the complete information relevant for production can be accessed. This information is also contained in an RFID chip attached to the workpiece carrier. The data is read at each work station, with detailed assembly information being subsequently displayed on the screen of the corresponding workplace. The parts to be assembled are supplied by a material flow system which considers the actual consumption of the production line. This method is very flexible and enables a reduction in parts

stocked near the assembly line so that the manufacturing process is optimised. A pick-by-light system additionally informs workers which components are required for the current production step. Should a problem occur, assistance from support personnel can be requested via each of the 20 touchscreens. Testing is the last activity at the assembly line. After the complete functionality of the scrubber drier has been ensured, the QR code is scanned and the machine posted in the system as fully assembled and tested. Production is then completed.

Industry 4.0 is a highly interactive sociotechnical system. Past experience shows that neither purely technology-centric nor purely human-centric design approaches can lead to a sustainable improvement in competitiveness. This is why a systematic overall view of the human, technical and organisational factors is a prerequisite for the management and organisation of processes in Industry 4.0 in order to design executable, tolerable, reasonable and satisfactory work. In this context, recent developments have created new momentum for issues like “digital factory”, “manufacturing data analytics” and “human/machine interaction”.

A concrete example is collaboration between humans and robots where specific human skills, such as the ability to learn and decide as well as flexibility, are combined with typical robot qualities, such as endurance, power and precision. Innovative, adaptive planning tools are needed in order to exploit the vast potential of automation, especially at small and medium-sized enterprises. This includes the software-based (partially) automated selection of robot systems on the basis of an in-depth analysis of the manual process as well as the use of custom-configurable human models. Besides better ergonomic conditions, this enables decoupling of the worker’s personal performance from the specific performance requirements of the work system in order to ultimately create age-compliant working conditions.

Prof. Dr.-Ing. Jochen Deuse, Institute of Production Systems, TU Dortmund

The Elabo information management project

Digital networking of all major instances of the value chain

The Elabo information management system connects all major instances of a company’s value chain in realtime via a database solution and the network of the parent company Euromicron AG. Efficiency, transparency, plant availability, quality assurance and service performance can be improved in this way whilst at the same time reducing costs and avoiding waste.

What measures were used to develop the solution?

Data glasses with text descriptions, even in different national languages, as well as visualisations guide workers through the different work steps. This also means that workers with lower qualifications can be employed. Employees can even control their workplaces from home using a tablet, for instance.

Humans will continue to be centre stage. They will direct Industry 4.0: Only humans bring intelligence and creativity to production. This is why Industry 4.0 needs a competent workforce.

Michael Ziesemer, President of the German Electrical and Electronic Manufacturers’ Association (ZVEI)

All workplaces use a uniform graphic user interface and permanently exchange data without any change in media. This data is automatically stored by the system and thereby enables a high degree of traceability. This helps customers to master ever-growing data flows while reducing complexity at the same time.

New workplace models

The discussion on the future of work is characterised first and foremost by technological progress in addition to a host of socioeconomic factors. In conjunction with the changes in work and process organisation mentioned earlier, new digital technologies will enable even individual and personal workplaces to be completely redesigned. Apart from the necessary data protection measures, completely new questions will arise in terms of health protection and industrial safety. Digital technologies will increasingly require greater working speed and flexibility from employees. Technical systems must be designed to protect workers from excessive strain and continued exposure to stress. The greatest success can be achieved here by including working conditions in the development of technical systems from the very beginning, by developing technology and work organisation parallel and by involving employees in the processes of introducing new technologies. The laws and rules for relations between the social partners are equally important in order to limit the process of de-structuring organised work through the use of digital technologies.

Other questions that arise concern the qualifications needed by workers who are today still directly employed at industrial firms. Further qualification activities urgently need to be expanded. Digital systems are to enable further professional development through informal learning and the use of intelligent adaptive assistive systems in order to counteract the risk of qualification polarisation. Adaptable human-machine interfaces will have a key role to play in the design of future automation solutions, and their design should lead to a high degree of acceptance among users as well as maximum intuitive use. In order to increase user acceptance, participatory processes are needed during the development and introduction phases, as well as systematic analyses with a view to the usability of the new digital assistive systems. The former calls for greater co-determination and better involvement possibilities for the workforce. The latter requires greater interdisciplinary co-operation which can lead to new disciplines where human perception and behavioural psychology will already be more relevant during the system development process.

In the coming years, it is foreseeable that integrated assistive systems will be increasingly developed on the basis of the current state of the art and will become a completely natural part of future human/machine systems. This may also permit the development of real tutor systems which could assume some of the functions of experienced employees. Such highly adaptive assistive systems will require powerful sensor systems which comprehensively consider not just the production process alone, but also the workers. The main task in this context is not to measure worker efficiency although the systems have considerable potential to do this. What matters instead is to identify the condition of a worker at any given point in time, i.e. tired, distracted, etc. (vital data monitoring). This also includes the specific worker's skills and abilities. The result is potential total surveillance of working humans with masses of personal data being captured. Note, however, that this is inevitable in order to implement highly adaptive assistive systems. A legal framework is hence required in order to rule out the use of data for more extensive surveillance of employees.

Mechanical engineering means building the future – We are building Industry 4.0. As the largest industrial employer in Germany, we are aware of our responsibility for people. One thing is certain even in Industry 4.0: Humans are and will always be at the heart of tomorrow's working world!

Hartmut Rauen, Deputy Executive Director, German Engineering Federation (VDMA)

The following use cases illustrate the potential offered by modern digital assistive systems for efficient, worker-adapted workplaces as well as continuous further development of employees.

motionEAP – A system to boost efficiency and provide assistance in production processes

The challenge

The trend towards customised products with a batch size of 1 leads to large numbers of variants and growing complexity in production and logistics networks. The prerequisites for remaining competitive on a global market are a high degree of production flexibility with short assembly, order picking, tooling and learning times as well as high quality standards and low production and logistics costs. Humans with their complex perception abilities as well as their gripping, sensing, hearing and visual capability and their cognitive skills are perfectly positioned to respond to changing market and production conditions in a quick and flexible manner. Besides changes in industry, additional challenges result from demographic change and an ageing society. Due to a shortage of young talent and skilled employees, companies are increasingly unable to adequately satisfy their needs in the respective fields of activity. Furthermore, stricter requirements for workshops for disabled people mean that new ways of employment and therefore also of support must be found for persons with impairments.

The motionEAP project

BMW's motionEAP project aims to develop user and process-orientated assistive systems for assembly and order picking processes and to implement and evaluate prototypes. The user-orientated development process is to reconcile the requirements of industrial companies and the needs of performance-impaired users. The assistive systems are to reduce the complexity and the time needed to train employees at different performance levels and with different professional backgrounds for new fields of activity.

Impact on the work environment

The use of motionEAP primarily concerns workers in the immediate assembly and order picking environment. First experience and results show that the use of the assistive system can enable more demanding tasks and/or increase the number of work steps per task and hence the performance level of workers with impairments. This change takes place without increasing cognitive burdens. Variable and flexible adaptation is possible not just with a view to the sequence of work steps, but also for the use of working space, for instance, by using both hands and picking several



small parts at the same time. Since a new assembly process can be set up quickly and without the need for complex explanations, the physical design of the work space and the arrangement of tools and equipment can be changed at any time. The training process which was previously necessary due to time-consuming training, demonstration and support during the initial phase can be significantly shortened or even replaced by the assistive system. Autonomously and without human support, the system can train an unexperienced worker with normal capabilities. The system additionally offers foremen a high degree of flexibility when it comes to their additional tasks of managing and planning assembly jobs. The assistive system can enable workers at different performance levels to execute complex activities with a large number of work steps at a constantly high level of quality.

Conference topics impacted

Work system design	1	
Quality of work	2	
Qualification issues	1	
Industrial safety	3	
Occupational health and safety	3	
Data sovereignty	2/3	(1 = very high 6 = low)



For more information about motionEAP, please visit:

www.motioneap.de

APPsist – Assistance and knowledge transfer: the example of installation and maintenance activities

The challenge

One consequence of the transformation to Industry 4.0 is the continuously growing complexity of machine operation and maintenance, production management and control. The parallel successive decline in the number of production workers with increasing work process complexity is leading to a rapidly and strongly growing demand for information and professional expertise. This is where intelligent adaptive assistive and knowledge services can help by providing formal and informal knowledge and know-how in a form that is adapted to the workers' knowledge and tasks.

The APPsist project

BMW's APPsist project aims to develop a new generation of mobile, context-sensitive and smart adaptive assistive systems for knowledge and work support for Industry 4.0. The AI-based knowledge and assistive systems helps workers to acquire knowledge and skills in interaction with the machines on the shop floor. This is carried out by opening the APPsist system on a mobile device where the system proposes specifically selected contents and activities, thereby helping workers to acquire knowledge and perform activities which they were previously unable to perform. Empirical knowledge can be acquired and knowledge gaps closed in this way.

Various application scenarios were developed in the APPsist research project for demonstration and validation purposes in co-operation with industrial application partners. These scenarios were deliberately defined with significant variability of the relevant "target group" and "complexity" parameters in order to demonstrate the performance and broad effectiveness of the APPsist system.

Impact on the work environment

The use of the APPsist system requires only minor changes in workplace layout because the device is mobile rather than stationary. However, certain changes are necessary because a suitable place must be found where learning contents can be processed outside the closely guided assistive steps, especially for learning time as a secondary activity. Work organisation must be adapted in such a manner that learning times are available in a plannable manner.

Although management and leadership structures will not change, demands on direct superiors will change with a view to a systematic design of qualification meetings and target agreements.

The solution approach

An assistive service can lead to monotonous work and restrict workers' autonomy through strict process definitions, but it can also enable greater work diversity and support learning near the place of work. The technical infrastructure designed for APPsist consists of mobile devices, concrete process support and a networked knowledge base and thereby opens up considerable possibilities for the second scenario. However, the technical provision of support services alone does not yet have a clear impact on work processes. Interaction between technical and organisational implementation is decisive for the concrete manifestation. This is why guidelines for system design and implementation as well as modules for works agreement templates are also developed in APPsist in order to enable practical implementation that supports qualifications and promotes autonomy.

The potential of the APPsist systems for skilled workers is not so much to provide assistance during the performance of process-related activities but to support activities typical for experts, i.e. knowledge integration, knowledge generation, process optimisation, etc. This means that different services and different adaptation rules may be required for this target group.

Conference topics impacted

Work system design	3	
Quality of work	1	
Qualification issues	1	
Industrial safety	4	
Occupational health and safety	4	
Data sovereignty	2	(1 = very high 6 = low)



For more information about APPsist, please visit:

www.appsist.de

InSA – Integrated protection and safety concepts for human-robot collaboration in cyber-physical work environments

The challenge

Robots and people will work closely together in the factory of tomorrow. Up to now, robotic and human workplaces have been strictly separated for safety reasons, for instance, using safety fences. However, if they were to co-operate closely this would promote efficient and smooth production. And when man and machine work together today, the robot stops immediately as soon as a dangerous situation is detected. The consequence of this is that production slows down or comes completely to a halt. What's needed are new protection concepts that permit close interaction between both players and keep disruptions in operations to a minimum.



The InSA project

As part of BMWi's InSA project, researchers are working on a comprehensive protection model that includes the user of a robot and his context, his environment, his activities and interaction. The system records all current activities and, taking the context and respective situation into account, assesses the risk potential which workers, for instance, could be exposed to due to robot movements. Wearable computing offers such a solution: Networked sensors integrated into typical work clothes can detect the positions of the worker's body parts and can be combined with safety equipment to form a robust system. The aim of this project is technical standardisation of these context-orientated production systems and their integration into smart pro-

duction environments. The system is being developed and tested for an assembly scenario in the automobile industry where the technical requirements for a suitable integrated protection and safety system are defined and measures identified on this basis.

Impact on the work environment

The analysis of the effects of human/robot collaboration on the design, assembly, programming and maintenance functions of a company showed that the effects on workers in the assembly process are relatively small whilst a greater impact can be expected in the case of designers, service technicians and programmers of CPS-based human/robot collaboration systems. Effects on the work process cannot be ruled out especially during the development of the human/robot collaboration system and during maintenance in the use phase. Designers of machines for human/robot collaboration systems will therefore be faced with the greatest changes in the fields of communication, co-operation, interdisciplinarity and knowledge acquisition. This is primarily due to the fact that the development of human/robot collaboration systems is a very complex task because the integration of "unsafe" CPS components and the need to warrant their interoperability are extremely demanding. Unlike conventional systems which are based exclusively on safe components, the major challenges that now need to be overcome are the implementation of a safe system for human/robot collaboration with a functionally safe design of the CPS protection components and the need to meet process-specific realtime requirements. This requires detailed knowledge of safety standards and of the specific characteristics of cyber-physical systems. This has direct implications for the integration of and co-operation with interdisciplinary development teams and for the further development of IT knowledge.

Conference topics impacted

Work system design	1	
Quality of work	3	
Qualification issues	2	
Industrial safety	2	
Occupational health and safety	2	
Data sovereignty	4	(1 = very high 6 = low)



For more information about InSA, please visit:
www.insa-projekt.de

Soziotex – Sociotechnical assistive system for production work in the textiles industry (impact of Industry 4.0 on work at a weaving mill)

The challenge

Modern textile machines are becoming increasingly complex as the number of electronic components, such as sensors and control modules, increases. This calls for more extensive operation and maintenance skills of all employees and especially older ones. The development and implementation of intelligent human/machine interfaces is a key field of action in order to enable primarily small and medium-sized enterprises to keep pace with the latest trends and to innovate. The use of assistive systems as technical support enables age-compliant work and qualification-specific assistance for employees who can then keep their jobs.

The Soziotex project

BMBF's Soziotex project aims to design, develop and introduce technical and social innovations for the textiles industry which are necessary for successful human/machine interaction with a focus on the implementation of intelligent human/machine interfaces, such as assistive systems. However, human resources, organisation and training issues will also be integrated as so-called "soft" factors into this research from the very beginning. The implementation of newly developed production techniques and processes as well as the integration of assistive systems have been and will be analysed using the example of weaving mills.

Digitisation is a challenge for the co-operative study system and a benchmark for its future capability.

Prof. Dr. Friedrich Hubert Esser, President of the Federal Institute for Vocational Education and Training (BIBB)

Impact on the work environment

IT systems will become assistants to workers in textile manufacturing. Computerised assistive systems will analyse the vast amount of operating data from machines, regarding, for instance, wear of mechanical components and will make the data available in edited form to workers as needed. Depending on the worker's authorisation level, he or she will then ultimately decide whether to change the worn part or shut down the machine. The assistive systems can identify the worker and his or her work profile and provide context-related information. Extended and changed worker competencies are required because part of the work content will change. A design of assistive systems which is conducive to learning supports the necessary development of competencies. When workers have a thorough understanding of processes and machines, this reduces the risk of production outage and accidents at work. In order to address the target stakeholders and acceptance by future users, the analysis focuses on the employees and their specific needs in order to design system components that are conducive to communication and learning and to evaluate the ergonomic situation at the place of work. This approach can help to remove concerns among workers with regard to new manufacturing processes and methods. The processes to be developed must provide employees with freedom to assume responsibility and to develop solutions on their own.

Conference topics impacted

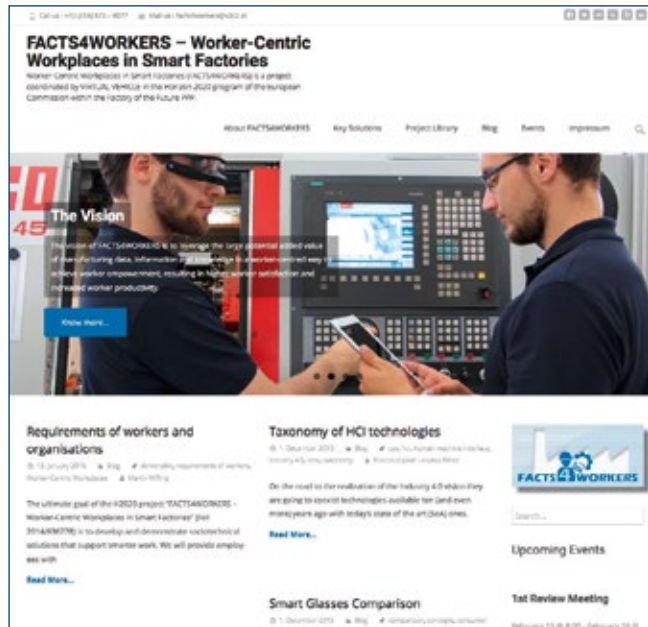
Work system design	1	
Quality of work	2	
Qualification issues	2	
Industrial safety	3	
Occupational health and safety	4	
Data sovereignty	3	(1 = very high 6 = low)



For more information about Soziotex, please visit:
www.soziotex.de

Projects at European level

FACTS4WORKERS



FACTS4WORKERS was launched in December 2014 as a European research project with a project volume of around eight million euro and 15 European research partners. The project moves people into the centre of modern production. Co-ordinated by the VIRTUAL VEHICLE Research Center, the consortium wants to identify ways of giving workplaces in the factory of the future an attractive and intelligent design and of strengthening production in Europe because more qualifications and greater investment in factories are expected to create new and better jobs in Europe.

The results of the research project are expected to open the door to a new industrial era where so-called “smart workers” are optimally supported by information and communication technology in order to enable flexible, efficient and reliable production. In this way, local competitive advantages will be used and (central) European production locations given a long-term perspective.

FACTS4WORKERS focuses on four application cases. Innovative interaction mechanisms, such as data glasses, are to display production information in the machine operator’s field of vision during work (assisted machine operator). Smart workers are provided with information when needed. Equipment to be used at the place of work is to feature intuitive interaction mechanisms via speech, touch or gesture rather than relying on text input (human-centric knowledge management). Smart networking of the large amounts of data generated in smart factories is required. This will provide predictive support for maintenance, spare-parts ordering and machine tooling (self-learning workplaces). Mobile, personalised and situation-adaptive learning systems will support life-long learning and the cross-generation transfer of know-how, especially in the context of demographic change. Context-based learning, fabrication lab concepts (FabLabs) or simulation in virtual-reality environments will qualify new production workers with the knowledge level of smart workers. Data glasses and wearables will provide suitable input and output possibilities for many applications (in-situ learning).

For further information: <http://facts4workers.eu>

MANUSKILLS



The MANUSKILLS project aims to trigger interest in manufacturing among young people through information and communication technologies as well as new training methods. Furthermore, age-compliant training tools for new production methods are to be developed for young adults. The project is specifically designed to conduct playful experiments with channels that attract young people, such as serious games (learning games), learning factory methods as well as social media and augmented reality. The project also determines an educational framework that ideally combines personal further qualification needs with production requirements.

MANUSKILLS targets teenagers whose interest in manufacturing is to be triggered, as well as young adults who are interested in acquiring skills for the new production methods within a shorter period of time.

MANUSKILLS has been sponsored by the EU since September 2013 and eight partners are co-operating in this project.

For more information, please visit:
<http://www.manuskills.org>

Satisfactory – Industry 4.0 becomes Work 4.0



In the Satisfactory project, solutions are being developed and tested to ensure maximum benefits from the latest technologies for shopfloor workers. Smart sensor technology is used here to identify and assess situations and to proactively trigger measures when necessary. Training and knowledge exchange are supported by intuitively understandable augmented-reality glasses. Collaboration platforms support co-operation among workers. Furthermore, worker motivation to perform even unpleasant tasks is to be increased through playful concepts.

The concrete solutions have so far been deliberately left open and are to be developed at the beginning of the project in a user-centric design process. Interviews will be conducted with employees in the factories involved in the project in order to explore their everyday working situations. Context scenarios and user scenarios will then be used to develop concrete solution concepts in several iterations, always with the involvement of the factory workers.

The Satisfactory research programme was launched in January 2015 with ten partners from five European countries.

For more information, please visit:
<http://www.satisfactory-project.eu>

Work 4.0

Taking work to the next level

New technological developments as well as a change in social values and demands on the organisation of work will lead to a fundamental transformation of the working world in the years to come. With digitisation entering all areas of our lives, employees are increasingly interested in more personalised professional biographies and a better work-life balance. This means new tasks, opportunities and challenges. With the “Work 4.0” dialogue process, the Federal Ministry of Labour and Social Affairs (BMAS) aims to focus on the needs and demands of workers, reduce concerns regarding new technologies and outline how personal freedom can be combined with social security.

Under the “Industry 4.0” catchword, the use of computerised, networked machines in industrial production has been the subject of intensive debate in recent years.

This debate was characterised by its focus on what is technically feasible whilst the labour factor and the impact

of new technologies on the working world and workers were largely ignored. With “Work 4.0”, BMAS has triggered a dialogue that is primarily designed to lead the debate on Industry 4.0 on a broader basis as a debate on the future of our working society. This is rooted in the conviction that technical and social innovation must be linked if the digital transformation process is to succeed.

For this to happen, we will have to find new answers: How exactly are digitised business processes changing work in factories? How are activities and job descriptions changing? How must education and job training systems respond to this? What can be done to counteract the loss of qualifications? What new physical and psychological demands on workers will arise in human/machine interaction? And what requirements must be considered in order to protect the data of employees?

Digital work should also be good work. The aim of the debate on Work 4.0 is a humane working world for tomorrow.



The chances for this are good if the design options are jointly used. This calls for a generally optimistic attitude: Even if some popular publications have once again forecast the impending “end of labour”, it is unlikely that we will run out of work. Instead, we can expect a profound change in the work profiles of various professions, and we should prepare for this. At the same time, automation processes can help to create better working conditions thanks to machines that relieve humans of monotonous and unhealthy tasks.

The first answer to a changing working world is life-long learning. More than ever before, qualifications and professional development are key to good opportunities on the labour market and the preservation of one’s earning capability. Employees and employers must be made aware of the fact that continuous professional development is the only way to maintain working capability. We also need to discuss the role of the Federal Employment Agency in this context.

At the same time, we should use the emancipatory potential of technology: Digitisation is opening up new options for employees, for instance, opportunities for a better work-life balance which can be considerably facilitated by flexible working times and places. Employers and social partners need the freedom to compromise so that they can reconcile the needs of the company on the one hand and the workforce on the other.

This momentum must also be used to design digital change in such a manner that new participatory options are focused on and existing communication structures improved. Digital change generates challenges for the system of co-determination: Greater internationalisation, division of labour and increasing work flexibility in terms of place and time can be obstacles to active co-determination for employees irrespective of the rights which they may formally have. They will find it more difficult to experience common problems as such and to voice and enforce collective interests. This calls for new forms of organising practical co-determination at companies, all the more so because the younger generation, in particular, has a keen interest in participation and is demanding more transparency, participation and cooperation at companies. The principle of guaranteed co-determination will be essential when it comes to using the enormous potential of digitisation in the interest of economic success and self-determined living.

Online platforms in the on-demand economy are about to become new nodes for the performance of services beyond the boundaries of regular employment. Although such business models are today still a marginal phenomenon, this development needs to be monitored closely because fair and equitable pay and social security must also be warranted by these new forms of earning money. The question as to how such protection measures can be sensibly configured is an important topic of our debate.

With the “Work 4.0” dialogue process, BMAS has set the framework for a partly public, partly technical dialogue on the future of the working society. This is not limited to work in the new production worlds of Industry 4.0. Instead, this dialogue aims to address and co-design the social conditions and rules for the future working society on the basis of the normative role model of “good work”. The dialogue process is designed as exchange between politics, academia, social partners and civil society. It aims at social education and societal self-understanding (public dialogue) on the one hand and at developing design opportunities and concrete options for action (technical dialogue) on the other. Furthermore, the technical dialogue is accompanied by BMAS research projects.

In April 2015, Federal Minister of Labour and Social Affairs Andrea Nahles presented the “Work 4.0” Green Paper as a basis for the dialogue process. The Green Paper outlines key trends, changed values and important fields of action for the future working society and asks 30 key questions on six fields of action. The dialogue process is to be completed by a “Work 4.0” White Paper at the end of 2016. This document is to present the findings and results from the dialogue and to discuss design options.

However, the debate on topics related to the working world of the future will not be limited to the technical level. A broad-based public discussion is needed in order to make citizens aware of the issue. Existing formats, such as the partnership for experts, the IT summit platform “Digital Working World” and the “New Quality of Labour” (INQA) initiative will also be used for this purpose. A half-time conference on 15 March 2016 and a final conference, presumably in November 2016, will offer platforms for extensive exchange with partners from different fields of society, i.e. academia and practitioners, associations and social partners, politics, business and civil society.



AUTONOMIK für Industrie 4.0

In the years to come, the highly flexible production of individual, digitally enhanced products and services will make its way into industry. Value added processes will change and new business models will arise. Germany's economy will have to take up this challenge in order to expand its current leading position. Industry 4.0, the so-called fourth industrial revolution, is the key to this change.

"Industry 4.0" describes the link between components and machines in the physical world and the communication possibilities offered by the internet. Workpieces will have electronic intelligence paired with an electronic memory. They carry with them the information about the required processing steps and independently activate processing jobs. Smart machines co-ordinate their handling and trigger the supply of the materials required. Industry 4.0 technologies are the foundation for a new quality in production networks and value chains across companies and borders, for new methods in the development and design of new products and services, as well as for the creation of new business models.

With its Industry 4.0 Future Project, the Federal Government has launched a new focus for its technology policy. The "AUTONOMIK für Industrie 4.0" technology programme by the Federal Ministry for Economic Affairs and Energy (BMWi) is going a long way to ensure the success of this endeavour. 14 projects involving around 100 partners from industry and academia have qualified for support by the BMWi which is backing the projects with funding in the order of €40 million. Scientific research measures will also address key cross-cutting issues related to IT security, law and standards, as well as the future of work in Industry 4.0.

For more information, please visit: www.autonomik40.de

