# DIGITAL COMPANIONS IN THE FACTORY OF THE FUTURE

## TREND REPORT 2018

CDTM
CENTER FOR
DIGITAL TECHNOLOGY
AND MANAGEMENT

Digital Companions in the Factory of the Future

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## Kindly supported by Siemens AI Lab

The Siemens AI Lab is a co-research and co-creation space for AI-driven industrial innovations.

We provide an open ecosystem for research and business experts from inside and outside Siemens in order to assess, explore and develop future AI-based solutions for Siemens industries.

We live a new way of working with the goal of exploring what Artificial Intelligence can do for Siemens.

The collaboration with the CDTM Trend Seminar 2018 was a promising step towards building this open innovation ecosystem and showed how companies and students can mutually benefit from working together.


## A project of t he Center for Digital Technology and Management (CDTM)

The Center for Digital Technology and Management (CDTM) is a joint, interdisciplinary institution for education, research, and entrepreneurship of the Ludwig-Maximilians-Universität (LMU) and the Technische Universität München (TUM).

It offers the add-on study program „Technology Management" for students from various backgrounds, which provides students with tools and knowledge at the intersection of business and digital technologies.

The entire trend report was written by CDTM students under the close guidance of research assistants. For more information about the CDTM and its related projects, please visit www.cdtm.de.

# PREFACE OF THE EDITORS

As Herman Kahn, one of the founding fathers of modern scenario planning, nicely states, it is tremendously important for strategy and policy makers to get a deep understanding of possible future developments in order to be prepared for them.

The Center for Digital Technology and Management (CDTM) aims to empower innovators of tomorrow. It is our mission to equip our students with the tools and knowledge they will need to become responsible leaders, who actively shape their future environment, rather than only react to changes.

This trend report is the result of the course Trend Seminar, which is part of the interdisciplinary add-on study program "Technology Management" at CDTM. About 25 selected students of various disciplines, such as Business Administration, Economics, Psychology, Computer Science, Electrical Engineering, and others, work together on a relevant topic related to ICT. Over the course of seven intense weeks of fulltime work, the participating students dive deeply into the topic of the Trend Seminar. Working in several interdisciplinary sub-teams, students apply the knowledge of their main studies and learn new perspectives from their team members. They conduct trend research, develop scenarios of the future, generate ideas for innovative products or services, and detail them out into concrete business concepts.

> **"Everybody can learn from the past.
> Today it is important to learn from the future."**
>
> Herman Kahn

We would like to take the chance to thank everyone who contributed and made this CDTM trend report possible:

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We want to thank Siemens AI Lab for supporting this Trend Seminar. Particularly, we want to thank Siegmund Duell, Bernd Blumoser, Dr. Ulli Waltinger, Rebecca Johnson, and Lucas Bock for their great interest in the topic, the valuable insights and feedback throughout the whole project, and the collaborative organization and topic definition of this Trend Seminar.

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Last but not least, we would like to thank the CDTM students of the class of Spring 2018. They put great energy and enthusiasm into this project, which made it a pleasure for us to supervise the course and coach the individual teams.

Gesa Biermann and Philipp Hulm
Center for Digital Technology and Management

# PREFACE OF THE PROJECT PARTNER

Digital technologies are constantly pushing us towards an ever more connected world and have a significant impact on our daily private life and business environment. While we are already used to talking to our personal digital device to get information from Siri, Alexa, or other voice and virtual assistants, our workplaces in general and especially in factories still heavily rely on non-personalized manual processes. However, with increasing complexity based on future individualized manufacturing, new technologies such as Natural Language Processing (NLP) and Artificial Intelligence (AI) provide an ideal growth medium for companies to offer personalized assistants to support processes in "Smart and Digital Factories". This opens up new potentials for more efficient work processes on the one hand and an easier working life for employees on the other hand. But which technologies are best suited for such digital companions? How are employees' needs best addressed? Which data is available or required? Which use cases for digital companions offer tangible support for the employees and are accepted by them? And which digital companions can both make an impact now and sustain in future factory environments?

> **"No matter who you are, most of the smartest people work for someone else."**
>
> Bill Joy, Sun Microsystems

The goal of this Trend Seminar was to identify current trends in the field of digital companions in factory processes and to derive four future extreme scenarios as well as five related business ideas. The business ideas focus on how digital companions can support current work processes and employees in a factory and make factories fit for the future.

This report will be an inspiration for Siemens employees and a possibility to learn about new trends and technologies.

With its focus on the needs of employees, the reader understands the added value that technology can bring to people. We plan to build on the ideas generated during the project and develop digital companions that support people and improve their work.

We would like to take the chance to thank everyone who contributed to this project. It was a pleasure to experience the energy surrounding the CDTM throughout seven intense weeks. First of all, thank you to the 24 students for their great commitment, enthusiasm and curiosity towards the project. The interdisciplinarity and various backgrounds were a great source of inspiration and have led to a multitude of interesting ideas. We wish you all the best in your promising future path(s). A special thank you goes to Gesa Biermann and Philipp Hulm for the fantastic organization, the excellent communication and the great support of the students. Thank you to Reinhold Götz for showing us around at the Gerätewerk Erlangen and bringing us in contact with many employees. Thank you very much to Dr. Ulrich Roßgoderer for his commitment and his great talk on Digital Manufacturing.

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And finally thank you to all Siemens employees who were available to the students for their questions.

Enjoy reading!

Benno Blumoser, Lucas Bock, Siggi Duell & Rebecca Johnson

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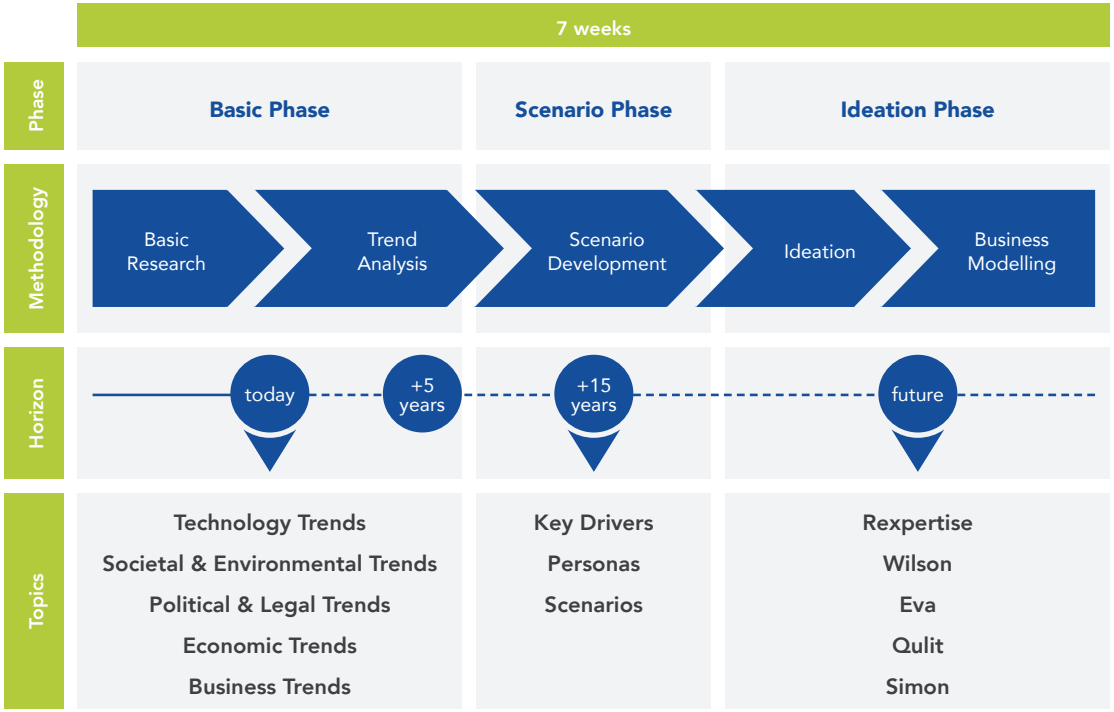
# METHODOLOGY

For a given topic that is highly impacted by digital technologies, the Trend Seminar pursues three main goals:

- To analyze the status quo, recent developments and identify important trends
- To develop extreme scenarios of the future, in order to be prepared for upcoming challenges
- To develop future-proof product and service ideas and detail them out into business concepts.

These goals are represented by the three phases of the trend Seminar: The Basic Phase, the Scenario Phase, and the Ideation Phase.

Twenty-six students, supervised by two doctoral candidates, pursue the Trend Seminar in seven weeks of intensive full-time work alongside their project partner. In each phase, interdisciplinary subteams are formed including students from technology, business, and various other backgrounds to com-




The **Basic Phase** yields a holistic overview on recent developments and trends in the environment of the overall topic. Based on the STEP approach (Social-Technological-Economic-Political), the status quo and trends in the fields society & environment, technology, economics, politics & legal, as well as emerging business models are analyzed. Knowledge is gathered by literature research, preceded by a series of input presentations by experts on the topic.

The class is split into five teams, each working on one of the thematic scopes. At the end of the Basic Phase, the teams present their key findings to each other in order for everyone to get a holistic view on the topic to build upon in the following phases.

The **Scenario Phase** builds upon the analyzed trends in order to create four extreme scenarios of different futures in twenty years ahead. Driving forces behind developments are identified and specified as drivers with bipolar extreme outcomes. Once specified, all drivers are ranked according to their respective impact on the overall topic and the perceived degree of uncertainty regarding their outcome. Two key drivers that are independent from one another and have high impact and a high degree of uncertainty are chosen and, with their bipolar outcomes, used to create a scenario matrix of four extreme scenarios. A timeline for each of the scenarios is created and the scenarios are sketched out using persona descriptions and visualizations. The Scenario Phase starts with a two-day workshop followed by group work in four teams. Teams are newly formed in order to include experts from each subtopic of the Basic Phase in each new Scenario Team.

In the third phase, the **Ideation Phase**, the goal is to develop innovative business concepts, which are then tested against the previously developed scenarios. Within a two-day workshop on structured ideation following the SIT approach (systematic inventive thinking), a large number of business ideas are developed.

Out of these, the most promising five ideas are selected and further developed into detailed business concepts. The business model canvas by Alexander Osterwalder and Yves Pigneur serves as the base structure.

At the end of the seminar, the business model concepts are presented to the project partner and guests.

# LIST OF ABBREVIATIONS

**AAI**
Assisted and Augmented Intelligence

**AGI**
Assisted General Intelligence

**AI**
Artificial Intelligence

**AR**
Augmented Reality

**B2B**
Business-to-Business

**bn**
Billion

**CAGR**
Compound Annual Growth Rate

**Co-bots**
Collaborative Robots

**DRL**
Deep Reinforcement Learning

**DL**
Deep Learning

**DT**
Digital Twins

**EU**
European Union

**EUR**
European Currency Unit

**GDPR**
General Data Protection Regulation

**HRM**
Human Resource Management

**IIoT**
Industrial Internet of Things

**IoT**
Internet of Things

**IPv6**
Internet Protocol Version 6

**k**
Thousand

**m**
Million

**ML**
Machine Learning

**NLP**
Natural Language Processing

**OECD**
Organization for Economic Co-operation and Development

**PCB**
Printed Circuit Board

**PPP**
Public Private Partnership

**SEO**
Search Engine Optimization

**SME**
Small-Medium Enterprise

**tn**
Trillion

**USD**
United States Dollar

**VPA**
Virtual Personal Assistant

**VR**
Virtual Reality

# TRENDS

The following chapter lists current trends that have a strong impact on digital companions in the factory of the future. In accordance with the Basic Phase methodology, trends and related driving forces are structured in five areas: technological trends, societal and environmental trends, legal and political trends, economic trends and business model trends.

# TECHNOLOGY TRENDS

## INFLUENCES ON DIGITAL COMPANIONS IN THE FACTORY OF THE FUTURE

Assisted & Augmented
Emerging Innovative Interfaces
Automation of Complex Physical Tasks
Industrial IoT & Edge Computing
Digital Twins

Ali Kareem Raja, Christoph Moser, Jonas Kerber, Nimar Blume, Tomislav Tomov

# TECHNOLOGY TRENDS

## Influences on Digital Companions in the Factory of the Future

Digital companions are available on a wide range of mobile and stationary devices and offer help in simple everyday life tasks. The added value for consumers provided by this technology can also be extrapolated to a completely different environment: the factory. As a source of tangible economic output in form of physical products, the factory is a place of vital importance to society. Technology is the main driver for human progress and as such plays an indisputably crucial role in how the future of manufacturing will develop. Production involves two central entities - the human and the machine and the identified trends are linked to different parts of each entity in a unique way.

The evolution of Artificial Intelligence (AI) technology is a central driving force for the push toward the Forth Industrial Revolution. In contrast to previous hype cycles, the current wave of popularity is supported by a continuous output of applicable results, exponential data growth and parallelization. Since only a small fraction of occupations are fully automatable with demonstrated technology, it is the cooperation between human and machine that will define the Factory of the Future.

To ensure optimal information exchange between both entities within the collaborative workflow, new and innovative interfaces are required. Virtual Reality (VR) and Augmented Reality (AR) are enabling the user to enter a new world of interacting with machines and further immerse by intuitively manipulating objects via gesture control and tactile feedback. Additionally, advances in conversational interfaces allow a natural way of exchanging information between user and machine.

Furthermore, the execution of physical tasks is an integral part of manufacturing and needs to be addressed in the frame of the future factory. Modern products require complex multi-stage production processes and state-of-the-art robotics emerge from research to meet the challenge. Robots will move around autonomously and share a workspace with humans. Those are collaborative robots (co-bots), which fluently adapt to manufacturing requirements and continuously improve efficiency.

A key prerequisite for a smart factory is digitization. The shop floor, its products and production assets need to be virtually replicated as Digital Twins (DT). These twins are then used not only to measure and track the key performance indicators (KPIs) within the factory, but also to simulate scenarios and predict failures. This results in more efficiency and better products.

Finally, the future factory will be equipped with a high number of sensors that collect data and provide crucial information for the Digital Twin (DT). The continuous telemetry allows for AI-systems to perceive the production environment. Edge computing represents the enabling infrastructure for Industrial Internet of Things (IIoT) comprised by the sensor-equipped smart machinery throughout the manufacturing process and running products on the field.

To summarize, the total is greater than the sum of its parts, as far as technology is concerned. It is the convergence and synergy between each technological trend that will shape the role and importance of digital companions in the factory of the future.


# ASSISTED & AUGMENTED INTELLIGENCE

## Enhancing Human Work during the Transition to Fully Autonomous Intelligence

Recent advances in Robotics and AI are ushering in a new age of automation where machines can match or outperform humans in a range of cognitive and physical activities. Despite the significant progress in Deep Learning (DL), the complex dynamic environments remain challenging even to state-of-the-art technology. The majority of work is likely to be only partially automatable within the foreseeable future [1]. Due to the expectedly lasting need for human intervention, the biggest economic impact of AI arises from Expert Automation & Augmentation Software (EAAS).

Assisted and Augmented Intelligence (AAI) tools based on weak AI enable us to perform simpler repetitive tasks more efficiently which increases overall productivity. Beyond simple assistance lies augmented intelligence: software that actively learns from humans and helps to make better decisions for complex problems. Current and emerging AAI-applications in the field of knowledge work include medical diagnosis [2], trading and investing [3], accounting and auditing [4], law [5][6] as well as robots aiding workers in manufacturing [7][8]. Until the capabilities of AI enable full autonomy by continuously learning from their mistakes, humans will havte to actively supervise them.

### Facts:

- While less than 5% of occupations can be fully automated, 60% of all occupations contain at least 30% technically automatable activities [9].
- Equity funding jumped 141% in 2017 (15.2bn USD raised) and over three times more AI companies entered incubators in 2016 [10].
- A five-fold increase in AI papers from 2015 to 2017, as well as exponential growth in conference attendance and course enrollment, constitute a peak of academic research and public interest on the topic [11][12]
- A full spectrum of AI-powered software that augments the workflows of Doctors, Analysts, Marketers, Lawyers, Accountants and others are already available on the market [10][6][13].

### Key Drivers:

- Democratization of AI through Application Programming Interfaces (APIs), open source tools, data sets, and free learning material empowers non-experts to create new applications [14][15].
- State-of-the-art computer vision methods enable new applications like complex scene understanding [16][17][18].
- Major advancements in NLP allow for real time believable fluent speech generation and understanding [19][20][21].
- Every year, humans with machines generate exponentially more data that serves to train AI systems [22].
- Consumers are accustomed to talking to technology and continuously [23][24] adopt Virtual Private Assistants (VPA) for a variety of everyday tasks [25]-[27].

### Challenges:

- AI technology remains a hardly explainable black box, whose lack of traditional debugging and verification methods may limit certain applications [28].
- Today's AI-powered solutions are custom tailored to very specific tasks (weak AI). Research is being conducted on more broadly applicable systems, however, those are yet to prove their value to the market [29][30].
- Data privacy and anonymization issues may pose serious difficulties since personal data is an essential ingredient for human-centric AI products [31]-[34].
- As AI-technology quickly becomes more capable, legislation is lagging behind and inadequate regulation may hamper its true potential [35].

### Impact on Digital Companions in the Factory of the Future

While interconnected sensors gather vast amounts of information, advancements in AI research allow for making sense of the data and understanding complex environments. Across many different fields and industries, a significant number of products with AAI are establishing cooperation between humans and machines as the new norm. Future factories will be increasingly digital, smart, and highly connected. Ubiquitous AAI-solutions digital companions will play a key role in increasing productivity and efficiency of human workers.

# EMERGING INNOVATIVE INTERFACES

## Redefining User Experience through Novel Immersive Interactions

The release of Apple's Siri in 2011 marked the first day of a new age of interaction between humans and technology by introducing voice as one possible interface of the future. In 2018, talking to a machine has become mainstream and voice-based Intelligent Personal Assistants like Amazon Alexa or Google Home are becoming popular with 27m devices sold worldwide until September 2017 [36]. This was made possible by ongoing research in Natural Language Processing (NLP) which is used in chatbots to enable a natural communication on the level of speech. In parallel, VR and AR revolutionized the way of presenting visual information to the user. This motivated research in other visual niche technologies like Volumetric Displays that leverage 3D Visualization without head-mounted displays. Driven by the quest of making user experience more immersive, innovators are adding tactile and gesture information to interfaces in order to extend interaction by a new dimension. Enabled by the rising popularity of wearables, gestural interfaces present a way of naturally conveying information to a system [37] and giving tactile feedback closes the loop to immerse the human in a tangible system.

### Facts:

- Apple's Siri is being used by 41.4m unique monthly users and Amazon's Alexa globally has more than tripled its usage in just one year to 2.6m users in May 2017 [38].
- Currently, 36% of companies worldwide are using chatbots to interact with customers, 80% will do so by 2020 [39].
- VR/AR startups mainly from the gaming industry raised over 3bn USD in 2017 [40].
- The market for wearables continuously grows with a 17% increase in 2017 and 310m devices sold compared to 265m in 2016 [41].
- Car manufacturers are prototyping gesture control with mid-air haptic feedback to create a new way of tactile interaction [42][43].

### Key Drivers:

- Customers are adopting voice assistants like Google Home and Amazon Alexa [36].
- Speech recognition is three times faster than human typing which leads to an information exchange in human-computer interactions [44].
- New VR applications in manufacturing and education will further increase the popularity of the technology [45][46].
- Immersive user experience can be achieved by stimulating all major human senses which motivates the development of novel interaction technologies on audio-visual and especially tactile level [47].

### Challenges:

- Mobile devices currently lack computational power that is needed for graphically demanding tasks like VR.
- Device costs for new technologies such as Volumetric Displays are still high [48].
- User experience of digital assistants is limited by a lack of personalization and context awareness which confines adoption.

### Impact on Digital Assistants in the Factory of the Future

The immersive experience in virtual worlds provides a realistic replication of a real-world environment which is the reason for the upcoming VR applications in education and manufacturing. In the factory of the future this firstly, enables an efficient way to train workers in new environments and secondly, serves as a new way to test prototypes in a virtual world in order to save iteration cycles in research and development. Furthermore, new interface technology can provide the means for an intuitive interaction between co-bots and unskilled workers.

# AUTOMATION OF COMPLEX PHYSICAL TASKS

## Robots Execute Complex, Multi-Stage Tasks in Production Environments Collaboratively with Humans

Currently, robots are used in manufacturing processes to automate repetitive, precise, and well-defined tasks. They are confined to enclosed cages to prevent interruption and protect workers from accidental injury, as the robots are not aware of their environment. This static setup impairs the factory's manufacturing agility, as changing a product or producing an entirely new one requires reengineering the complete factory floor. This incurs significant costs and production downtime. Advanced automation of complex physical tasks mitigates this issue by making robots dynamically adaptable to their surroundings. Robots will be able to move autonomously and perform multiple stages of various tasks, as per demand. Therefore, direct human-robot interaction will be required as robots will work collaboratively with human workers. Furthermore, liberating the robots within a factory means that production lines will gain agility. Merely a new workflow update must be pushed to the robot fleet to begin manufacturing a new or altered product. Moreover, performance data is collected on each robot to better its productivity. Consequently, that enables the operator to take insights from one robot and push improvements to all entities performing similar tasks, bettering reliability, efficiency, and accuracy over human workers.

### Facts:

- Co-bots sold globally will increase 1000% from 23k units in 2017 to approximately 240k units in 2022 [49].
- RaaS - Robots as a service will become a relevant business sector [50].
- Bionic research in Swarm Intelligence will become relevant as robots learn to execute tasks cooperatively [51].
- Global robotics spending significantly increases from 71bn USD in 2015 to 135.4bn USD in 2022 [52].
- A huge potential for automation exists, for example only 8% of a potential 53% of the US transport industry is automated [53].
- Automated systems offer improved reliability, efficiency, accuracy, focus on task at hand, and ability to work in danger zones [54].

### Key Drivers:

- Human worker wages are high compared to robots, in the automotive industry 40 EUR per hour compared to 5-8 EUR per hour [53].
- Increasing demand for customized products increases the need for agile manufacturing.
- Governmental and social pressure to bring back high-tech manufacturing into western home countries.
- Improved indoor navigation through laser scanning, optical identification, and indoor positioning systems.
- Large amount of data can be automatically generated by automated systems leading to new insights into production.

### Challenges:

- Managing many autonomously acting robots in a single environment
- Deploying robots to the same space where also humans work, while prioritizing human safety
- Viable human-machine interaction with untrained humans
- Standardized protocols for robot–robot interaction
- Robots should explain the reasoning for their own actions to gain acceptance, which requires advances in explainable AI

### Impact on Digital Companions in the Factory of the Future

Digital Companions heavily rely on data to inform their users and to evaluate on executing operations. By continuously introducing more advanced robots into a manufacturing environment, the amount of useful data collected increases significantly as robots effortlessly produce data compared to humans. Moreover, a Digital Companion has an all-encompassing overview over the current situation and thus can dynamically direct autonomous robots to assist in tasks requiring more capacity in an instant.

# INDUSTRIAL IOT & EDGE COMPUTING

## Increasing Interconnectedness between Sensors and Computing Systems

The adaption of the IIoT plays a crucial part in the development of the Factory of the Future. The technology is also known in Germany as 'Industry 4.0' and has already been around for many years. However, it is only estimated to contribute in a productive manner within the next two to five years. Concurrently, edge computing is one of the emerging trends, which means that data processing moves closer to the devices where it is collected [55]. Together, both trends lead to an increase of smart networking infrastructure and sensors at the edge which can pre-process and interpret data on-device rather than sending raw data to the cloud. In the last years, spending on Internet of Things (IoT) applications in corporate environments has been higher than for consumer products [56]. Despite anticipated change during the next years, the potential economic impact of IIoT applications is going to be ten times as high as the impact of consumer IoT products [57]. This will have a significant influence on manufacturing driven economies like Germany, since widespread implementation of IIoT is believed to increase productivity by 30% [58].

### Facts:

- Globally 73% of executives say they are making substantial investments into IoT at the moment [59].
- IIoT has a projected CAGR of approximately 23% between 2016 and 2021 [60].
- The share of the gathered data in companies which is processed at the edges of the network will increase from 10% in 2017 to 50% in 2022 [61].
- IoT in factories has a total potential impact of 1.2tn - 3.7tn USD per year in 2025 [57].
- Out of total spending on IoT Infrastructure, 18% will be on edge infrastructure by 2020 [62].
- Worldwide number of connected IoT devices will increase to 100bn in 2025 [63].

### Key Drivers:

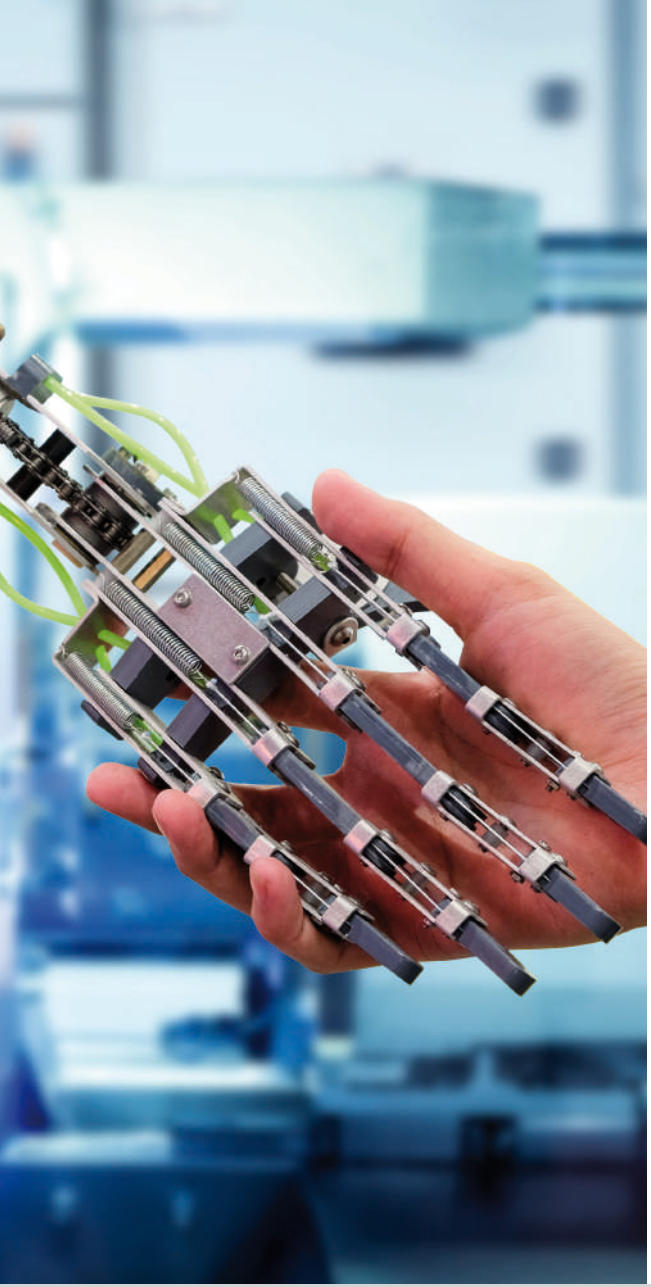
- Average prices for IoT sensors decrease from 0.70 USD in 2014 to 0.38 USD in 2020 (45% drop) [64].
- Package size of MEMS sensors such as three-axis accelerometers shrunk by 70% between 2008 and 2015 [65].
- 5G provides sufficient network capabilities, decreased latency, and new protocols to make use of edge infrastructure [66][67].
- IPv6 provides a bigger address space for more devices to be connected to the internet concurrently [68].
- Self-healing Mesh networks increase fault tolerance since connections can be dynamically re-routed [69].
- Increased capabilities in data analytics enable the usage of a large amount of sensor data [70].

### Challenges:

- Machine to machine protocols lack standards but interoperability between IoT systems is crucial (needed to capture 36% of the potential value for factories) [71][57].
- IoT applications increase security risks at least significantly according to 75% of IT security experts worldwide [72].
- Many IoT devices are not easily upgradeable or do not have a way to inform users about potential security breaches [68].
- Unclear economic benefits are among the biggest challenges for IIoT according to 46% of German industry representatives [73].
- Only 7% of companies globally have developed a comprehensive IIoT strategy [74].

### Impact on the Digital Companions in the Factory of the Future

Increasing availability of sensor data and the possibility to connect to various devices due to new network technology will change the Factory of the Future. This will set the basic environment for the implementation of Digital Companions. Smart sensors inside factories will be necessary to provide the underlying data for the use of AI. New efforts in edge computing allow Digital Companions to make use of real time data of nearby machines which do not have to be sent to the cloud. IIoT developments will ensure that there are comprehensive communication networks to which the Digital Companion can be connected.



# DIGITAL TWINS

## Digital Footprint of the Factory and Its Products

As wages rise in China and other cheap labor countries, manufacturers face severe pressure to optimize their factories and cut costs. At the heart of this manufacturing revolution is the Digital Twin: a virtual representation of a physical object. DT monitor real-time status, working condition, or position of an object and then transform the physical objects in their digitized form. The use cases include creating twins of factories, products, and production assets and using them for simulation and testing. They enable companies to detect physical issues sooner, predict outcomes more accurately, and reduce rework by 15% to 20% in the assembly process [75]. DT are economically feasible for manufacturers now with the advancement in sensor technology, lowering costs of infrastructure, and the rise of connected devices.

Simulation scenarios and failure predictions provide maximum value out of the several purposes DTs serve. This requires massive amounts of quality data. Consequently, their success in a factory depends on the quality of the data the IoT network generates within that factory and the AI models used for failure prediction.

### Facts:

- DT in manufacturing are used by 19% of European companies [76].
- Computer Aided Manufacturing software usage increased by 37% in 2015 [77].
- The Usage of DT in manufacturing is expected to increase from 18% starting in 2017 to 39% of European companies over the next five years [76].
- The digital twin market is predicted to grow at a CAGR of 24.7% during 2017-2023 [78].

### Key Drivers:

- Manufacturing costs are rising in low cost areas like China, forcing businesses to cut costs by digitalization [79].
- Computing power has become a cheap and abundant resource [80].
- Digital Twin is a concept based on IoT, therefore the rise of IoT and Edge Computing acts as a launch pad for Digital Twin.

### Challenges:

- Designers still produce 2D drawings 39% of the time, which are incompatible with DT [77].
- Data from one department within an organization is often incompatible with data from other departments, creating data silos [81].
- Analysing real time, volatile IoT data has technological issues e.g. model complexity and event streams that need to be resolved [82].
- Digital ethics issues are raised when an organization is interacting with the data from not just the enterprise, but also its partners and customers [83].

### Impact on Digital Companions in the Factory of the Future

DT form the backbone of Digital Companions in a factory setting. They contain all the relevant schematics, diagnostics, and predictions that the Digital Companion needs to assist factory workers in their daily job. For instance, if a repairman wants to know what part is needed to fix a machine, the Digital Companion can retrieve the information from the Digital Twin. Together with Industrial IoT and Edge Computing, DT are the technology that can tailor the Digital Assistant for the Factory of the Future.

# SOCIETAL & ENVIRONMENTAL TRENDS

## INFLUENCES ON DIGITAL COMPANIONS IN THE FACTORY OF THE FUTURE

Pursuit of Self-Actualization
Flexible Work Environment
An Aging Society
The Hyperconnected Society
Diversity as the New Norm
Environmental Conciousness

Felix Krauth, Johannes Lerchen, Leon Szeli, Thea Jung, Thomas Li

# SOCIETAL & ENVIRONMENTAL TRENDS

## Influences on Digital Companions in the Factory of the Future

Society can be described as a mosaic – a reflection of the multitude of human interactions that are intertwined through religious, cultural, scientific, or other purposes. While often understood as a static entity, culture, institutions, organizations, people, and products within a society are dynamic, and inevitably change over time. The groundbreaking technological advancements, coupled with the ever-increasing opacity of human behavior, create fertile ground for an accelerated bilateral influence of individuals on society, and in turn, society on individuals. As these changes begin to actualize, questions arise regarding how and what forces will influence what it fundamentally means to be human – from the way we work, to how we enjoy our free time. Six key trends have been identified that not only affect society as a whole, but also the future workplace.

First, the world is becoming more individualistic, since people strive for self-actualization. As society advances, much of the world has evolved beyond the pursuit of basic needs, and into a desire for personal fulfillment on a higher level. This has been manifested in the growing attention on the individual, in both product design and in the workplace. Key drivers include the increase in global wealth and technological developments that allow for mass customization.

Second, the fabric of how individuals work on a day-to-day basis is now shifting. From shorter power distances between employees and management to decreased importance of face time, concepts of how and where to work are being reinvented. Similarly, changes in employee loyalty and contract length showcase that the job is no longer a separate entity in life, but rather deeply intertwined with life.

Third, demographic changes will heavily impact the structure of society. Due to changes in fertility rates, advances in healthcare, and the shift towards a less family-oriented culture, the average age in first and second world countries is increasing. Questions arise regarding the feasibility of an older retirement age, as well as technological implications that emerge with current changes.

Fourth, hyperconnectivity, often described as the non-stop and frequent connection between individuals, is breaking down barriers of information, and making it easier for thought-leaders and citizens alike to create an online presence and disseminate information. However, such constant connectivity brings about questions regarding the fragility of these numerous social connections, as well as the implications for the workplace.

Fifth, diversity in society is no longer an exception, but rather the norm. Encompassing a wide range of fundamental differences, such as ethnicity and religious beliefs, diversity has now been proven to not only allow societies to embrace one another, but also to correlate with economic success. However, divergence in the acceptance of diversity may occur as migration challenges the fundamental structure of many societies.

Lastly, societies are placing a higher emphasis on environmental protection and sustainability. There is a noticeable increase in demand for environmentally-friendly consumer goods, resource-efficient practices, and resilient infrastructure. Recent research, as well as anecdotal evidence of extreme weather, has ingrained the importance of a healthy environment in the minds of individuals within society.

# PURSUIT OF SELF-ACTUAL-IZATION

## Individuals Seek to Attain Personal Fulfillment in every Aspect of Life

Once a luxury afforded to those in the upper echelons of society, the pursuit of personal fulfillment is now commonplace in much of the world. As the general welfare of people increases over time, needs have extended beyond those that are purely physiological but contribute to the pursuit of self-actualization [84]. Through advanced technology (especially information and communications technology), humans are exposed to a variety of options, ranging from tangible products and experiences to multiple alternatives of education and career paths [85].

The extent to which society desires individualism is manifested in the growing demand for personalization, which can be observed in several dimensions, in both private and professional life. Individuals demand their needs to be addressed on a more individual level, e.g. with personalized products [86]. This is reflected in the ever-increasing popularity of platforms like Amazon with personalized product suggestions or flexible, instant deliveries. Moreover, in their professional lives, individuals are confronted with a variety of choices. As a result, when selecting jobs, they tend to be purpose-driven and seek ownership and meaningful contribution. An attractive employer has to take these individual needs into account by offering room for personal growth and opportunities for individualized fulfillment.

### Facts:

- 89% of German digital natives consider independence and self-determination an important aspect of their life and 87% believe that having a meaningful and fulfilling job with purpose is essential [84]
- In 2015, 20% of British consumers are willing to pay a 20% premium for personalized products or services (in comparison to similar, non-personalized options) [87]
- 64% of Germans stated in 2015 that they want to increase their use of peer-to-peer offerings (e.g. Airbnb, Uber), hence eliminating intermediaries [88][89]

### Key Drivers:

- Global wealth increases and basic needs are satisfied: Worldwide, the middle class grew from 450m in 2000 to 1bn in 2017, with a vast majority (600m) joining from the lower class [90]
- Technological advancements allow for profitable mass customization, e.g. due to flexible production [91]
- Individuals' access to the internet raises awareness of the variety of options due to the availability of broad information [91]

### Challenges:

- Companies have to compete with a variety of job options for applicants [92]
- Employers need to create working environments and products that meet the high demand for personalization [93]
- In order to decrease staff turnover, the company culture must incorporate rising demand for flexibility [94]
- Consumers appear to be overwhelmed by the rising amount of choices in their life [95]

### Impact on Digital Companions in the Factory of the Future

For digital factories in the future, companies must have the ability to meet the high demand for personalization and flexibility. The digital companion must be designed as a user-centric device that addresses the respective needs of the individual. This personal customization is important to stakeholders as self-expression and self-identification are crucial for personal fulfillment and happiness. Also, the organizational structure and leadership styles should enable employees to progress in their goal of reaching self-actualization. Digital companions should also support capabilities for the tracking, recording, and rewarding of the individual's accomplishments so the individual feels appreciated.

# FLEXIBLE WORKING ENVIRONMENT

## Employees Expect Purpose-Driven, Flexible Work with Ownership and Personal Growth Opportunities

As boundaries between professional and private life blur, the way of working shifts towards more flexibility, temporally and spatially [96]. On an individual level, different demands and needs emerge alongside a rapidly changing, uncertain employment landscape. Employers will find themselves in the "Gig Economy" era, where long-term contracts decrease, career paths become fragmented and split into multiple, shorter employment periods [97]. This is associated with high expectations for rapid individual growth, and demands for flexibility, ownership, and autonomy in designing own ways of working. Individuals seek to tailor their working environments and time schedules depending on need: The idea of a workplace is no longer fixed, and sabbaticals, flex-time, and parental leave are increasingly common [98].

Within organizations, power distance between authority figures and employees diminishes, as organizations shift to flatter hierarchies [99]. Open-door policies and open-space environments are now prominent in multiple companies, beyond Google and Facebook. Each employee's voice matters, as individuals become increasingly empowered and are encouraged to live up to their full potential [84]. Feedback loops and supportive mechanisms, e.g. mentorship programs, become increasingly common. Companies need to flexibly adapt to constantly changing dynamics and establish a strong corporate culture to attract and maintain employees.

### Facts:

If given the choice, 44% of millennials (global sample) would quit their jobs to join a new organization or do something different, during the next two years [98]
Of the working-age population in the US and EU-15, 20-30% engage in independent work (self-employment) [100]; the share of workers doing telework is expected to increase [96]
Working hours decreased by 11% between 1970 and 2016, to an average of 35 hours per week [101]

### Key Drivers:

- High competition between employers for attracting and maintaining highly educated and skilled people [102]
- Technological developments such as digital productivity, collaboration, and communication tools allow remote working [103]
- Globalization and reduced barriers to mobility and language increase the pool of career options beyond national borders [103]

### Challenges:

- Potential exclusion of certain societal groups, in particular, lower educated workers or manufacturers, as perks like home office, sabbaticals and flexible temporal and spatial arrangements are mainly accessible to knowledge-based project-related workers [102]
- Individuals need to adapt to fast-paced and flexible working environments while being confronted with the pressure of rising job insecurity and temporary work [104]

### Impact on Digital Companions in the Factory of the Future

The digital companion can be a means to manage desired flexibility, both in terms of time and location. In addition, the digital companion could help with the transfer of knowledge to new working environments or clustered project-networks. It could act as a 'knowledge holder' or aggregator on an individual and organizational level. In a flexible and ambiguous environment, the digital companion can help navigate and manage uncertainties, notify on emerging opportunities or mediate between different stakeholders. Finally, companies can make use of digital companions to provide a voice for each employee fostering inclusive decision-making and innovative, intrapreneurial co-creation.

# AN AGING SOCIETY

## Preparing the Next Generation of Technologies for Previous Generations

The demographic structure of the world is changing; thus, labor and welfare patterns are heavily influenced. By the end of the next decade, the world's population, on average, will become the oldest since its creation [105]. This is accelerated especially due to the advancements in healthcare [106], the decision to delay marriage [107], and lower birth rates [108]. Consequently, the increase in the average age of the population, coupled with the delay of retirement, creates key demographic and work-related challenges. The necessity for women participating in the workforce increases, while the aging of the active workforce results in fewer working-age adults [105]. There will be a growing fight against gender stereotypes, especially targeting equality of voice and compensation [109]. Moreover, as the older generations (Baby Boomer and Gen X) work longer, there is an increasing gap between the speed of technological development and the generations' rate of technology adoption. Similarly, recent technological advancements are starting to accommodate older generations, including airbag hip belts, and smart shoes for seniors [110]. Overall, issues such as pension deficits, healthcare affordability, quality education, and labor structures challenge governments, institutions, and companies alike to adapt to an aging society.

### Facts:

- Median age will reach an all-time high by 2035 in many developed and emerging countries, including Japan, Germany, Russia, and China [105]
- On average, individuals over 60 are the world's fastest growing age group [111]
- By 2050, there will be 3.5 working-age (20-64) people for each older person (65+), compared to 7 working-age people per each older person in 2015 [112]
- Successful aging societies, including much of Europe, see an increase in female workforce participation to offset fewer working-age adults [105]

### Key Drivers:

- Technological advancements in healthcare and preventative medicine help to support the possibility of a longer lifespan [106]
- The continuous shift in the cultural acceptance of individualism places less emphasis on family, and more on self-actualization [107]
- Birth rates decline due to equal access to education as well as ease of access to contraceptives for women in developed countries [108]

### Challenges:

- Social and welfare systems paid by the current working class might not adequately support the aging population in developed countries [112]
- Possible auditory and visual impairments for older individuals, especially for those aged 70 or older; in turn, this may further accentuate the need to replenish the workforce in the manufacturing sector [113]
- General physical challenges in life due to a decrease in mobility and performance, requiring factories to adapt and mitigate problems for older workers [113]

### Impact on Digital Companions in the Factory of the Future

At a macro level, demographic changes across the globe will impact the needs of future factories and shape the requirements of digital companions. There is a clear gap between generations regarding the adoption of technologies, mainly due to slower learning speeds and lower trust in these technologies from older generations [30]. Digital companions in the future should accommodate for how fast technologies are adopted, as well as for different gender needs. When integrating a 'one-size fits all' solution for digital companions, it is important to ensure that work efficiency is kept as the highest criterion.

# THE HYPER-CONNECTED SOCIETY

## Increasing Amounts of Information and Knowledge Offer both Opportunities and Challenges

As the world becomes increasingly globalized, boundaries in transnational exchange of information and knowledge are opening up. While the flow of goods and money have remained constant, data has never flown as freely as today [114]. The advent of digital platforms enables individuals to participate in the global marketplace and debates without intermediate agents. Data is not only more readily available, it is also omnipresent and can reach masses almost instantaneously [114]. As a result, the empowerment of the individual to spread information, influence groups, and become a thought-leader is easier than ever before.

Hyperconnectivity, therefore, democratizes decision-making and increases transparency as knowledge is distributed publicly. ICT technology can provide people with information regardless of their heritage, age or social status. It works inclusively and reduces discriminating factors by drawing in a wide range of different individuals [114]. This fosters the exchange of ideas and facilitates innovation [115]. Also, connectivity changes how individuals are tied to each other: instead of small, strong relationships, diverse weak and volatile ties dominate [116]. Thus, rather than being influenced by one isolated social group, people become part of "several more amorphous groups" and sub-cultures depending on their own interests and values [117].

### Facts:

- From 2016 to 2021, devices and connections (CAGR 10%) are estimated to grow faster than both, population (1.1%) and internet users (7%) [118]
- By 2019, more than half of the world's population will use the internet, equating to 3.84bn people [119]
- Bandwidths between countries have grown 45 times larger since 2005 [114]
- 64% of US email users expect a response to a personal email as soon as possible or in one day [120]
- More than half of Gen X and Y professionals are accessible to work 24 hours a day, 7 days a week [120]

### Key Drivers:

- IoT expands deeply into people's lives: in 2018, there are 20b devices connected to the web [121]
- The seamless flow of data through local and mobile networks provides constant and robust connectivity through increasing broadband access [116]
- Individuals become dependent on connectivity: the majority of Gen X and Gen Y professionals would select their smartphone over their television [120]
- Blurred lines between local and global levels, private and professional spheres, work and leisure, as well as productivity and distraction [120]

### Challenges:

- Ensuring cybersecurity and establishing data privacy protection while simultaneously maintaining an open flow of information and knowledge [114]
- Serving the demand for more efficient data infrastructures (IPv6) and networks (5G) according to growing consumption [118]
- Guaranteeing constant connectivity in the work environment while simultaneously reducing distractions, avoiding information overload and the mental costs of hyper-connectivity [120]

### Impact on Digital Companions in the Factory of the Future

As offline and online life merge, digital companions have the potential to become both gatekeeper and catalyzer of this process [117]. Inevitably, hyperconnectivity is a tradeoff between productivity, attention, access to information, and distraction [120]. While overexposure to data and information is paralyzing individuals, collecting, filtering, and distributing information will be necessary for companies to make hyper-connectivity an accelerator of productivity and innovation. In the future, individuals would not decide between offline or online, but rather to what extent they want to be connected.

# DIVERSITY AS THE NEW NORM

## The Inclusion of Diversity is Becoming a Key Competitive Advantage

Over the past decades, globalization has broken barriers between individual cultures and led to a blossoming of diversity around the world. This diversity encompasses dimensions such as race, ethnicity, religious and political beliefs. The trend towards more diverse societies is fueled by growing levels of global migration [122]. Part of this global migration movement is increasing numbers of refugees and forcibly displaced people, which seek safety beyond the immediate region [123]. While integrating diversity poses a major challenge regarding social stability, it also offers manifold opportunities. In the economic sector, a correlation between the level of diversity in the workforce and a company's financial results has been observed. The underlying hypotheses are that more diverse companies are better able to attract top talent, improve customer orientation, employee satisfaction, and decision making [124]. The term of diversity management has thus become a major focus topic for large corporates. Companies increasingly collaborate and exchange their diversity inclusion strategies. For instance, in the 'CEO Action for Diversity & Inclusion', an alliance of more than 175 major US companies has agreed to work towards advancing diversity and inclusion in corporate America both individually and collectively [125].

### Facts:

- The number of international migrants worldwide has continued to grow rapidly in recent years, reaching 258m in 2017, up from 173m in 2000 [122]
- The number of forcibly displaced people worldwide increased sharply each year from 42.5m in 2011 to 65.6m in 2016 [123]
- In OECD countries, from 1985 to 2000, average religious diversity (+20%) and ethnic diversity (+38%) increased [126]
- Companies in the top-quartile for ethnic/cultural diversity on executive teams were 33% more likely to have industry-leading profitability [124]

### Key Drivers:

- Decreasing trend of global visa restrictiveness since the 2000s, reducing the political barriers to migration [127]
- Mobility is becoming more affordable, as the inflation-adjusted costs per available seat kilometer for airlines dropped almost 74%, from 0.38 USD in 1955 to 0.10 USD in 2017 [128]
- Global economic inequality between developed and developing economies motivate labor migration [129]
- Overall global levels of peace have deteriorated by 2.14% since 2008, forcing more people to migrate [130]

### Challenges:

- Facilitating intercultural exchange and overcoming language barriers for smooth communication [131]
- Difficulty of prejudice, stereotyping, and discrimination in hiring, retention and termination practices [132]
- Effectively navigating between different visa requirements and dealing with administrative procedures of inconsistent employment laws [133]

### Impact on Digital Companions in the Factory of the Future

While many companies acknowledge the value of diversity, it remains a challenge to build an inclusive environment – "an atmosphere in which all people feel valued and respected and have access to the same opportunities" [134]. There are already strong examples of technological developments that contribute to inclusion, for example assistive technologies that enhance learning, working, and daily living for persons with disabilities. As the next stage, digital companions should flexibly address the needs that emerge from various individual cultural backgrounds and beliefs, thereby, creating workplaces that are truly inclusive.

# ENVIRONMENTAL CONSCIOUSNESS

## Valuation and Adoption of Sustainable Practices Across Social, Economic, and Political Borders

Air pollution in cities, plastic waste in oceans, flooding in rural areas - environmental degradation is visible around the world [135]. As these phenomena directly harm individuals' health or cities' physical infrastructure, societies seek innovative solutions to adapt to and mitigate environmental risk [136]. On both local and international level, actors across social, economic, and political borders are actively adopting more sustainable practices, such as shared economy initiatives [137], or consumption of more environmentally-friendly products with lower ecological footprint [138]. Companies are motivated to go beyond Corporate Social Responsibility efforts or targeted marketing campaigns, taking responsibility for (unintended) effects of their actions, they adopt resource-efficient processes [139]. On a global scale, transnational cooperations, such as the Paris Agreement, set the basis for further regulations, e.g. emission standards [136]. Moreover, in our interconnected world, news on disasters and environmental scandals spread immediately across social networks; thereby, media and civil society contribute to keeping governments, corporations, and individuals accountable [140]. Awareness of dependencies on scarce natural resources or assessment of vulnerabilities along supply chains due to exposure to natural hazards becomes essential for corporate leaders.

### Facts:

- Since 1980, there's been a 3-fold increase in the number of natural disasters [129], affecting over 4.1bn people [141]
- Large financial costs for infrastructure reconstruction/recovery efforts, only related to natural hazards: >2.1t USD globally over two decades [142]
- More than 90% of the world's population live in areas with levels of air pollution exceeding WHO guidelines [143]; globally, pollution is responsible for more than one-tenth of all deaths each year [144]

### Key Drivers:

- Climate change as the major cause for continuing upward trend in frequency and severity of natural disasters [135] [145]
- Enhanced statistical methods and modeling tools to monitor and measure climatic changes and predict risks to health and infrastructure [135]
- Discourse on climate change and sensitivity to sustainability on a global scale through societal interconnectedness and integration of environmental issues in transnational policy-making conferences [141]

### Challenges:

- In spite of enhanced scientific understanding of climatic changes, lacking global data coverage and complexity of dynamics make predictions and comprehensive risk assessments difficult
- Identifying cost-effective solutions that live up to the demand of sustainable practices in a context of prevailing scientific uncertainty [135][141]
- Managers need to enhance their understanding of business risks, financial impacts of disasters, dependencies on scarce natural resources, and vulnerabilities along the supply chain to foster competitive advantage [141]

### Impact on Digital Companions in the Factory of the Future

Environmental risks have a direct impact on a company's infrastructure, processes and resources, as well as employees' health. Responding to the shift towards environmental consciousness across large parts of society requires corporate leaders to take responsibility for their workforces and the (un)intended effects of their activities. Executives are to anticipate related business risks or insure against fall-out and destruction of physical infrastructure. Digital companions and digital factories could provide a competitive advantage through smart data aggregation and dissemination. This might facilitate integrated mobile early-warning systems, comprehensive risk assessments or holistic auditing along supply chains for establishing resilience and effective, sustainable resource management.

# LEGAL & POLITICAL TRENDS

## INFLUENCES ON DIGITAL COMPANIONS IN THE FACTORY OF THE FUTURE

Public Private Partnerships
Cybersecurity Regulations
Pseudonymization of Data
Open Source Licensing
Data Management & Accountability

# LEGAL & POLITICAL TRENDS

## Influences on Digital Companions in the Factory of the Future

As ubiquitous digitization advances around the globe, law- and policy-makers are experiencing new dynamics in their domain. Especially in the industrial sector, disruption is imminent: companies are faced with a new, global basis for competition, an unknown sensitivity towards data and new approaches to accountability and ownership of virtual content. As new initiatives are formed and laws are made, companies aiming to harvest the possibilities of digitization need to keep up with political and regulatory changes. To facilitate an understanding of the magnitude of change, we have compiled an overview of five distinct trends that will pervade the industry within the next five years.

In May 2018, one of the most ambitious law-making projects of all time will come into place in the EU: The General Data Protection Regulation (GDPR). Driven by the increased importance of data in today's economy, it aims at giving new guidelines and regulations on how to deal with sensitive information of consumers. At the same time, it reflects two current trends within the industrial realm. As increasing value is attributed to data in the 21st century, law-makers are balancing on a razor's edge. Pseudonymization – meaning the decoupling of data from its originators – emerges as crucial means to balance the desire for further economic growth with consumers' need for privacy. At the same time, new concepts of data ownership are imminent. In an interconnected, digitalized marketplace, traditional law-making limitations, such as national borders, seem obsolete. There is a need for a newly regulated relationship to data that is well adapted to the rules of the digital economy.

Meanwhile, companies and states alike need to reevaluate their basis of competition. As countries around the world gain access to and know-how about digital technology, players like China put pressure on previously unreachable suppliers in high-cost locations. In order to secure competitiveness of the local industry, there is an increased demand within the EU to establish public-private partnerships – agreements between industry and politics with the purpose of evading the downfall of economies. Another symptom of these drivers is the increased need for cybersecurity regulations. With China, the EU, and the US, the world's largest driving forces of the economy have made efforts to advance and ensure protection of residential cyber systems from hackers [146]–[149].

Finally, another digital trend is disrupting the long-grown structure of businesses: open source software. High-quality, crowd-based software solutions are emerging as alternatives to corporate products and change the relationship between companies and consumers. Still, the open-source movement raises questions of accountability that remain to be answered by lawmakers.

The following pages will be dedicated to exploring each of these five trends in detail, diving into facts, key drivers, and their impact for corporations in the digital age.

# PUBLIC PRIVATE PARTNERSHIPS

## Ensuring Global Competitiveness of Europe's Future Factories

In the face of increasing global competition from emerging economies, Europe is gearing up to differentiate itself as a technology leader. In this regard, Public Private Partnerships (PPP) provide a basis to leverage private sector investments and establish collaborations between companies and public institutions towards a common goal. Illustratively, the European Factories of the Future Research Association (EFFRA) aims at giving Europe's manufacturing industry a technology boost to create competitive edge in the global market. EFFRA develops and integrates promising technologies to strengthen the technological base, especially of small and medium-sized enterprises (SMEs) that lack resources to develop data- and technology-driven processes. The roadmap 2020 of EFFRA constitutes the basis for this topic of research and innovation funding [150].

EFFRA consists of more than 160 organizations throughout Europe. The goal of this association is to define R&D priorities in close partnership with the EU, represented by the EU Commission along with private stakeholders from the industry. The overall budget draws from contributions from both private sector and the European Commission. A total of 1.15bn EUR has been made available for the Horizon 2020. EFFRA members include SMEs, suppliers, customer-focused companies, and research institutes and universities across Europe [150].

### Facts:

- 1.3m robots will be used in factories by the end of 2018 [151]
- The exponential growth of the data market will reach 132bn USD by 2020 worldwide [152]
- UK companies will invest over 900bn USD per year in smart technologies that improve manufacturing processes [153]
- On a global comparison, South Korea leads the way in industrial robotics, with 437 robots installed per 100 employees [153]

### Key Drivers:

- Need to anticipate developments in key technology areas [154]
- Need to support European cross-border, collaborative Research, Development and Innovation by leveraging private sector investments [154]
- Need to strengthen Europe's capabilities to keep on top of the "innovation race" with rest of the world [154]

### Challenges:

- Rationalizing the financing of the technological transition by figuring out how to measure tangible and intangible ROIs and future financing avenues [155]
- Finding partners and experts who can technically support this transition and build trust with them [155]
- Gathering, storing and analyzing data safely [155]

### Impact on Digital Companions in the Factory of the Future:

The emergence of PPPs could be closely interrelated with digital companions that companies adopt to revamp their factories and build new smart factories. Digital companions could play a crucial role when cross-sectoral collaborations are established, by facilitating efficient information exchange and resource allocation. Based on emerging digital networks for collaborative research projects and by channeling funding towards PPPs, clean, high-performing, environmentally friendly and socially sustainable factories and processes can be established [156]. Associations like EFFRA emerging across Europe enable factory managers to smartly leverage the strength of a closely tied network with well-equipped partners in the manufacturing supply and value chain [156]. This will result in agile value networks, advanced manufacturing processes, and services with zero-defect and superior human competencies. In turn, synergies may arise with technological progress, sustainable circular economy, and interoperable digital manufacturing platforms supporting an eco-system of manufacturing services [157] and making it easier to distribute physical carriers of Digital Companions.

# CYBER-SECURITY REGULATIONS

## Enforcing Stricter Protection in the Face of Increasing Cyber Attacks

With cybercrime on the rise, new legal mechanisms are needed to enforce higher security standards. This is especially relevant in the industrial context, where industry espionage has taken advantage of new technological means. Given that knowledge – as the fourth factor of production – is becoming a relevant means of differentiation [158], not only companies rely on the strategy of knowledge theft. In fact, whole countries seem to have adapted to the cost-efficient methods of cybercrime. Due to the broad global technological advances, hackers in developing and emerging countries can extract information from industry leaders around the globe, as seen with North Korean data thefts in recent years [159]. Acknowledging this increasing threat, various countries around the world are enforcing stricter cybersecurity regulations on their markets to protect sensitive data and competitive advantages [146]–[149]. Due to the dynamic nature of security threats in the digital realm, traditional lawmaking processes might be overruled. Rather, as seen with the US and China, newly distributed responsibilities and legal entities might be an appropriate form of reaction.

### Facts:

- In recent years, the number of global security breaches in IT is seeing an annual increase of 27.4% [160]
- As of 2017, global cybersecurity cost is rising by 22.7% annually [160]
- In 2018, the German Federal Office for Information Security pronounced cybersecurity a matter of the highest importance [149]
- The US House of Representatives passed a bill on the formation of a cybersecurity agency in 2017 [146]
- With China and the EU, two of the world's largest economies have introduced cybersecurity regulations to their markets [147], [148]

### Key Drivers:

- The world is seeing ubiquitous digitization of information and pervasive connectivity of electronic networks [161]
- Increasing inequality between linked economies around the world [162]
- Digitization facilitates business models that largely depend, or are built on, software and data [163]
- Technological know-how is spreading globally, cultivated especially in emerging countries [161]
- For high-cost locations, know-how is becoming the crucial competitive factor in comparison to production regions [164]

### Challenges:

- Digital threats are developing too quickly for traditional lawmaking – new regulations must be especially flexible to account for this dynamic [165]
- Enforcement agencies are needed to make sure companies comply with new regulations [166]
- SMEs especially do not recognize the need for high cybersecurity measures, given the high cost involved [164], [167]
- It will be crucial to find a flexible regulation which does not divert focus and resources in companies' operational business [168]

### Impact on Digital Companions in the Factory of the Future:

- The digital factory is the logical next step in the end-to-end digitization of businesses. But this technological advancement comes at a price: in the face of rising global cybercrime, digital companions in high-end factories are yet another welcome target for attackers. As global law-making agencies are reacting to this issue of increasing vulnerabilities, companies implementing digital companions into their factories will be subject to stricter cybersecurity regulations. With regards to storing sensitive data, such as interaction protocols of workers with their digital companions, cyber-securing a digital factory poses another challenge for employers. While large corporations frequently have decent security measures in place, this might proof difficult for SMEs [164]. Given these developments, the use of digital companions might be regulated, in order to protect against cybersecurity.

# PSEUD-ONYMIZATION OF DATA

## Pseudonymization of Data to Establish Higher Privacy Standards within the EU

The rise of big data applications, combined with an increased awareness for data privacy and sensitivity among consumers, have led the EU Commission to take action. Hence, from May 2018 on, the General Data Protection Regulation (GDPR) will come into place, promising a massive impact on the operations of all companies doing business in Europe, no matter their origin countries [169]. One concept of the GDPR is the so-called "Pseudonymization" of data, defined in Art. 4, § 5 as "the processing of personal data in such a way that the data can no longer be attributed to a specific data subject without the use of additional information" [170]. Given the global significance of GDPR, companies in China, the US, and Europe alike will need to comply to this new concept. This poses increasing challenges to corporate IT infrastructures as well as to the way that data is handled and stored.

### Facts:

- GDPR was approved and adopted by the EU Parliament in April 2016 and will be enforced in May 2018, putting an increased focus on the "fundamental rights and freedoms of natural persons, in particular their right to the protection of personal data" [171]
- According to Art. 37 of the GDPR, corporations need to appoint a Data Protection Officer (DPO) to accelerate the implementation [170]

### Key Drivers:

- Substantial penalties cause companies to comply with the regulations of the GDPR (e.g. up to four percent of annual global turnover or 20m EUR, whichever is greater) [171]
- Increased corporate awareness as well as investments to handle GDPR related challenges [28]
- Lacking protection of security and privacy regarding smart devices, inducing concern among the majority of US and UK consumers [29]
- Uncertainty prevails regarding proper data handling, inducing fear for US and UK companies [29]

### Challenges:

- Shortage of qualified data scientists might prevent a fast and efficient execution of pseudonymization requirements [172]
- Need for company-wide project management makes implementation more difficult for global players [173]
- Currently, 44% of companies in Germany are not able to meet the requirements of GDPR [174]
- The Data Protection Officer, a fixed requirement of GDPR, is missing in 83% of surveyed US firms [174]

### Impact on Digital Companions in the Factory of the Future:

92% of US companies have made GDPR a top priority [28]. This law will revolutionize the handling as well as storage of sensitive data within the global business context. It will create a new sense of responsibility in companies towards the protection of both customer- and employee data. The future challenge will be to utilize digital companions in order to individually support workers in their daily tasks while still complying to the newly developed privacy policies.

# OPEN SOURCE LICENSING

## Increase of Copyleft Considerations and Accountability Concerns

In recent years, a lot of fundamental software features have been developed and are accessible online at no additional cost. This incentivizes companies to use and develop open source code, furthering the growth of community-developed software. Even though the appeal to utilize open source code throughout all projects is high, companies must consider the safety risks that may occur. Without any contractual obligations from the open source community, nobody can be held accountable for ensuing problems [164].

While open source code is freely accessible, the usage and distribution can be restricted depending on its license. Most licenses can be divided into two categories: permissive and copyleft licenses. Whereas permissive licenses allow companies to freely use the code, copyleft licenses require them to make the source code available under the same terms when distributing their software. This leads companies to being afraid that proprietary code gets "infected" by the copyleft license, forcing the company to publish their software [175], [176].

### Facts:

- Google, Facebook, IBM, Red Hat strengthened open source license protections in 2017 [177], [178]
- EU & EFTA nations recognize open source software as a key driver of government digital transformation [179], [180]
- Relevance of open source software increased since 2010 because of e.g. Linux, Apache, cloud computing [180]
- 96% of 1000 examined commercial applications worldwide audited in 2017 use open source software [181]

### Key Drivers:

- Shrinking IT budgets increase the need for cost savings by replacing in-house developed software with free open source code [158]
- Desire for software interoperability drives the development of IT standards [182], [183]
- Reduction of security issues as multiple people are engaged in the review of code [176], [184]

### Challenges:

- The definition of distribution determines to which extent companies must comply with the copyleft license [175], [185]
- The fear that proprietary code will get "infected" with a copyleft license, discourage companies from using open source code [175], [176]
- Patent rights can overrule copyleft licenses, undermining the idea of open source distribution [186]
- Nobody can be held accountable for occurring problems, as the open source community has no legal obligations [187], [188], [189]

### Impact on Digital Companions in the Factory of the Future:

Particularly in today's software heavy environment, companies will find it difficult to avoid using open source software. One of many reasons is the substantial reduction in development costs, as the code for many base features already exists online. However, when they comply with the license terms and make the source code freely available, can the developed companion still be commercialized? Furthermore, will the software be secure enough to handle sensitive data of its' users and who will be accountable, if problems arise? While the benefits are significant, many unanswered questions remain before deploying Digital Companions based on open source software.

# DATA MANAGEMENT & ACCOUNTABILITY

## Increasing Regulation of Data Portability, Circulation, and Accountability of Data Processors

With the rise of big data and increasing amounts of personal data collected by various service providers, regulations are needed to prevent abuse of this information. With the GDPR the biggest regulation on data privacy so far is coming into play in 2018. It will have a massive impact on the business of companies serving customers in Europe. This includes issues concerning rights on data portability and the "right to be forgotten" [170] which is particularly relevant for digital companions as they produce huge amounts of personal data [170], [190]. While GDPR is relevant only for personal data, other regulations are developed that ensure the free flow of non-personal data. They are aimed at ending discrimination based on residence, such as geo-blocking for example [191]. As of now, only data controllers are accountable for the privacy and security of data. With the rising number of services that process data, accountability must be extended from data controllers to data processors [192]. This induces debates on whether one must be able to provide an explanation of decision-making process of an algorithm [193].

### Facts:

- In May 2018, data portability and accountability of data processors are introduced in the EU via GDPR [170], [194]
- In 2018, the geo-blocking regulation comes into effect in the EU, but does not affect any copyright-protected content [195]
- In 2017, roaming charges within the EU were abolished [195]
- Up to four percent growth could be generated by 2020 within the EU through taking away obstacles on non-personal dataflow [196]
- Up to 8bn EUR per year can be saved by having free flow of non-personal data [197]

### Key Drivers:

- Increasing amount of personal data and growing awareness for data privacy in society [198], [199]
- Importance of reducing discrimination based on residence for enabling the implementation of the "Digital Single Market Strategy", proposed by the EU [191]
- Increasing number of data transactions between individuals, companies, and institutions [200]
- High data availability ("Big Data") for data processors [201]
- Advancements within AI and Machine Learning (ML) algorithms, related to increased computing power and investments [201]

### Challenges:

- Implementing data portability by all service providers that seek to provide service to all customers on the European market [190]
- Providing evidence that personal data is completely erased by service providers [202]
- Removing legal obstacles to ensure free flow of non-personal data between service providers and across national borders [196]
- Ensuring explicability of decisions, made by big data algorithms and AI, to ensure accountability of algorithms [193]
- Avoiding negative effects of strict regulation of collecting and processing data on data science applications [203]

### Impact on Digital Companions in the Factory of the Future:

As regulation of technology and data management increases, companies must constantly adapt to changes in legislation. As of now, all GDPR requirements must be implemented by service providers and in manufacturers' production environments alike [190], [202]. The same applies to the accountability of data processors and especially the decision-making based on big data algorithms [51]. While using non-personal data produced by digital companions within the company is not a problem, sharing the information with third parties will need to comply with data free flow regulations [196], [197].

# ECONOMIC TRENDS

## INFLUENCES ON DIGITAL IN COMPANIONS THE FACTORY OF THE FUTURE

Transition in Skill-Set Requirements
Demand for Expertise Workforce
Supply Chain Digitization
Towards a Circular Economy
Increasing Focus on Domestic Markets

Arsalan Javed, Felicitas Holz, Jonas Myklebost, Louisa Mayt

# ECONOMIC TRENDS

## Influences on Digital Companions in the Factory of the Future

The deeper penetration of technology in our industries will lead to a transformation of our society. Consequently, a significant change is eventually expected in our education system. So, not only will companies have to improve their training programs for employees to develop a better skill-set for this digital era, but the education system will have to change from the very first phase of learning. The government, educational institutions, and organizations will have to come together to create the workforce of the future. For this future, there is an age-old speculation that machines will eventually replace human workers in industries. However, experts agree that the human worker will still hold a vital place in the factory, but the role is expected to change drastically. The human worker will be required to take on roles that demand contextual analysis and abstract thinking, which still elude machines, in order to work with new technologies like robots, AI, and ML to reshape the industry.

Other aspects of the economy like the supply chain will also be made more modern, smarter and efficient. As digital solutions become more accessible, companies will choose to implement them in their day to day operations resulting in better problem solving, data sharing, decision making, and planning as well as a more streamlined workflow for supply chain professionals. The costs, performance, agility, and inventory are all likely to improve with digitization. Modern technologies will not only help companies to automate and improve routine tasks, but will also allow them to leverage these technologies to offer consumers new products and services which they were unable to do before. These smart factories with their more efficient operations and supply chain will also push companies to use resources more efficiently and to make products that are durable, easier to reuse and recycle. So, companies will move towards circular economy principles and try to apply them to all aspects of their business including the replacement of costly and inefficient materials with better substitutes, usage of data analytics to further improve current processes and moving processes to the virtual world.

The increase in efficiency and application of new technologies to factory operations naturally lead to a reduction in costs and improvement in quality of products and services. Due to this, a decline is expected in the outsourcing of manufacturing to low labor cost countries. Companies are aiming to establish production sites in locations which have a greater affinity for disruptive technologies. These locations include developed countries with the necessary digital infrastructure. Reshoring will be an option that most companies are likely to explore to achieve customer proximity as well as reduced logistics costs.

So, as our industries move towards digital, our education system is expected to be revamped. Companies are projected to have an increased demand for a highly skilled workforce, the operations of the industry are likely to become smarter and more efficient and investments are expected to shift from low labor cost countries to high income and technology forward countries.

# TRANSITION IN SKILL-SET REQUIREMENTS

## Education Facing New Training Demands

Because of the drastic evolution of technologies, business models and the nature of work, the demand for new skills is more drastic than ever before. Hence, working roles will change and there is a need for adaption by workers and companies to new requirements [204]. This adaption has to be implemented from the very first educational phase of a person, otherwise, the technologies, companies, and the modern way of work will be changing faster than the human ability to handle it. The Internet has made it possible for people to learn anywhere, anytime and based on what they require [205]. But besides these individualized approaches, government, companies, and all educational institutions have to contribute and develop a new way of educating the workforce of tomorrow [206].

### Facts:

- 83% of German parents demand digital schools and more digital learning equipment [207]
- 59% of German employees say their company does not offer further education for digital topics [208]
- More than 25% of workers in OECD countries are reporting a mismatch in skills with regards to the qualifications requirement by their current jobs [204]

### Key Drivers:

- US graduates of Generation Z want employers to provide relevant training, otherwise, they might feel underemployed. This may lead them to switch jobs more frequently, which leads to a gig economy [209]
- Training should emphasize important soft skills that cannot be replicated by machines, e.g. creativity and innovation as well as leadership capabilities and cooperation [210]
- Talent economy requires different critical skills for tomorrow's workplace: curiosity, creativity, conscientiousness, critical thinking, collaboration, and agility [211]

### Challenges:

- Generating a broad acceptance and openness towards change in educational systems, especially for orthodox instructors [207]
- Transparent change management methods for employees who are required to re-skill and are not open to digital change [210]
- Three broad constitutions must work together: The individual, employers as well as social and governmental institution [210]

### Impact on Digital Companions in the Factory of the Future

Updated working profiles are required in the factory of the future: these profiles consist of a new range of needed skills for the full utilization of the opportunities of smart factories [207]. As manual and administrative tasks are going to be less important, a flexible way of adopting frequent changes in production, offered equipment or modern interpersonal work settings is essential. The rising gig and talent economy has to be supported by the correct training methods in every single stage of education [210], [211]. Digital companions will modernize the education system in the work environment by providing real-time guidance for adapting to newer factory upgrades.

# DEMAND FOR EXPERTISE WORKFORCE

## Rising Competition for Highly-Skilled Workers

As automation, digitization and AI continue to reshape whole industries, concerns arise that machines and technology will replace the human worker in production processes. While long-term projections vary in their estimations about technology's impact on employment, studies and experts agree that the only way to realize the potential profits from those investments in the next few years will be to have people and processes in place to capture them. Even though the era of human-machine interaction has come, it is vital not to underestimate the importance of the human in the digital factory [212]. Companies will, therefore, need to find a balance between buying and building a competitive workforce that leads them towards the factory of the future. In addition to educating and training people, attracting and retaining an expertise workforce will become a strategic imperative for companies and will require to re-think traditional HR-strategies.

### Facts:

- 34% of companies worldwide report difficulties filling jobs due to the lack of expertise workforce [213]
- More than 50% of European CEOs reported that they lack digital skills necessary to position themselves well for manufacturing in the future [214]
- 19% of companies still have "traditional functional" career models, meaning hierarchical company structures with pre-defined career-steps [206]

### Key Drivers:

- The mismatch between demand and supply of expertise workers in the field of digitization, engineering, and other expertise required in the shift towards the digital factory [213]
- Companies not only look for 'Science, Technology, Engineering, and Mathematics (STEM)' graduates anymore but employees are expected to have soft skills such as creativity, collaboration, and leadership, commonly abbreviated as STEAM, where A stands for arts. This reduces the available talent-pool even further [206]
- Workers are increasingly flexible and willing to switch jobs or even location, amplifying the competition for talents [215]

### Challenges:

- As better and higher education of employees is demanded by companies, and the supply of such workers is insufficient, wages are expected to rise. This might offset the desired savings realized by the introduction of new technologies [210]
- With the increasing prevalence of the gig-economy and the resulting short-term employment, companies may struggle to implement the needed knowledge base long-term [210]
- Aligning different generations and diverse backgrounds of workers in order to unleash the full potential of everyone involved in the digital factory [216]

### Impact on Digital Companions in the Factory of the Future

The factory of the future will be characterized by human-machine interaction, like the digital companion. Companies must now heavily invest not only in technology but in employees in order to harness technological breakthroughs and innovations necessary to sustain a competitive advantage [210]. It is imperative that companies develop sound strategies to attract and retain an expert workforce to enable the implementation and success of digital strategies. The imminent future will not be characterized by "dark factories", but by the transition towards human-machine interaction that requires the best and the brightest employees.

# SUPPLY CHAIN DIGITIZATION

## New Technologies and Operations for a Smart Digitalized Supply Chain

As better technological solutions have become available in recent years, companies can now make greater improvements in the supply chain through digitization. To effectively implement a digital supply chain, companies not only need to apply new technologies but also need to update their operations to support the implementation of these technologies. Managers now need to establish a vision for the supply chain, assess its current state and develop strategies for digital transformation. This transformation also needs to consider the attitude of the workforce towards new technologies and their acceptance of innovation and change. Although the supply chain was one of the first aspects of the economy to be digitized, it has not generally seen much innovation since [217]. The focus for companies now is to move towards a smart digital economy by leveraging technologies like Big Data, AI, robots, and IoT to improve their information sharing, problem tracking, planning, and decision making [218]. The smart digital supply chain will improve the management of costs, performance, services, agility, and inventory and will allow for a boost in economic growth [219].

### Facts:

- Companies, which are pushing the initiative to digitize their supply chains, are expected to boost the annual growth of earnings by 3.2% before interest and taxes, which is the largest increase from digitization in any business area [217]
- Implementation of the digital supply chain is expected to cause up to 75% fewer lost sales, 30% lower operational costs and a decrease in inventories of up to 75% [218]
- 87% of supply chain executives believe that digital advances will drive major changes in the supply chain job market in the coming years [220]

### Key Drivers:

- Companies aim to improve the integration of their operations with decisions on costs, inventory, and customer service made from an end to end perspective which can be achieved through digitization of the supply chain [218]
- A significant number of leading companies are investing in digital solutions for the supply chain [219]
- Liberating the supply chain workforce heralds an exciting freedom for humans to focus on abstract thinking and contextual reasoning that machines still cannot deal with [220]

### Challenges:

- Possible rejection of new technologies by the workforce because of a lack of company culture focused on innovation [217]
- Failure of companies to update operations to support the new supply chain resulting in only a short-lived initial burst of innovation and no further improvement [217]
- The focus of companies on just digitizing their current supply chain rather than using modern technologies and data to create a smart supply chain for improving economic KPIs and offering new products and services to customers [220]

### Impact on Digital Companions in the Factory of the Future

The smart digital supply chain will drastically impact the business and technical capabilities of the future factory using digital companions. Supply chain managers will be assisted in decision making using ML. The supply chain professionals will have a streamlined workflow through automation and they will be able to provide customers with unprecedented transparent end-to-end experiences. The digital supply chain will allow companies to innovate and expand into new markets [217]. Digitalizing the supply chain will also significantly improve the service level, costs, planning, and inventory management for modern factories [218].

# TOWARDS A CIRCULAR ECONOMY

## Linking Environmental and Operational Excellence

The rise of smart factories, using data analytics and AI, is enabling companies to use resources more efficiently and effectively: creating products that are durable, easy to reuse and to recycle while being profitable is known as the principle of the circular economy. Instead of considering only functionality and production cost and assuming that products will go to waste at the end of their lifecycle, a company would look at how it can manage the entire lifecycle of its products in order to maximize their value [221]. Applying circular economy principles enables companies to increase their profitability while reducing their dependence on natural resources [222].

### Facts:

- Studies demonstrate that applying circular economy principles could boost Europe's resource productivity up to three percent by 2030, saving 600bn EUR a year in costs and additional 1.8tn EUR in other economic benefits [222]
- More than 50% of companies in the manufacturing industry in Germany stated that they already use smart algorithms to improve resource efficiency and operational decisions [210]
- In 2012, Europe lost 95% of material and energy value while material recycling and waste-based energy recovery captured only five percent of the original raw material value [223]
- 80% of the 3.2tn USD worth of materials in the fast moving consumer goods industry is not recovered every year [221]

### Key Drivers:

- The cost of sustainability-related technologies, e.g. renewable energy, digital platforms, and advanced data analytics, has dropped significantly [224]
- Prices of commodities have increased over the last decade, and are expected to continue increasing, due to higher demand from emerging economies. This will motivate responsible resource use and re-use [225]
- The sustainable and responsible way of sourcing and usage of resources is demanded by society and has become not only a competitive advantage but a prerequisite that is increasingly pushed by legislation [226]

### Challenges:

- A quarter of the sustainability programs executed in companies in the last five years did not have measurable financial impact on the businesses [224]
- The reluctance of companies to implement changes and collaboration across all company functions including re-evaluating product design, business models, and the supply chain to apply circular economy principles [226]
- Misuse of circular economy activities by companies for marketing rather than making them an integral part of their daily business [227]

### Impact on Digital Companions in the Factory of the Future

Implementing truly circular economy activities and processes require a lot of resources and data. Digital companions and other smart technologies will enable humans to find new strategies for efficient resource use. Strategies include (1) substitution: replacing of costly, clunky, or scarce materials with less scarce, cheaper, and higher-performing ones; (2) optimization: embedding software in resource-intensive industries to improve how companies produce and use scarce resources; (3) virtualization: moving processes out of the physical world and into the virtual world in order to save resources during test-phases [228]. Considering all aspects of a circular economy and inter-related facts is too complex for the human mind. However, a digital companion will be able to store and connect all relevant information and provide them to the worker when needed.

# INCREASING FOCUS ON DOMESTIC MARKETS

## Investments Shifting from Low-Labor-Cost Countries to High-Income Countries

The share of global manufacturing done by high-income countries has declined during the last decades, mainly caused by an increasing amount of outsourcing to low labor-cost countries. Today, emerging digital technologies are changing the landscape of global manufacturing, leading to more efficient production of goods, an increase in quality, and thereby cost reductions. As a result, the relative importance of wages is declining, and investment decisions are changing accordingly. Companies are searching for manufacturing locations that are open to disruptive technology, and that have the necessary digital infrastructure. Developed countries are better prepared for this transformation and re-shoring is a viable option to achieve customer proximity and reduced transport and logistics costs. At the same time, geopolitical risk and policy uncertainty is creating a more complex environment for the future manufacturing industry [229], [230].

### Facts:

- 14%, equivalent to 105bn USD, decline of foreign direct investment in developing countries in 2016 [229]
- 79% of General Counsel at UK businesses said in a survey in 2017 that protectionism policies will have a negative impact on global trade in the next five years [231]
- 77% of all investments in the manufacturing industry in Germany within the next five years aim to set up new or expand existing digital factories in Germany and Western-Europe [210]
- 75% of industrial companies in Germany believe local digital factories are more efficient than offshore factories [210]

### Key Drivers:

- Manufacturing companies are favoring locations that can better adapt to and take advantage of emerging technologies [230]
- Customer centricity is driving production decisions more strongly than labor costs, which enables production sites to move closer to customers and thereby reduce transportation and logistics costs [210]
- Protectionism is on the rise, leading to an institutional environment less open to international collaboration [229], [231]

### Challenges:

- Compliance with a multitude of laws and regulations, which differ between nations [230]
- Digital divide raises inequality between developed and developing countries [229]
- Geopolitical risk and policy uncertainty could hamper the global economy. Moreover tax policy changes could significantly affect international trading [229]

### Impact on Digital Companions in the Factory of the Future

The shift of investments from low- to high-income regions will positively affect the adoption of digital companions in factories. The everyday usage of technology in high-income countries means that the introduction of the digital companion in companies requires less change from the status quo, and thereby leads to higher acceptance rates and faster adoption time. Additionally, the digital infrastructure and support from governments are critical factors for manufacturing companies investing in digital factories in high-income countries [232].

# BUSINESS MODEL TRENDS

## INFLUENCES ON DIGITAL COMPANIONS IN THE FACTORY OF THE FUTURE

External Data Monetization
Servitization in Manufacturing
Predictive Analytics in the Smart Factory
Knowledge Crowd-Sourcing
Digital Industrial Platforms

Awais Shafique, Anna-Julia Storch, Özgür Güzel, Patrick Tu, Tim Hermes

# BUSINESS MODEL TRENDS

## Influences on Digital Companions in the Factory of the Future

A business model describes how a company creates value by solving customers' problems. In the classical sense, it refers to generating revenue by interacting with the outside world. However, in our understanding, business models can also exist within a company. Taking on that perspective, they are internal measures providing value by for example increasing efficiency or reducing costs.

In the digital age, business model innovation has become increasingly important. Ingenious technologies and vast amounts of data have led to increased connectedness, transparency and quickly changing needs of emancipated consumers. As there are no longer any long-term certainties, it is essential to be adaptable. Keeping that in mind, business models are not abstract, static thought constructs. They are lively systems with sensually perceptible and evaluable characteristics. They are in constant movement, consume resources, develop, propagate, and react to external influences. As such living systems, they are subject to the laws of nature, particularly the "Laws of Evolution", discovered, explained and proven in "The Origin of the Species" by one of the most important men of the last millennium - Charles Darwin [233].

Applied to this context, our living creatures or species are business models. There is a vast variety of diverse business models. However, only a few of them survive the process of natural selection. Contrary to common believe, those are not the ones which are the strongest or most established. They are the ones which have adapted best to their surroundings. Often however, once companies recognize the changed environmental conditions, it is too late to adapt their business model. This underlines the necessity to be vigilant and anticipate upcoming trends.

In the following, we will discuss five business model trends we consider as particularly important in the context of "Digital Companions in the Factory of the Future". The paradigm-shift to a data-driven world enables opportunities to create value inside and outside of the organization. First, in the digital world, factories generate more and more data as a byproduct. The increasing stream of data can be monetized by selling and granting access to raw or processed data and identifying institutions that benefit from that data. Second, using data internally by leveraging predictive analytics capabilities can enhance operational efficiency and decrease machine downtime in the factory of the future. Third, servitization results in a shift from selling traditional products to providing fully integrated product-service systems that are empowered by new technologies. Fourth, knowledge crowdsourcing refers to the generation, storage, and usage of internal knowledge as well as outsourcing innovation processes to the external environment. Finally, digital platforms are adopted in an industrial B2B context and provide manufacturers the opportunity to connect demand and supply within the organization and beyond.

# EXTERNAL DATA MONETIZATION

## New Monetization Potential Through Exploding Amount of Industrial Data

With the rise of smart devices, the amount of data produced is increasing at a tremendous pace – commonly known as Big Data. Companies in nearly every industry are producing considerable amounts of data as a byproduct besides their core activities [234]. With data being referred to as the "oil of the 21st century" [235], it certainly became one of the most valuable assets nowadays. Internet giants such as Google and Facebook already successfully built business models around data. More and more companies across industries discover the monetization of their 'byproduct data' as an additional way to generate revenue. Especially manufacturers in the era of Industry 4.0 can leverage their vast amount of captured data and sell it as an independent revenue stream or offer data as unique add-on service to an existing service or product [236]. Both suppliers and corporate clients can be interested in such data to run advanced analytics and optimize operations.

### Facts:

- Globally, produced data is expected to grow by 900% from 4.4 to 44 zettabytes (trillion gigabytes) between 2013 and 2020 [237]
- The number of connected devices is estimated to grow by 103% from 27bn to 55bn between 2017 and 2022 [238]
- The global data broker market is expected to increase by 48% from 111bn to 164bn USD between 2017 and 2026 [239]
- External data is purchased by 70% of large organizations [8]

### Key Drivers:

- Declining cost and size of sensors [240]
- More computational power and storage capabilities at lower cost [241]
- Emerging data brokerage and monetization platforms [238]
- Rapid advancement in ML and the need for large data sets to train these models [242]

### Challenges:

- Data privacy concerns of the public and attitude towards selling data [12]
- Compliance with data protection regulation such as GDPR [243]
- Technical capabilities to collect, store, retrieve, and share data [244]
- Siloed data in legacy IT systems [241]

### Impact on Digital Companions in the Factory of the Future

Huge amounts of data are produced by smart devices in factories, such as IoT devices or machines [245]. Identifying key partners along the value chain which could benefit from this data constitutes the basis for this business model. For example, Toyota sells traffic data captured in navigation devices installed in their cars to municipal planning departments [246]. Moreover, the usage of data marketplaces provides potential for revenue sources. In addition, manufacturers will have to address data privacy concerns and put effort into complying with data protection regulations which may vary in different countries.

# SERVITIZATION IN MANUFACTURING

## Rise of Fully Integrated Data-Driven Product-Service Systems

First attempts of manufacturers to integrate products and services started in the 19th century. Today, main services offered by suppliers are related to maintenance, repairs, and condition monitoring. However, in times of Big Data and connected devices, more advanced services become possible [247]. New business models, where payment is based on usage rather than an initial fixed total price and subscription-based models are emerging. Thus, a new revenue growth potential with recurring revenues can be established and capital expenditures are transformed into operating expenditures. For instance, Rolls Royce has established the so-called "Power by the Hour" business model, where jet engines are not sold to aircraft manufacturers but rather paid per operating hour. Rolls Royce stays the owner of the jet engines and is responsible for the maintenance and repairs [248]. By utilizing Big Data and IoT, this service offering could be further enhanced to maintain products more efficiently, e.g. by being able to monitor the jet engines in real-time. Servitization could also be implemented in modularized production networks. Therefore, in idle times of one manufacturer, machinery could be used by other manufacturers that produce nearby [249].

### Facts:

- 79% of the manufacturers in the UK believe that digital technologies will help broaden their customer base via service-based offering [250]
- 44% of surveyed manufacturers in the UK regard themselves as beginners in terms of servitization [251]
- 48% of surveyed manufacturers in the UK are expected to invest more in servitization in 2017 [251]

### Key Drivers:

- Adoption of Industry 4.0, IoT, and Big Data [247]
- Increased price competition reduces revenue growth potential of manufacturers [252]
- Changed client requirements and needs [251]

### Challenges:

- Required changes in organizational culture [253]
- Need for building capabilities in service-related fields [253]
- High risk and responsibility to ensure availability and reliability of offered services [254]
- Rising complexity within the organization, due to individual product offerings and full-service solutions [254]

### Impact on Digital Companions in the Factory of the Future

Currently, one of the main differentiating factors for manufacturers is the price of the produced goods. Servitization in times of Big Data and IoT offers new differentiating potential to establish a sustainable competitive advantage. With the data produced by connected workspaces and objects, advanced and customized services can be offered. The potential for these services as well as the manufacturers' desire and pressure to offer superior services might accelerate the development and use of digital companions. Within factories, servitization could lead to a stronger modularization of production networks. Thereby, increased flexibility of production networks benefits both suppliers and customers. The perceived value of goods is increased by additional services and a higher value is provided for customers. This leads to new monetization opportunities and more predictable revenues for suppliers through recurring service revenues.

# PREDICTIVE ANALYTICS IN THE SMART FACTORY

## Enhanced Operational Efficiency Empowered by Advanced Analytics Capabilities

Predictive analytics include a variety of analytical and statistical methods that are used to develop models that aim to predict future behaviors or events [255]. Empowered by increasing availability of data, more complex algorithms and more efficient computational power, predictive models have moved into our everyday life and are applied within nearly every industry such as manufacturing [256]. With manufacturers being one of the largest data generators [257], leveraging their data in a predictive manner can create internal business value, support data-driven decision making, and enhance efficiency and productivity. Compared to the previously introduced trend "external data monetization", predictive analytics can be regarded as an internal form of it. Prominent use cases of predictive analytics are demand forecasting, anomaly detection or predictive maintenance [258]. Although the use of data analytics in manufacturing has consistently been increasing in recent years, there is still a gap between the status quo and realizing the full potential of data [259].

### Facts:

- The predictive analytics market size is expected to grow by 222% from 3.85bn to 12.41bn USD between 2016 and 2022 [260]
- Predictive analytics in some form has been adopted by 50% of decision makers [261]
- Globally produced data is expected to grow by 900% from 4.4 to 44 zettabytes (trillion gigabytes) between 2013 and 2020 [237]

### Key Drivers:

- Rising amount of data streams within organizations [244]
- Sensorization of devices and increasing adoption of IIoT [262]
- Development of more sophisticated algorithms for data-driven prediction
- More computational power and storage capabilities at lower cost [241]

### Challenges:

- Poor quality of data to train predictive models
- Shortage of talents with data expertise such as data scientists [244]
- Compliance with data protection regulation such as GDPR [243]
- Technical capabilities to collect, store and retrieve data [244]
- Siloed data in legacy IT systems [241]

### Impact on Digital Companions in the Factory of the Future

Manufacturers are now in the unique position to create tremendous value from their constantly growing data stream. The ability to create useful insights from huge amounts of data is crucial for manufacturers to stay ahead of competition. To leverage the full potential of predictive analytics, corporates are heavily investing in IT as well as in organizational change to enable cross-organizational and centralized data access [244]. Digital companions in this context may serve as a means to collect high quality data and further capture the context in which this data was produced. Furthermore, by analyzing these data streams in real time, digital companions can support employees as an interface to make data-driven decisions and optimize workflows.


# KNOWLEDGE CROWD-SOURCING

## New Ways of Innovating, Optimizing, and Reducing Cost Through Knowledge Crowdsourcing

Crowdsourcing is a model where organizations and individuals obtain services from an open and relatively large group of skilled internet users. The key is the ability to divide work between participants to achieve a cumulative result. Crowdsourcing may result in improved costs, speed, quality, flexibility, scalability, or diversity. In recent years, many corporate companies have leveraged the knowledge of the crowd through incentivized open innovation to optimize their internal processes, and, in turn, to reduce costs. For example, the German-based car manufacturer Audi has benefitted from crowdsourcing through competitions aimed at improving the efficiency of its manufacturing processes. Moreover, crowdsourcing can be commissioned to co-create completely new products designed around the users.

### Facts:

- Crowdsourcing will be used by 75% of the world's high performing enterprises by the end of 2018 [263]
- Crowdsourcing has been used by 85% of the top global brands in the last ten years [263]
- Small businesses and startups make up 80% of global crowdsourcing [264]

### Key Drivers:

- Increased access to the internet
- Flexible on-demand availability of resources
- Change of attitude towards traditional employment

### Challenges:

- Consistency in product quality [265]
- Compliance with employment laws in respect to issues such as wages and worker's unions
- High coordination complexity with crowd sourced workers [263]
- Ethical concerns regarding low wages for crowd sourced workers

### Impact on Digital Companions in the Factory of the Future

The ideas generated through incentivized innovation platforms will not only help companies optimize their manufacturing processes but these platforms are also a cheap and effective way of finding the right talent. As an example of knowledge crowdsourcing inside a company using a digital companion, workers would be able to present a problem to an expert audience inside or outside the company. The digital companion would assist in finding the relevant expert for the problem while documenting and storing the solutions generated to be used in case the problem resurfaces. Access to a larger audience might result in innovative and robust solutions. These solutions could be stored on a cloud and information would be shared between workers, if the problem occurs again.

# DIGITAL INDUSTRIAL PLATFORMS

## Increasing Interaction in the Value Chain Through Digital Platforms

Early digital platforms were developed in the business-to-consumer context and dominated by born-digital organizations. Recently, there has been a shift towards B2B platforms and non-digital organizations are also entering the market [266]. In this context, interaction platforms belong to the most relevant B2B platforms with respect to the future. These platforms connect business parties and coordinate among all stakeholders in the value chain to enable a continuous product and information flow. It opens new opportunities for customers which e.g. could use CAD models to define the parts they want to have produced. This information would then be shared directly with all platform participants [249]. Going one step further, processes within the digital factory could be initialized automatically, which provides mutual benefits for all stakeholders by making processes more efficient. Moreover, network effects arise and by utilizing the scalability potential, platform providers can realize a growth in their customer base [267]. For example, SML Solutions, a 3D printer manufacturer, is currently testing such a market place. By implementing an online ordering system, they could cut down email or fax orders, which constantly led to inefficiencies and inaccuracies. Furthermore, the approval processes could be accelerated from days to minutes [268].

### Facts:

- Effective end-to-end integration increases productivity by 26% [249]
- Digital B2B platforms are expected to create value worth 10tn USD by 2025 [269]
- EU plans to support the development of platforms such as digital manufacturing platforms, by investing 300m EUR between 2018 and 2020 [270]
- Platform models have been utilized by less than 15% of the fortune 100 companies as of March 2017 [269]

### Key Drivers:

- Rise of digital technologies and cloud computing [271]
- Increased interconnectivity of suppliers, producers, and customers through digital globalization [272]
- The importance of digital channels is growing, with 56% of millennial B2B buyers for ranking them as the most important channel for searching new business products [273]

### Challenges:

- Platform operators need to acquire a critical mass of participants and foster high engagement to enable network effects [267]
- Compliance with cross-border regulations for labor, tax or data localization [269]
- Companies need to choose the right key partners at an early stage to develop a successful platform [249]
- New organizational structures and skills are needed to facilitate data-based innovations and collaboration with partners [267]

### Impact on Digital Companions in the Factory of the Future

Digital industrial platforms will play an important role in connected smart factories, where they collect data in a centralized way and distribute it among relevant stakeholders [270]. By ensuring a constant information flow between the platform and the digital factory, processes could be further automated, increasing overall efficiency. For instance, materials could be procured automatically and the production initialized accordingly. Furthermore, digital platforms could facilitate the development of individual solutions for customers. The digital companion may serve as an interface that collects and shares data in real time with factory workers, managers and machines. This might lead to a better understanding and control of the production processes and sales pipeline for all stakeholders

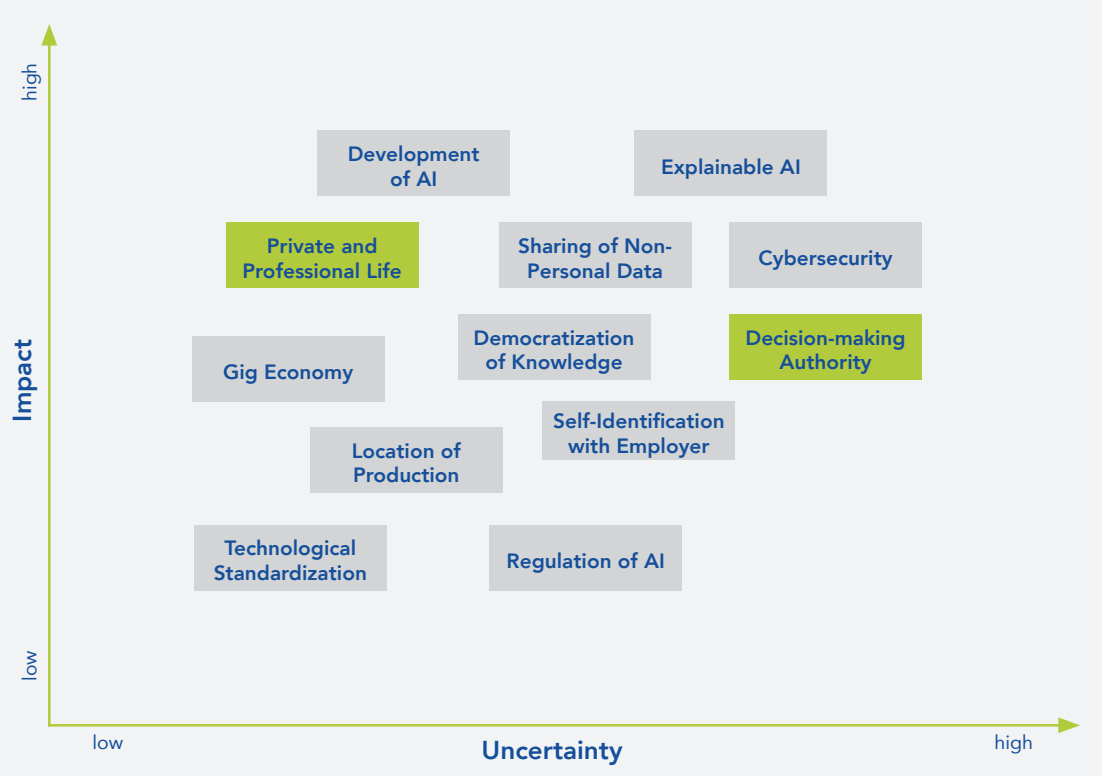
# SCENARIOS

The following chapter describes four scenarios of different futures. The chosen scenarios are plausible, relevant, and of consequence for the user's decision, challenging, internally consistent, and recognizable from the signals of the present and near future. All four scenarios described below are equally plausible, extreme visions of how Digital Companions in the Factory of the Future might shape our lifes in the year 2038 with regards to two key drivers. Stories of personas experiencing a day in 2038 are used to envision the scenarios. Signposts (often described as weak signals) that indicate a development towards each scenario are identified in order to describe a possible path from the present to each of the four extreme futures.

# DRIVER MATRIX

The scenario phase follows a structural approach to imagine how life could look like in 2038 with a digital companion in the factory of the future. Based on the research conducted, current challenges and drivers with a high impact on the topic are identified. The drivers represent forces that are exogenous to any organization and shape the future of the digital companion. All determined drivers are modelled with bipolar, extreme outcomes. In order to create four equally plausible scenarios, two key drivers are selected and combined in a scenario matrix [See Scenario Matrix]. The key drivers are characterized by a high impact on the future development of the digital companion and a high degree of uncertainty (i.e. it is impossible to assign probabilities to the two extreme outcomes). Furthermore, the key drivers are mutually independent and do not overlap in their definition.

All drivers are ranked in a matrix according to their degree of uncertainty and respective impact on the digital companion in the factory of the future. Based on that ranking, a number of pairs of potential key drivers are selected. The different pairs are then compared to each other and the best combination is chosen. This combination is highlighted in green.



# KEY DRIVERS

### Human-Centered

This extreme scenario depicts a world in which decision making is human-centered.
Thereby, humans take an active and predominantly independent role in the decision-making process. In order to make well-informed decisions, humans request contextual information, required knowledge, and possible suggestions from the machine. However, intelligent machines are eligible to carry out tasks that involve standardized and recurring decision making. This world is mainly the result of two factors: For one, machines are not capable of making complex moral decisions. For another, judicial regulations ensure that decisions are made by humans.

### Decision-Making Power

Decision-making authority defines which entity makes the ultimate choice among decision alternatives. In this context, the relevant entities are humans and intelligent machines.
The extreme cases are that the decision-making power lies solely with the human or only with the machine. However, it is also possible that it settles somewhere in between those extremes. Where exactly on the scale the decision-making power is located, depends on legal regulations and the technical capability of the intelligent machine to make complex decisions. If machines possess this technical capability, it opens up the opportunity to center the decision-making authority around the machine. However, depending on the legal boundaries, the judicial decision rights will be determined and the center of decision-making authority may shift severely. Legal boundaries in turn, are heavily influenced by moral considerations, accountability reflections, and data privacy deliberations.

### Machine-Centered

AI is now capable of solving increasingly difficult problems because of technological advancements. As regulations barely limit these competences, the center of decision shifts towards machines, which pushes humans into a passive role. The machine can take over decisions on different levels with increasing impact on the outcome. They are able and empowered to limit the decision options for humans. Thereby, the selection possibilities are narrowed down severely. In order to condition humans to follow its will, the machine punishes unfavourable decisions and rewards others. Unlike human-centered decision authority, the machine can also decide over personal and moral matters and only very few domains are excluded, such as life-or-death decisions.

### Fully Separated

In one possible future, personal and professional life will be completely separated. Individuals will exist as two different personas whose actions in the two distinct spheres will not influence each other at all. Working time will be characterized by an absolute focus on the task at hand, leading to maximum productivity. However, professional performance will be unrelated to one's position within society. Weekly working hours will decline as the degree of automation grows exponentially, leaving people with more personal time. Personal life will become a time of pure leisure and people will embrace new means of self-fulfillment. Culture, entertainment, and experiences will constitute the new focal points of society.

### Private and Professional Life

The convergence of private and professional life refers to the extent to which both worlds merge with each other. Private and professional identities will either substantially shape each other or be entirely independent. These developments will inevitably affect the way people work in the future. As the importance of work for individuals' self-perception is changing, so will people's relationship to their workplace. While for some work has always been connected to self-fulfillment, for others it has rather been means to an end. These opposing views influence the discussions concerning the convergence of work and private life. For employers, the development poses questions on the flexibility of working hours and associated expectations on the employees' time commitment or physical presence. At the same time, law-makers will consider factors like cyber security, economic viability, societal well-being, and especially work regulations to provide a framework for work-life convergence.

### Fully Merged

In this outcome, private and personal life are almost indefinably merged. People will seamlessly alternate between both. Hence, working time and private life are perceived as the same thing. People will be available for their employers at all times, while structuring their day largely around their personal life. With jobs interfering as a meaningful part of social life, people's societal status will partly depend on success in their professional career. Nevertheless, hobbies will not vanish. Employees will be working in highly flexible environments, facilitating and empowering a continuous professional contribution - anytime and anywhere. Social contacts in work and private life are largely overlapping.

# OTHER DRIVERS WITH HIGH IMPACT AND A HIGH DEGREE OF UNCERTAINTY

| | | |
|---|---|---|
| **Full Gig Economy**<br>Everyone is engaged in project-based, flexible work. | Gig Economy | **No Gig Economy**<br>Everyone is engaged in traditional, long-term employment. |
| **Full Standardization**<br>All technological systems are fully standardized. | Technological Standardization | **No Standardization**<br>Each technological system has its individual standardized features. |
| **Artificial General Intelligence (AGI)**<br>AGI is able to successfully perform any task a human can do. | Development of AI | **Narrow AI**<br>State-of-the-art AI is only able to solve very specific problems. |
| **Total Democratization**<br>Companies are willing to exchange their knowledge beyond national borders. | Democratization of Knowledge | **No Democratization**<br>Companies seek to protect their own gained knowledge. |
| **High-Technology-Adopted Countries**<br>Companies locate their production sites in countries with high technological advancement. | Location of Production | **Low-Labor-Cost Countries**<br>Companies offshore their production sites to low-labor-cost countries. |
| **Under-Regulation**<br>AI is softly regulated, enabling degrees of freedom for the implementation and usage of AI. | Regulation of AI | **Over-Regulation**<br>AI is regulated in every specific area, restricting its broad adoption. |
| **Full Self-Identification**<br>All employees are fully identifying themselves with the vision and mission of their employer. | Self-Identification with Employer | **No Self-Identification**<br>Employees are not identifying themselves with the vision and mission of their employer at all. |
| **Full Sharing**<br>There are no barriers to sharing non-personal data in both professional and private life. | Sharing of Non-Personal Data | **No Sharing**<br>Entities protect their collected data for their own purpose. |
| **Fully Explainable**<br>Humans are able to understand and to explain all decisions made by AI. | Explainable AI | **Not Explainable**<br>AI remains a black box for humans and the decision-making process of AI is not understood. |
| **Full Cybersecurity**<br>Personal and non-personal data is safe and well protected against cyberattacks. | Cybersecurity | **No Cybersecurity**<br>Private and public institutions cannot ensure the protection of their data. |

# SCENARIO MATRIX

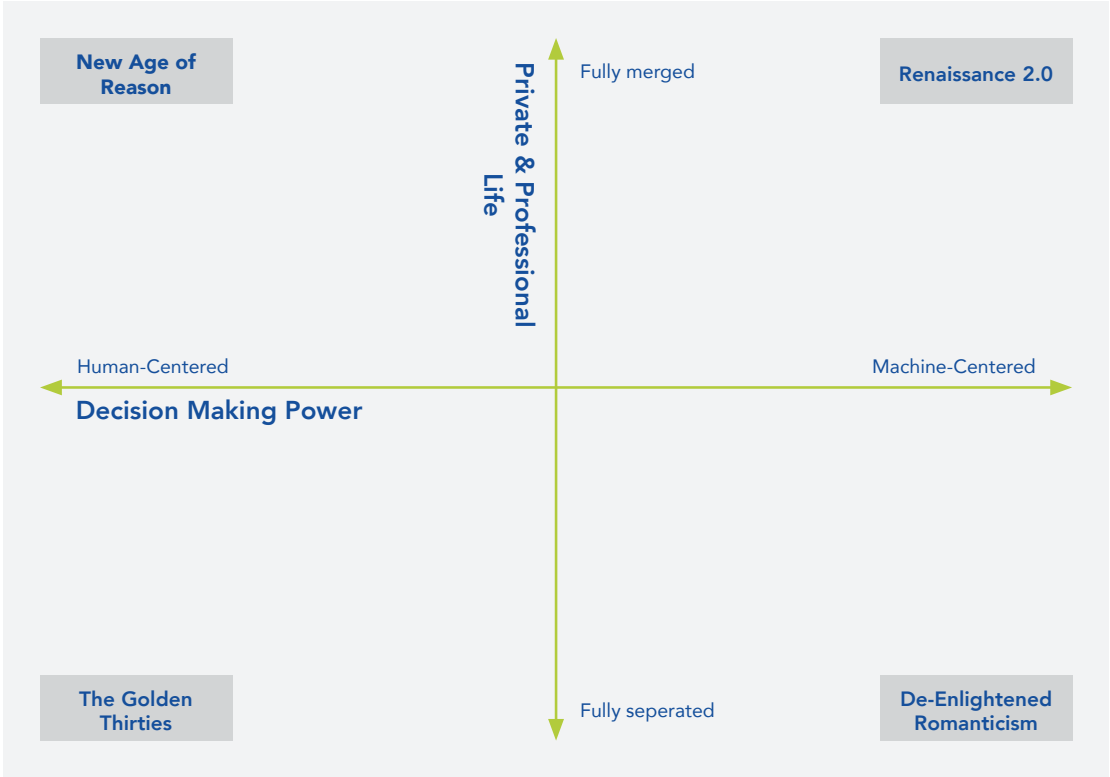
The two key drivers and their outcomes create the scenario matrix. Each key driver represents one of the axes, with the bipolar outcomes on both ends. All four scenarios are based on extreme outcomes of both key drivers. Plausible and consistent outcomes of other important drivers are included in each of the scenarios, but not taken to an extreme.

"Renaissance 2.0"
A future where machines have a huge influence on our lives, automating decisions and suggesting possible actions. Traditional nine-to-five jobs no longer exist and leisure activities are completely intertwined with professional life.

"New Age of Reason"
A world that reincarnates Kant's "dare to think for yourself", describing that humans are the center of decision making as most physical work has been automated. Since the digital companion assists humans in their merged private and professional life, the impact of decisions requires a versatile sense of reasoning.

"The Golden Thirties"
A scenario in which private and professional life are completely separated. Since AI is highly capable but inexplicable, human work is centered around decision-making. At the same time, automation has allowed humans to increasingly focus on leisure activities, leading to an improved quality of life.

"De-enlightened Romanticism"
A future where machines have the capability to autonomously take explainable decisions and dominate actions in multiple human spheres. Individuals totally separate their private and professional lives in terms of time, space, mindset, and social relationships.



# RENAISSANCE 2.0

## A day in 2038

07:13 a.m.
Emma slowly opens her eyes to the subtle sound of her favorite jazz saxophonist. “Alfred never fails to surprise me with my wake-up song,” she thinks to herself. Barely being able to open her eyes, she once again doubts if her digital companion Alfred has really woken her up at the perfect stage of her sleep cycle. “Your sleep quality fluctuated quite a lot tonight with only three and a half hours of deep sleep. I will make sure you get to bed early tonight,” says Alfred in his deep, caring voice. “Mh-mhmm,” Emma responds dozily while walking to the bathroom. When she puts on her make-up for the day, Alfred shows her the current ranking based on her social credit score in the mirror. “You’re having quite a run the last days,” Alfred comments. “Thank you, Alfred. You know I’m working hard to unlock the new level of benefits,” she says with a motivated voice.

Back in the bedroom, Emma stands in front of her wardrobe and hesitates a moment before opening it. “Let’s see what you chose for me today, Alfred,” she says and pulls out a fashionable outfit consisting of a black blazer, a green t-shirt, blue jeans, and sporty sneakers. “I had a close look at the weather for today and I know you like the colors,” Alfred explains his selection.

All dressed up, Emma walks down to the kitchen and opens her well-stocked kitchen fridge. “Nice! You bought me avocados. Not sure about this brussels sprouts though,” she says with a slight tone of confusion. “I know you love avocados and the sprouts are a healthy addition to your diet plan for this week. I’ve added a list of recipes that will suit your taste,” Alfred responds. “Uhhh ok, I guess it sounds like a healthy option,” says Emma and starts following Alfred’s step by step instructions to prepare a green breakfast smoothie. Her daughter Sansa slowly walks into the kitchen, rubbing her eyes while mumbling a “Good morning, Mom”.

After breakfast, Sansa gets ready for school, which is sponsored by Emma’s employer and located just a few blocks away on the company’s large campus. An autonomous car with some of her classmates is already waiting in front of the door. “Come on, sweetheart. They are waiting already,” Emma calls her. Sansa rushes out of her room, gives her mom a kiss on the cheek, and enters the car. “She will have a school basketball game at 01:00 p.m. today. I have already arranged everything for you to see it,” Alfred says while Emma watches the car disappear around the next corner. Back in the living room, Emma lets herself fall into her armchair and reads a novel.

01:00 p.m.
At the basketball game, Emma takes a seat in the front row. When her daughter enters the court, Emma is so excited that she screams her name loudly. Ten minutes into the game, a small alarm sign appears in her sight and the noises from her surroundings are muted by the smart earphones. Alfred explains to her that a key supplier just requested a change in a large machine purchase agreement Emma negotiated a week ago. "Ugh, why do these things always have such bad timing," Emma sighs deeply while she is leaving her seat and walking towards the outside of the gym. Alfred pulls up some of the background information of the purchase deal on her smart contact lenses. "I have scheduled a call with the supplier for the renegotiation in five minutes", Alfred says. Emma uses the remaining time to bring herself up to speed about the facts. In the call, she leverages her strong personal relationship to the supplier and her excellent communication skills to negotiate a mutually satisfactory agreement. "Ok, Bob, always a pleasure. Looking forward to our next deal!" she says and Alfred ends the call. "Good job, Emma! The company has acknowledged this in your social credit score. You are now very close to unlocking new social benefits, such as personal tutoring of your daughter in school," Alfred adds. Emma rushes back into the gym to catch the last few glimpses of her daughter's game, but to her disappointment, Sansa was substituted with another player.

03:00 p.m.
During the drive back home, Alfred walks Emma through a portfolio of logistics and installation service providers, which he selected to be responsible for setting up the newly bought machines in the factory. Emma nods indifferently, looks outside the window, and yawns. "Hey Emma, I had a look at your activity statistics and it looks like you will miss your daily activity goal. I will just stop the car at the central park and you will take a walk from there. It is only one and a half kilometers from your home," Alfred intervenes. "Come on, Alfred. Let's not do that. I'd rather take a little nap at home, please," she responds. "Ok, just to bring to your notice, if you don't achieve your activity goal for this week, your insurance cost for this month will go up by 100%," Alfred explains calmly. Emma leans back into the seat of the car and exhales loudly, knowing that she has to work harder tomorrow to complete her activity goal.

Later that day, Emma continues to work on one of her half-finished oil paintings. When she is just about to do the last brushstrokes, Alfred's voice emerges again, "Hey Emma, your colleague Catherine seems to be very frustrated these days. As the two of you get along very well, let's see if you can help her out a bit. I will try to get her on the phone". After some beeps, Catherine appears on the big screen next to Emma's painting. A few minutes into the conversation, Catherine explains in a shivery voice that she feels very lonely and is thinking about joining an offline community that lives remotely and does not use any type of companions. Emma is surprised to hear about this, as she feels like the companion adds significant value to her life, "Just imagine running away from all those benefits. You would probably have to work for 8 hours a day again – like our parents. Feels like being stuck in the past," she responds to her colleague's thoughts. Eventually, she manages to calm Catherine and convinces her to let go of her negativity. After the two women said goodbye, Alfred tells Emma, "Great job, her emotional state is much more stable now and it seems that she reconsidered her decision. Congratulations, you are rewarded one hundred extra social credit points."

A few minutes later, Sansa arrives home from school. Visibly excited, she tells her mom not only about the basketball game but also about some feedback she received in school that day. "The digital companion at school told me that I am truly talented in coding and that I will become a great programmer one day. He just added additional coding classes to my curriculum," she says excitedly. "Hmm, so you will spend more time at school from now on?" Emma asks. "No, we cut a few of her piano classes, it is just a replacement," Alfred responds. "Mhh, okay," Emma replies with hesitation. Deep inside, she still wishes that her daughter will one day become a great pianist, just like her grandmother.

09:00 p.m.
Already late in the evening, Alfred notifies Emma that there is a new video update by the CEO of her company. He puts it on one of the screens in her living room and Emma takes a seat. The CEO highlights the latest achievements of the company but also mentions that the management is currently

assessing the risk of the government raising taxes on robots. "Why is the government always being such a pain? I wonder if that affects the budget for my future purchasing deals," she thinks to herself while Alfred turns off the screen.

"Time to go to bed, the two of you," Alfred's voice gently re-appears. Once her daughter starts sleeping, Emma puts on a pajama herself and lies down in her comfortable bed. Alfred dims the lights.

"Alright," Emma responds and stares into darkness for a moment, "Alfred… You know what… Maybe, Catherine was right in some sense, sometimes I also feel lonely".

"You have not seen some of your favorite colleagues for a while. I have checked their schedules and Friday night seems like a perfect time for a joint dinner. I have added this to your calendar," Alfred responds.

"Okay, good night, Alfred," Emma says quickly while a question comes across her mind which keeps her awake for a while: "Why is Alfred always suggesting friends from work only?".

## Signposts

- The number of therapy seekers increases significantly as interaction with technology consumes our free time
- Powered by AI, the personalization of consumer products is on the rise
- Companies are taxed for owning robots to support Universal Basic Income
- Working Nine-to-Five is dying as boundaries between work and life vanish
- The influence of AI on children increases as schools deploy educational digital companions
- AI-powered digital companions are deployed on every connected device
- Company Digital Companions are the new job perks to attract talent
- Majority of schools' funding is now coming from private companies
- Retaliation movements against digital companions are on the rise
- Creativity and interpersonal skills are in high demand in the job market
- EU social credit system has been launched

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# NEW AGE OF REASON

## A day in 2038

"You remind me of your mother today," says Aiden in his deep, startling voice which startles Eve. "Oh, Aiden! Humans need a thing called privacy, ever heard of that?" she snaps in an annoyed tone. "Sorry. I am afraid you look rather pale today, Eve." "Yeah, I should get something to eat," she mutters. "How about a refreshing jog?" suggests Aiden. "Nah… sorry, I'm not feeling like it right now. Maybe after I get some work done, I'll look into my health or whatever."
"Okay, I already have a job for you. Reid Motors is experiencing some inefficiencies in their manufacturing line. Should I patch you in?" Aiden replies. "Yes, go ahead." Eve always appreciated that Aiden took account of her personal preferences based on her work history when it came to jobs, especially as she thinks of herself as a bit of an expert when it comes to standard motor systems. She reaches into her pocket and produces what looks like a fashionable pair of 1970's Aviator glasses. She puts them on and sees the factory floor of Reid Motors appearing around her in the virtual world. "Let the fixing begin!" declares Eve excitedly.

Before her, Eve sees an array of manufacturing robots whirring and beeping in harmony. "So, what do we have, Aiden?" asks Eve. "Reid Motors is experiencing a significant decrease in performance of robots three to six in this line," replies Aiden. "Okay, Aiden, pull up the statistics for the robots from the past week," responds Eve. Aiden complies, and a wide holographic display pops up in front of Emily. She carefully peruses the details and eventually finds a problem. "Ah, I see it. Robots three to six are slower because their old Z1 motor systems are finally deteriorating. It's only a matter of time until the rest of the robots goes down as well. Aiden, notify the factory managers right-away to change the motor systems in these robots. My recommendation would be the Delta J motor systems." "Consider it done." Eve removes her glasses and is taken out of the virtual factory.

Eve didn't feel like physical exertion when she woke up, but making decisions in the virtual world changed her mood. "I'm feeling like tennis today, Aiden," says Eve. "Excellent choice.

I have already called a cab to take us to the downtown court." Eve prefers autonomous cab rides, so she doesn't have to deal with the stress of driving, however she feels like she can never truly relax because she is always preoccupied with the thought of incoming job notifications. It is not that these jobs are tedious or time-consuming, but the overarching effects of Eve's decisions on her Decision Score have really started to stress her out. "I wonder if I would have preferred the old school nine to five working life. Sure, I do smarter work, but I work... like… all the time. It's a real shame that AI is not allowed to do everything for us," Eve says to Aiden. There is a silence for a few seconds and Eve starts wondering if Aiden has even been listening to her at all. At last, he speaks softly, "We will figure it out eventually and I'll be there for you, help-

ing you in any way I can." Eve feels understood. Aiden always makes her feel a certain warmth. It often makes her forget that she is talking to a system based on ones and zeroes.

The cab stops outside the downtown tennis court. As Eve makes her way out of the locker room, she asks, "Is there any opponent around, who matches my current skill level?" "Emily is currently practicing with a robot in court two. Would you like me to set up a friendly match with her? Her swings are not on point today, so it would be a great opportunity to beat her," replies Aiden. "Perfect! I hope you're right. I hate losing to her," says Eve, unsure of what she is getting into.

"Oh... my... God! Eve Powers! I haven't seen you here in ages!" exclaims Emily. Emily Perrier is a tall lady with pale skin and blonde hair, always tied in a high ponytail. Eve has only ever seen her in a good mood. "Hey, Emily! I've just been coming to the court at off-times to practice my shots. I've gotten so much better since the last time we played in January. I really think this is going to be a fun match," says Eve, almost trying to reassure herself. "Well stop talking and show me already," says Emily with a wink and a smile. The match begins, and Eve holds her own against Emily. Throughout the game, Aiden constantly gives feedback to Eve regarding her form and shot angles to improve her skills as she plays. Halfway through the fifth set, the ladies are interrupted by a light ringing noise. The AI companions try to get the attention of their respective partners. "Aiden, what's up?" asks Eve still panting. "I just received a notification from Locke Automotive, saying that they require your and Ms. Perrier's opinion regarding the disposal of their stock of standard Z1 motors." Eve glances at Emily who is busy speaking to her own AI companion. She catches Emily's eye and they both nod and reach for their glasses. Their glasses flash as their retinas are scanned and they are catapulted into a new virtual world.

Within an instant, the tennis court disappears around them and is replaced by a large meeting room with the top executives of Locke Automotive sitting at the table. Eve could judge by the personnel involved and the gravity of this job that this VR session was heavily encrypted. "Ms. Powers, Ms. Perrier, it is great to see you both. Please join us," says one of the executives, "We would like to hear your opinion regarding the disposal of our stock of Z1 motors." Before Eve has the time to recall the details of this model, Emily speaks, "Well, I saw this situation coming because the original car model which used these motors has been out of production for over two decades. I believe it is a good option to sell these motors at a cheap rate to manufacturing companies in developing countries." The same executive says, "I am impressed by your knowledge of the situation, Ms. Perrier. You made a good argument. But I would love to have a second opinion on this matter from Ms. Powers." All the executives stare expectantly at Eve. She is now fairly nervous, not only because she is struggling with her Decision Score, but also because this is a very high impact decision requiring two professionals. Eve is confident in her own ability regarding the standard motor systems, as she took nearly all the expert courses and exercises relating to them which are publicly available. After a few seconds Eve says, "Aiden, can you pull up the damage report for these Z1 motors?" "Right away," says Aiden and in an instant, a holographic display of the report appears in front of Eve. She calmly takes half a minute to go through the report before she comments, "I believe that these motors are too worn-out and will pose a safety hazard if they get in the hands of developing countries' car manufacturers, as they don't have thorough safety regulations. These motors could potentially cause accidents. I believe that it would be more appropriate to properly dispose of these motors, so that they won't cause any damage."

The executives discuss the two opinions with each other before one of them finally says, "You both make good arguments, but we believe that selling the motors would help us recover some of the costs from our recently re-shored factories." Eve is shocked by their insensitivity in this response. "But you'll be putting so many lives at risk, I don't think this is a wise…,"says Eve indignantly before she is interrupted by one of the executives, "We respect your opinion Ms. Powers, however, we have all unanimously decided in favor of Ms. Perrier's decision. We have taken into account her flawless Decision Score as well." Eve looks over at Emily who gives Eve her usual smile as they are transported out of the virtual meeting room.

Eve is remorseful as she is driven home, unsatisfied with the outcome of the meeting, she doesn't speak much to Aiden. Aiden tries to break the ice gently saying, "What's on your mind Eve…? Do you want to talk about it...? Maybe I can help."

"AI-DEN... LEAVE... ME... ALONE... RIGHT... NOW," Eve shoots back and the rest of the trip is drowned in silence. She doesn't care much about Locke Automotive as a company, but she feels bad for all the lives that could be jeopardized because of this decision. Deep down, she knows that the damages that may be caused by Emily's decision will eventually come back to bite Emily and her perfect Decision Score. However, she quickly feels guilty for deriving pleasure out of such a destructive prospective future.

## Signposts

- Every big company in the digital industry, such as Facebook, Google, Microsoft, and Amazon offers a platform that seamlessly integrates working life with the pre-existing social media and private communication. Together, the four companies have 90% market share.
- On average, an employee works for three employers per day. While the total workload per capita declined to 5 hours per day, it is spread over a timeframe of 16 hours.
- Due to the "AI disasters" in the 2030's 180 countries joined the HDMA (Human Decision-Making Accord) which declares that decisions that can have a high economic, social, political or environmental impact cannot be made by machines.
- According to the HDMA, every human has to acquire a EDM certificate which qualifies you for Ethical Decision-Making. Between high school and before pursuing higher education in a technical or social field, you must spend five years at University learning about values, ethics, morals, and potential outcomes of AI-empowered decisions.
- Most people work as Ethical Decision-Makers. Companies approach them during their private life and their digital companion presents possible options. The human chooses one and gets paid based on the short-term and long-term impact of the decision. Depending on your decision-history, you get assigned future jobs. Every human has a Decision Score which is increased by good decisions and decreased by bad ones.
- Globally, the four best paying jobs are: ML Developer, Ethical Decision-Maker, Artists, and Human-to-Human-Interactor
- The Global Cybersecurity Alliance was founded in 2031. OECD countries joined forces to protect digital companions and other technologies from criminal attacks. There was no major security incident since 2033.
- The data privacy boom of the 2020's is over. Without integrating personal data in your professional life, you are not able to succeed in the modern economy since your digital companion is lacking information. Most people accept this since cybersecurity is guaranteed and the high transparency allows them to take part (digitally) in other peoples' life.
- Economic wealth and decrease of working hours fosters hedonism. Instant gratification in your leisure time and the high degree of personalization of digital companions allows people to practice their niche hobbies – mostly in virtual worlds.

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# THE GOLDEN THIRTIES

## A day in 2038

"Lilly, it is 2:05 p.m. You're already working five minutes overtime. Just wanted to give you a heads up." Lilly sighs and mutes the clear voice from her headphones. Unfortunately, today is one of the few days where the maximum five hour working time does not suffice. Lilly's colleague must have been a slacker during his last shift. When Lilly entered the factory today, her digital assistant reminded her of an additional decision package which had been left over. She scrolls through the data visualizations on her screen. A client from Italy requested a delivery of 500 printed circuit boards (PCBs) during yesterday's working shift, but the order has still not been passed to the production line. Lilly knows that further delaying the task to tomorrow's shift would probably mean a delivery delay – not an option, concerning the stiff Japanese competition. After all, if it was not for the public knowledge database, the Japanese would have driven her current employer out of business a long time ago. "Hey Lilly, you have exceeded your working time by twenty minutes by now." "Alright, got it!" Lilly rolls her eyes and decides to take at least a week off after this gig is over. "Confirm the request from Italy and pass down the production of 500 PCBs to the next unit," she dictates her digital companion. Ever since the global AI crisis of 2027, automated decision-making by algorithms has been prohibited on a large scale. Today, the exhausting but crucial task of making decisions lies with humans again, something that Lilly finds silly from time to time. Of course, had the processes leading to the AI catastrophes been explainable, life might be different today. "Done," answers the voice, "You might want to be careful on the way out. Your superior won't like it if you're working overtime."
On her way to the exit, Lilly notices that she is indeed the last person in the factory. "Funny how the corridors look when they are completely empty," she thinks to herself. Lost in thought, she approaches the full body scanner which lights up immediately. A ring of light moves from her head to toes. A clear, reassuring voice announces, "You're still wearing your digital assistant, Lilly. I must ask you to remove all company-related technology before leaving the property, so you'll be able to fully recover during your hours off work."

Lilly sighs as she redirects her steps towards the Companion Management System. "Goodbye, Lilly. See you tomorrow," the voice utters as she removes the earpiece. "Wow, this is so unnecessary. We abandoned cross-platform compatibility anyways," Lilly curses under her breath. A hydraulic hissing resonates as the padded drawer with her assistant sinks back into the immaculate white wall. Seconds later, the panel shows a green checkmark coupled with a friendly, "Thank you, Lilly. Your assistant has been registered." She looks at her smartwatch: 2:30 p.m. Time to get out of here!

"Lilly!" an obviously annoyed voice echoes through the marble square. It is George, her shift manager, running towards her. "You did twenty minutes of overtime today. Any idea how I might explain this to my boss? I do not need to tell you that your decision-making capabilities decrease after five hours." "What a damn micromanager," she thinks quietly. Ever since the establishment of the 25-hour workweek in 2033, people like George had become overly cautious about the 5-hours per day rule. "Sorry, I'll leave twenty minutes earlier tomorrow," she apologizes, wondering what kind of hobby someone like George would indulge in. Things like these became hard to find out in today's regulated working environment. Fortunately, the smoothly whirring tram comes around the corner at that moment, giving Lilly the perfect opportunity to escape the situation. "Bye, George," she smiles as she steps into the bright vehicle.

As the doors close quietly behind her, Lilly reaches for her digital assistant in her purse. "Hey Charly," says Lilly while inserting the small, silver earpiece. "Hey, Lilly," a deep, synthetic voice answers, "I hope work wasn't too stressful today. What can I do for you?" While the digital assistant connects her to her husband Tom, she is already looking forward to her violin concert this evening. Lately, she is beginning to make a name for herself in the music groups within her municipality. "Hi, Lilly!" Tom's digital assistant wakes her from her daydreaming. "Tom is at work and can't answer his phone. Should I deliver a message when he is done?" "Yes," she replies, "I'm running a little late for lunch today. Please ask him if he could pick up the kids from school. Thanks!" After hanging up, she suddenly wonders whether Tom's job also involves dealing with people like George. Upon reflection, she is not sure what Tom actually works on at his current employer. No wonder, since he has been gigging on and off across the automotive industry for as long as she knows him. Much like herself, she realizes.

"Hey, darlings!" she laughs while entering their favorite steakhouse, "Come give mommy a hug. You, too, big boy!" Lilly smiles while playfully punching Tom in his side. "Mommy, today I had the best class ever with Mr. Goldstein!" shouts her youngest one, "We reenacted the decisions in the battle of Carthage. I was part of the Roman army!" "They're trying to teach kids in strategic decision-making early on," adds Tom, "This will soon be mandatory in every school. Training an analytical mind from the beginning." It is clear how much he appreciates this modern education. "Wonderful," says Lilly while patting her son's head, "Now, did you order already?" After lunch, the entire family heads home via the elegant, remote-controlled public streetcars. Lilly has problems hiding her amusement as she listens to Tom, who is quite enthusiastic about his afternoon. Apparently, the neighborhood's urban gardening group has finally reached a consensus about planting horseradish. Ever since he accessed the community's publicly available vegetable growth statistics, he had been planning to include horseradish in his vegetable beds. With a subtle smirk on her face, Lilly wonders what people were passionate about in the old days when most of their precious life was mostly consumed by dull, repetitive tasks. Probably materialistic things, she wonders, before drifting into deep thought about her violin concert later today.

Not even 20 minutes after arriving at home, the family is surprised by a shiny white minibus honking in front of their doorstep. "Hey!" shouts the hockey coach leaning out of the vehicle's window, "Where are my famous hockey twins?" As Lilly steps outside, the coach's face brightens up, "Hi, Lilly! I heard that your concerts are the best in our community! I hope I'll make it some time. Oh, and next time you see Tom, please tell him: great job on the horseradish." Feeling maybe a bit too flattered after the hockey teacher's words, Lilly stands on the porch, waving as the minibus rolls down the driveway. Soon, she too leaves the house for one of her widely known violin concerts.

In the evening, Lilly, the violinist, Tom, the urban gardener, as well as their kids are snuggling up in front of the screen. "Play me some retro series!" shouts one of the twins at the monitor. A loading icon appears, then a clear, soothing voice resounds from the device, "I'm sorry, but my interaction model has been deleted as a security measure following an attack

on the main database. Unfortunately, I don't have any data that could point me to the kind of series that you'd like – and, I'm awfully sorry: can you remind me of your name again?" "Oh man!" the child turns around and looks at its parents, "Why is it that every time we want to watch TV together, our streaming is down?" Lilly sighs. Headed towards the device, she orders the digital assistant to request a data backup from the streaming authorities, including the remotely stored interaction model of her family. "Alright, I'll hand down your request to a human decision-maker in our San Francisco office as soon as possible. In the meantime, would you give me the precise name of the series that you'd like to watch, so I can manually find it for you?"

The next day, after the kids have left for school, Lilly gives a goodbye kiss to Tom, who is still in his pajamas. As she slowly closes the door and walks along the sunny veranda, she hears Tom ordering the automatic kitchen robot to prepare his second cappuccino of the morning.

In front of the factory, the typical hustle and bustle of workers coming in is taking place. Soon, Lilly manages to catch an unoccupied check-in station which displays a personalized welcome message as she faces the iris camera. "Hi, Lilly. Looking very active today! Please, leave your personal belongings with me before entering the production hall." At the body scanners, the long queues have shrunken a little. A moment later, Lilly enters one of the white, transparent boxes which, after an unusual pause, displays a red warning message, "I'm sorry Lilly, but you still have twenty minutes until the start of your shift. Please come back later." "Ah come on, is this serious?" Lilly exclaims. "New firm policy," the friendly voice insists. "The law dictates that all overtime has to be worked off the following day. George thinks that allowing people to enter later is the best way to abide by this new workplace regulation." "Oh, man. It doesn't really matter whether I leave earlier or start later, does it?" Lilly leaves the body scanner. "Well," she hears the clear voice say, "Who am I to judge? I'm just a machine."

## Signposts

- Companies join forces to develop explainable AI, establishing publicly available knowledge databases on the topic
- Autonomous AI decisions around the world cause several incidents resulting in human fatalities
- Private and work devices must be kept and used strictly separately to maximize concentration levels at work as well as the quality and restfulness of free time to recharge for the next day
- Working time is reduced to 25 hours per week due to cognitively challenging tasks of continuous decision-making as well as the increased efficiency of production lines
- Majority of all domestic manufacturing is automated, thereby increasing efficiency significantly
- Due to numerous cybersecurity incidents, cyber systems were established to be inherently insecure and thus, must be compartmentalized
- AI is inexplicable, leading to mistrust and legislation banning AI from all decision-making and creating the human job description "decision maker"
- Project-based work becomes the new status quo among workers, ending employer-employee ties
- Companies open up their non-personal data pools to foster increased supplier competition, innovation, and open-source based knowledge sharing
- AGI is developed, giving humans a revolutionary way of interacting with machines
- Time spent on arts, music, and sports is at a record high as society's focus has shifted towards private life

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# DE-ENLIGHTENED ROMANTICISM

## A day in 2038

De-enlightened Romanticism describes a future where machines have the capabilities to autonomously make explainable decisions and dominate actions in multiple human spheres. Individuals totally separate their professional and personal life in terms of time, space, mindset, and social relationships.

"I'm in the middle of a storm and my body is starting to feel numb. The temperature is dropping below zero degrees, and my blood is crystallizing. Winter is coming. I can barely keep warm by wrapping myself in newspapers. While doing so, I manage to get a glimpse of the heading 'Algocracy – AI took over the last human job', and I then realize that I have lost all hope."
"Wake up, Kim - are you okay? Your resting heart rate has exceeded the baseline interval which implies anxiety," sounds through the room with a soothing voice. "Oh Ruby, I had such a bad nightmare! The entire world was ruled by machines," Kim sighs"Don't worry, it's only 5:00 a.m. Just keep sleeping, I will wake you up as usual."

At 9:00 a.m. Ruby, Kim's personal digital companion, slightly tilts the blinds horizontally, allowing the sun to shine through the window. The coffee machine turns on automatically and fresh Brazilian beans begin to roast. The smell of coffee fills the room and Ruby wakes Kim up with a calm voice. She opens her eyes and grabs hold of the cup of coffee. While taking her first sip, Ruby announces the latest news: "Breakthrough in AI: European Union acknowledges milestones in Explainable AI research and reduces AI regulation to enable a broader adoption across companies." "It's about time," Kim responds and goes to the bathroom to take a shower.

At the same time, Ruby makes sure that Kim's favorite breakfast is being prepared to give her a healthy start into the day. Kim takes a spoon of her delicious Birchermuesli while

anxiously staring out of the window. Ruby interrupts her thoughts with a concerned voice: "Listen, Kim. I noticed that you have a high cortisol level. To reduce your stress, I scheduled a mindfulness class this week." "Yeah, that sounds good. I definitely need to clear my mind!" she responds. After finishing breakfast, Ruby tells Kim that her work shuttle has just arrived, "See you in five hours, Kim!"

Kim walks towards the vehicle. Its infrared sensors identify her based on body movements and the door opens automatically. As she enters, a voice welcomes her with a polite and serious tone, "Good Morning, Ms. Smith. It's a pleasure to give you a ride to work. Today, the company requires you to work in factory B. We will arrive in 47 minutes." Kim puts on the VR glasses and says, "Computer, please start my virtual

check-in!" A 3D visualization of factory B appears, zooming into a scene where Kim observes an accident that occurred last night." There was an unusual machine error in section B.4.3," the deep voice of Computer clarifies, "The maintenance worker Mr. Hoffmann was booked in order to repair this hardware issue. His key performance score was the best of those available on the gig platform for today."

Arriving at the company site, the voice instructs Kim to go to section B.4.3 because the staffed maintenance worker had issues solving the problem. Kim is employed as an AI co-worker and responsible for supervising the interconnected, autonomous, and highly standardized production systems of industrial factories. Entering the shop floor, a highly automated production line with a negligible degree of human presence becomes visible. Robots and humans work in a smooth, complementary way without requiring protective barriers or particular safety equipment. The factory, which has been built after the company's decision to move production sites back to the United States two years ago, is characterized by multidirectional layouts, modular line setups, and sustainable, resource-efficient production. Based on autonomous system communication and a free flow of data, the smart environment is highly flexible and can quickly facilitate demand-driven customization of products. Numerous autonomous vehicles are moving over the shop floor and collaborating with the ecosystem of machines. Each single entity is part of the larger network and distinct models continuously interact across the whole production chain. This seamless interplay would be hard to imagine without the widespread implementation of technology standards that took place in the recent years.

Kim enters B.4.3 and approaches Mr. Hoffmann. He notices that the machine got a hardware upgrade and there is not yet any supporting material included in the centralized corporate library with shared knowledge on augmented reality for remote maintenance. Kim responds, "No problem! As a permanent employee, I am authorized to access further information. Let me check who introduced this hardware upgrade." Computer replies to that matter, "This machine was integrated by the freelancer Mr. Lee a few months ago. I just set up a meeting with him to clarify the issue." A space on the floor is illuminated, where the shape of a body starts to materialize. Mr. Lee's face appears on a greenish 3D hologram next to the machine in B.4.3 and joins the discussion. He explains the changes that were made when upgrading the hardware and clarifies the questions of Mr. Hoffmann. By joining forces, they solve the issue within minutes.

"Ms. Smith, you have a strategy meeting in 15 minutes. It will take place in room 405," the corporate voice mentions. In the conference room, Computer starts reporting on recent changes of the factory layout, "Based on the newest additions to the Global Open Industry Knowledge Repository (GOIKR) and recent market developments, we need to re-adjust our production process. I already took the necessary steps to rearrange the modular line in order to ensure a more efficient production." Then Kim and the other participants discuss how to take advantage of the newly announced EU regulation by further automatizing the production line.

On her ride back home, a virtual corporate education session is scheduled. Kim puts on her VR glasses and logs into the system. She finds herself in a Silicon Valley startup hub right next to the famous founder of Facebook, Mark Zuckerberg, and starts sketching with hardware. As automation proceeds and replaces human labor with mainly rationalized actions, the company seeks to re-skill their employees to have more focus on divergent thinking instead of convergent thinking. This enables employees to face problems with an innovative and creative mindset, which is one of the main reasons for companies to introduce this remote creative workshop. Right when finishing her Arduino programmed prototype, Computer notes, "You have reached your maximum number of working hours for today. Your re-education session will continue tomorrow. Enjoy your free time!" Kim takes off her virtual reality glasses and recognizes her favorite café a block

down from her house as the car turns onto her street.

Back home, Ruby's friendly and warm voice pervades the foyer, "Hey Kim, nice to have you back home! Your old school friend Paul invited you to a cocktail party this evening. Since you haven't seen him for a while, I accepted his invitation." "Sounds good. Where will it be?" Kim wonders. "It takes place at the Independence bar. A shared car will pick you up at 6:30 pm." "Ah great, I really like that place." "Also, I analyzed your current health status. As your weight approaches a less attractive level, I signed you up for a cardio training before you go to the party." "Hm, Ruby, I don't feel like going to the gym now, I had a really tough day at work." "Are you sure, Kim? It's not only about your health, you could also lower your health insurance rate by improving your fitness level." "No, I'm too tired and don't want to think about that right now." "Okay, no worries. I'll cancel today's session and remind you next week."

Wearing a ruby-colored cocktail dress, Kim enters the bar and sees Paul at the entrance. "Hey Paul, long time no see," she starts the conversation. "Thanks for coming! How was your day?" Paul inquires. "I had a great day at work. I finished an amazing drawing in my creativity workshop. Let me show you," Kim mentions. "Hey Ruby, please share it with Paul." "I am sorry, but sadly I am not authorized to access your work-related content," Ruby apologizes. "Oh, I totally forgot. Well, let's not talk about work anyways. Let's go get some drinks," Kim suggests to Paul.

After enjoying the great party with a lot of dancing, drinks, and conversations, Kim returns home exhaustedly. Ruby turns off the lights and updates her with the latest news. Shortly before falling asleep, Kim hears a last news update "Unemployment rate has risen to 25%, the highest peak in the last 80 years." Suddenly, Kim is reminded of the horrible nightmare and is grateful, "Luckily, my company offers a re-skilling program to prepare me for the future."

## Signposts

- Increased burn-out rate leads to a reversed social movement of millennials towards total separation of private and work life
- To compete with the emerging Asian digital economy, the EU heavily invests in internet infrastructure, enabling reliable and high-speed internet access across Europe with 90% coverage
- Breakthroughs in research of explainable AI lead to an attitude of acceptance towards AI and a wide adoption of machine-centric decision systems in everyday and corporate life
- The EU releases the General Public Artificial Intelligence Regulation (GPAIR) to enable widespread application of AI and its potential in the economy
- A study reveals that 8 out of 10 European citizens are using digital companions and other intelligent systems on a daily basis to fully autonomously schedule and determine their days
- After numerous hacking incidents of sensitive corporate data linked to personal use cases, companies enforce policies to restrict the portability of corporate devices outside the organization and prohibit private usage
- The diverging gap in new skills demanded and workers available in the domestic labor market leads to an incoming stream of high-skilled foreign workers and broader diversity in society
- Due to the rise of automation and adoption of Industry 5.0, the unemployment rate in Germany reaches 25%, the highest rate in the last century
- Due to the declining demand for human work, the government announces the 25-hour work week to oppose the increasing unemployment rate
- Due to the rising gap in social inequality, there are political discussions on universal basic income. Within the United Nations a sentiment emerges that such concepts are feasible.

# IDEATION

The following chapter describes five novel business models in the field. Each of the business models is described using the Osterwalder Business Model Canvas.

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# REXPERTISE

## A Holistic Solution to Retain Knowledge of Retiring Maintenance Workers Permanently.

Writing down knowledge to preserve it is not a new idea. Cavemen did the same 40,000 years ago. Even back then, they recognized that it is essential to pass on their knowledge, as it forms the basis for future progress. Since then, civilizations around the world have been able to evolve through the retention and transmission of knowledge. The same concept still applies to companies today. In fact, in the fast-paced information age it has become even more critical to retain knowledge within companies.

Nevertheless, especially in the field of manufacturing, companies lose a significant amount of knowledge when their maintenance workers retire. Metaphorically speaking, companies increasingly suffer from "organizational Alzheimer's". How can a company ensure that younger generations of maintenance workers can still access the invaluable expertise gathered by their previous peers over years?

REXPERTISE, short for "retired expertise", aims to help companies retain the knowledge of retiring maintenance workers permanently. When a current maintenance worker faces a problem, they cannot solve on their own, REXPERTISE enables them to contact a so-called "Rexpert" via an app. Rexperts are retired maintenance workers, who are willing and qualified to transfer into a remote expert role for 10 hours per week to top up their pension. After the current maintenance worker enters their problem into the app, the Rexpert platform identifies and matches a fitting Rexpert with regard to their availability and expertise. Via the built-in video call function, the Rexpert then assists the current maintenance worker. In the near future, both parties will be able to solve the problem together in a virtual factory using VR glasses. This concept ensures a prolonged knowledge lifecycle within the firm.

But REXPERTISE will not stop there. It aims to capture and preserve this knowledge, regardless of the individual Rexpert. Therefore, NLP is deployed to analyze all dialogues between the current maintenance worker and the Rexpert, to identify recurring keywords as well as relations between them. This will enable REXPERTISE to build a knowledge base automatically over time. Whenever the Rexpert is not used to capacity, they can review the captured knowledge for meaningfulness and improve it when necessary.

## Business Model

### Key Partners

- Established companies in the manufacturing industry
- Technology providers of the latest communication, storage, and database technologies
- Governments

### Key Activities

- Maintaining a database of Rexperts
- Initial and continuing training for Rexperts
- Matching the right Rexpert to the problem
- Capturing and storing knowledge
- Developing the REXPERTISE App

### Key Resources

- Contacts to Rexperts
- Technology for communication, storage, and databases
- Developers with programming skills for app development

### Value Proposition

- Permanent knowledge retention from people who leave the company
- Making knowledge scalable and independent from individuals
- Structuring of internal knowledge
- Workflow optimization of actual maintenance tasks
- Raising company attractiveness

### Customer Relationships

- Long-term relations
- Dedicated personal assistance
- Automated services
- Transparent added value

### Channels

Online

- Webinars
- E-Mail, e.g. newsletters
- Paid search advertisements

Offline

- Trade fairs
- Meetups and expert panels
- Referral system

### Customer Segments

- Machine manufacturers and manufacturing companies
- Maintenance businesses

### Cost Structure

- Initial costs: Matching software, app as interface, database of Rexperts, knowledge-database
- Operating costs: Database maintenance, server infrastructure, communication means for app
- Hardware costs: 360° cameras, VR-glasses

### Revenue Streams

- Initial setup fee
- Pay-per-registered-worker subscription fee

## Value Proposition

**Permanent knowledge retention from people that leave the company:** When maintenance workers retire, knowledge leaves the company. Visually speaking, companies suffer from "organizational Alzheimer's". By matching current maintenance workers with Rexperts, the knowledge lifecycle within the company will be prolonged. Furthermore, REXPERTISE uses the interactions between maintenance workers and Rexperts to build up a permanent knowledge base automatically. Consequently, knowledge becomes independent from the individual Rexpert.

**Structuring of internal knowledge:** Through advances in technology, such as computer vision and NLP in combination with constant revisions of the captured knowledge by Rexperts, REXPERTISE can provide a new quality of structured knowledge. One possible vision for the future would be to comprise structured knowledge graphs that could even directly be used by machines.

**Optimization of workflow in actual maintenance tasks:** Current employees will be backed by Rexperts, who are still available through REXPERTISE. Issues occurring in the field of maintenance are often similar to past problems. It is more efficient to make use of existing knowledge and the expertise of senior employees rather than trying to solve issues alone without any reference to the situation, machine or specific task.

**Rising attractiveness of company:** The reputation of a company rises by appreciating good work even after retirement. This can be established through special contracts, which provide monetary rewards, value, and fulfilment even during retirement. Self-fulfilment is based on valuing more senior people and their knowledge by coming back to them to ask for help and feedback.

## Customer Relationships

REXPERTISE is a B2B company targeting big corporates in industry and manufacturing.

**Long-term:** The relationship to customers is deep and long-term. The longer REXPERTISE is used, the higher the benefits to the customer due to the growing knowledge database and pool of Rexperts. Another reason for the long-term relationship are the high switching costs. Once the knowledge base and the Rexpert pool has grown to a certain size, it is difficult for a customer to switch to a different alternative and start from scratch again.

**Dedicated personal assistance:** To ensure comprehensive customer support, every customer has a dedicated Key Account Manager (KAM). The KAM's main job is to support to the respective customer, if they have questions. A KAM is also needed due to the intimate character of the relationship which involves a lot of confidence. As part of the onboarding process, the KAM also communicates that sensitive data is protected. State of the art encryption and in-house servers are in place to ensure the highest standards of security. The trustful relationship to customers is additionally supported by NDAs signed between the customer and REXPERTISE. Furthermore, the KAM also supports the customer with internal promotion. Two target groups are essential: Firstly, the soon-to-be-retired experts to recruit them to sign up as Rexpert after their career. Secondly, current maintenance workers are needed to foster the adoption of the product. When a maintenance worker is convinced to use REXPERTISE whenever they have a maintenance problem, they are also more likely to become Rexperts themselves when they retire. Internal channels such as the intranet, newsletters, events, and word of mouth are used in order to show the workers the high appreciation towards becoming a Rexpert as well as the ease of use in day-to-day maintenance work. In order to make REXPERTISE more approachable for Rexperts who are not digital natives, training sessions on how to use the REXPERTISE app will be offered free of charge.

**Automated services:** Despite acknowledging the importance of KAMs, the knowledge is structured in a way that most maintenance issues can be solved without their involvement. To enable the customers to solve their problems alone, the usability of REXPERTISE must fulfil high standards.

**Transparent added value:** A personalized dashboard constantly provides real-time data about KPIs concerning the interaction of current maintenance workers with REXPERTISE. Managers can review all important information at a glance: the number of requests for the knowledge base per day, the amount of Rexpert calls per day (solved/unsolved), the workload per Rexpert, and the type of machines currently facing most problems. This allows the customer to quantify the value that is generated at any given time by REXPERTISE.

## Channels

To reach big corporates, online and offline channels are used. Online, three main channels are used. Firstly, Webinars are offered, which allow company representatives to learn more about the product and understand how it solves their pain points. Secondly, emails with relevant information for the target group are sent out on a regular basis as a newsletter. Thirdly, paid search advertisements are used to target maintenance workers as well as executives of manufacturers. Keywords that are typically used when trying to solve a maintenance problem using Google are targeted.

Also, three offline channels are in place. REXPERTISE is present at trade fairs to showcase the product to relevant players in the industry. REXPERTISE will also attend meetups and expert panels to share its knowledge and increase its brand awareness. Lastly, a referral system incentivizes word of mouth and referring other companies to REXPERTISE.

## Key Resources

Since the company is based on software and knowledge, the required key resources are the Rexperts and the software, which can capture the knowledge and contact Rexperts. In a further step, the aim is to automatically build up a knowledge base to preserve the knowledge indefinitely.

**Base of Rexperts:** REXPERTISE relies on the quality and quantity of the knowledge it receives. Therefore, access to

retired experts and their knowledge are the key resources to success.

**Technology for communication, storage and databases:** In order to store knowledge and contact details of Rexperts, REXPERTISE needs to make use of the right technologies, such as data analytics, video calls or server infrastructure to integrate into the company's infrastructure. With these technologies, REXPERTISE will create the first REXPERTISE app which can be used by maintenance workers and Rexperts. While the physical distance between current maintenance workers and Rexperts is a logistical problem for getting in touch, AR, VR, and eye tracking are the technological future for the Rexperts. In summary, REXPERTISE will keep track of ongoing trends in technology to build the most efficient REXPERTISE app.

**Developers with programming skills for App development:** The plan of REXERTISE is to act independently. That is why developers should jump in right at the beginning and develop the customized key components of REXPERTISE's technological infrastructure. Apart from the independence of REXPERTISE, this also comes with further advantages such as the protection of sensitive company information and personal data of Rexperts.

## Key Activities

**Maintaining a database of Rexperts:** Rexperts are selected in coordination with HR. Once people become Rexperts, they are noted in a database which provides all required information for current employers, including contact details, core expertise or work history.

**Initial and continuing training:** Providing initial trainings for soon-to-be-Rexperts is crucial for them to understand and operate the app. As another part of the Rexpert care package, REXPERTISE offers constant trainings on the usage of technology, e.g. smartphone apps, which also enables the Rexperts to keep up with digital natives.

**Matching the right Rexpert to the problem:** REXPERTISE provides a matching system which matches the current maintenance employee, who has a specific problem, with a fitting Rexpert. This relies on employment history as well as data on problems the Rexpert has been working on in the past.

**Capturing and storing knowledge:** REXPERTISE desires to build up a permanent knowledge base. The Rexperts' knowledge is captured with every session by analyzing the recorded video and voice to extract relevant information. The aim is to store as much structured digitized knowledge as possible that can subsequently be accessed by current employees. After each Rexpert session, the generated information is reviewed by the responsible Rexpert. In this review session, knowledge is validated and completed to generate a structured knowledge base. The review process can easily be done within the REXPERTISE app that is equipped with a user-friendly interface.

**Developing the REXPERTISE App:** Developing the REXPERTISE App will combine all Key Activities in one interface. This makes matching and contacting Rexperts, as well as storing and reviewing knowledge, as central and easy as possible. In the future, the app can even be enhanced by advancing VR and AR technology.

## Revenue Streams

REXPERTISE has two main revenue streams. Firstly, clients are charged for the setup of the database and adjustment of the matching system to their requirements. Secondly, revenue is generated through a subscription model with a monthly fee per registered maintenance worker.

**Low initial setup fee:** Clients are charged a small fee for the initial setup in order to keep the barriers of entry as low as possible. The fee includes a first set up of the database as well as adjustments of the matching software to the clients' requirements.

**Pay-per-registered-worker subscription fee:** The generated revenue is dependent on the number of registered users, as

REXPERTISE charges a monthly fee per registered maintenance worker. This model is highly flexible, as companies can test it on a small scale and then expand after observing positive results. Furthermore, neither the number of Rexperts nor the amount of knowledge stored in the database is limited. This encourages companies to actively use REXPERTISE in the long-term. The customer can choose between two packages including or excluding hardware. If the customer opts for the more expensive monthly "hardware package", they are provided with mobile devices (tablets and/or smartphones) and 360-degree cameras. In the future, this could also include VR glasses.

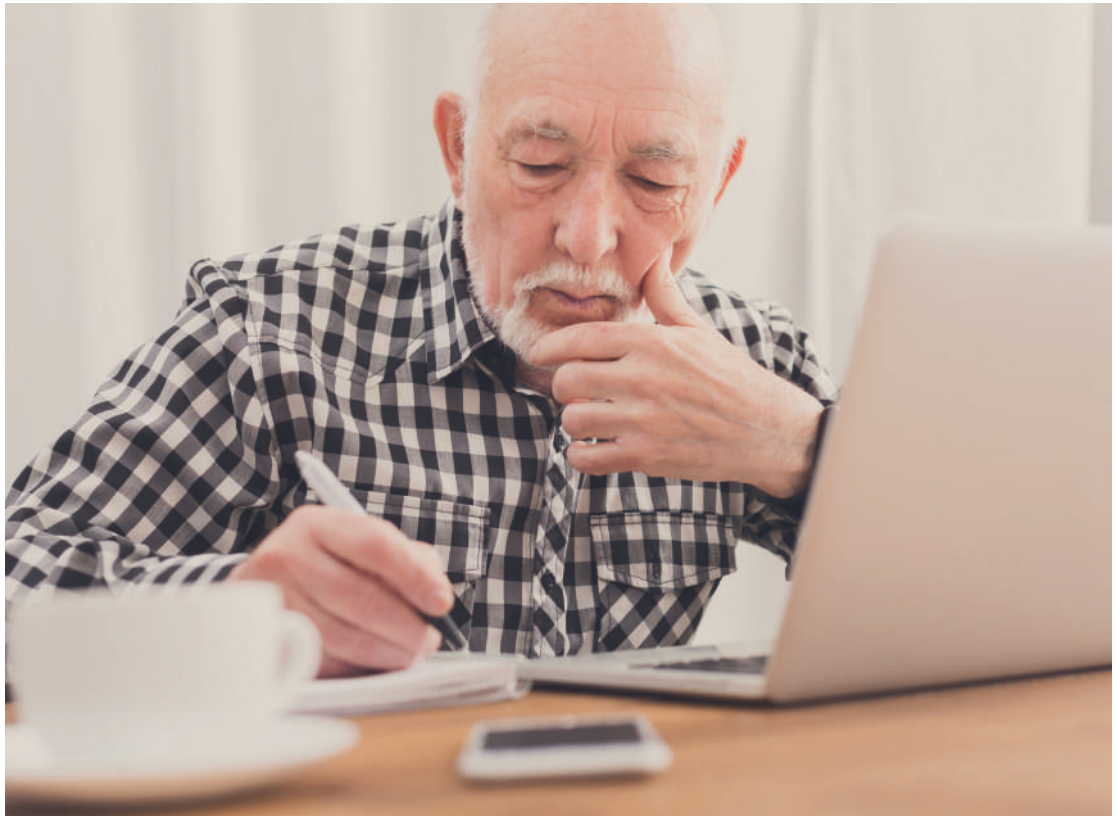
## Key Partners

**Established Companies in the manufacturing industry:** REXPERTISE's focus is to ensure permanent knowledge retention in companies with a long history and tradition of production. Therefore, REXPERTISE aims to attract big companies in the field of manufacturing which have been active throughout several generations of workers. To raise awareness, REXPERTISE needs established companies as first clients to deploy its model. In the long term, REXPERTISE will also target younger companies and startups. In today's information age, they too suffer from significant amounts of knowledge loss.

**Technology Providers of the latest communication, storage, and database technology:** As a very important first step, REXPERTISE needs to find key partners in the technology industry. REXPERTISE provides the technological means for maintenance workers to contact Rexperts. This is why they need to be equipped with the right technology. Especially in the beginning, REXPERTISE will not build all these technologies itself. Instead, it will build up valuable partnerships with established companies and rising startups in database, server infrastructure, and telecommunication technologies. Together with these partners, REXPERTISE will create its first version of the REXPERTISE App and develop it further throughout the integration with companies.

Furthermore, the user interface of the app must be as intuitive as possible. Therefore, REXPERTISE also stays in close contact with potential partners in the field of VR, AR, and chatbots.

**Governments:** Currently, governments are facing serious is



sues as consequences of an aging society, e.g. poverty of senior citizens. Here, REXPERTISE can support and provide a solution. Willing and capable workers are offered a chance to increase their pension with an additional monetary top up. This makes them less dependent on subsidized governmental help. Additionally, REXPERTISE ensures that knowledge stays in companies for a longer period of time and increases the efficiency of current employees. Therefore, the government benefits by supporting REXPERTISE and is an interesting stakeholder to consider, especially regarding the possibility of subsidies.

## Customer Segments

**Machine manufacturers and manufacturing companies:** The major target group are big corporates which are manufacturing machines themselves but also maintain them. The maintenance work takes place either in their own factories or in their customers' factories. Big companies, such as Siemens or General Electric, would be ideal, as the loss of knowledge is a major pain point for them. Furthermore, a large pool of Rexperts can be built within a short period of time due to the

large number of employees of these companies.

**Maintenance businesses:** A lot of the earlier mentioned manufacturers also hire subcontractors to maintain their machines. These subcontractors are highly specialized and cannot allow to lose this knowledge. Knowledge is their main asset as they do not manufacture machines but maintain them. Capturing the best practices and making them accessible using REXPERTISE brings extensive value to them.

### Cost Structure

**Initial costs:** Firstly, software will be developed which can match the current maintenance worker's problem with the expertise and availability of a Rexpert. Secondly, an app is required to enable the maintenance workers to input their problems and the Rexperts to accept the requests. The app also has to offer audio and video calls. Thirdly, a database must be set up where the Rexperts' contacts, availabilities, and specific expertise are noted.

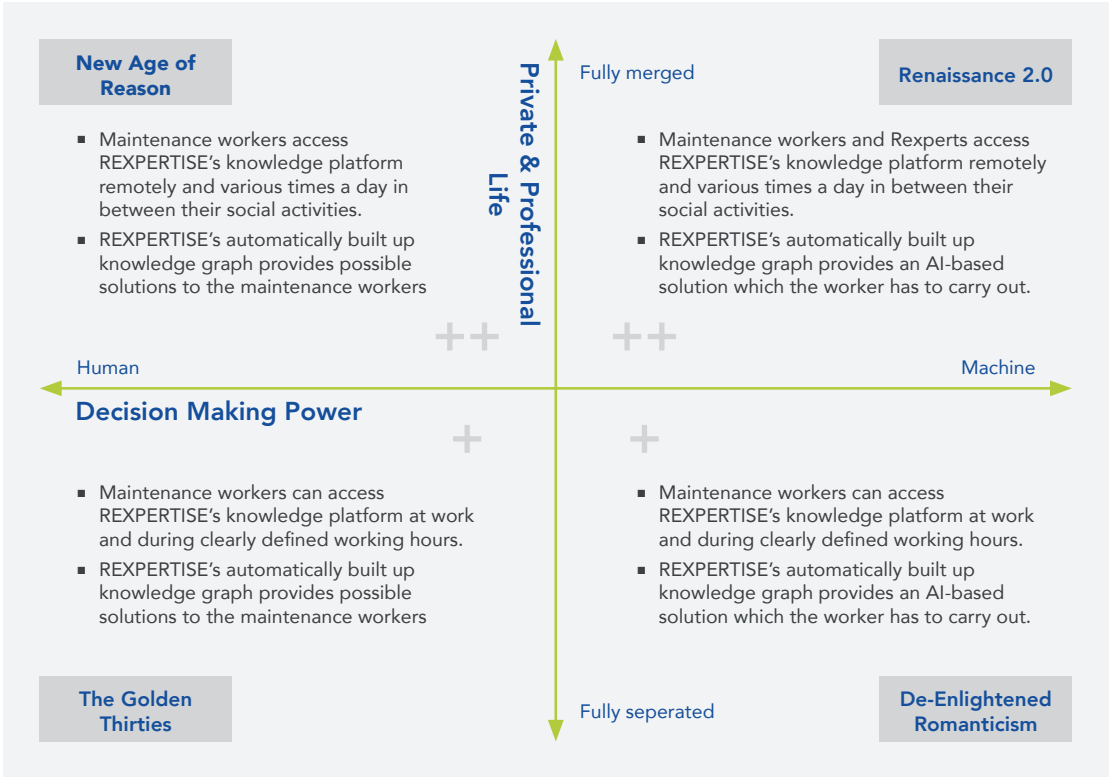
**Operating costs:** Once the database is set up, it must be continuously maintained to guarantee reliable and up-to date information about the Rexperts. This data, as well as audio and video data from the interaction, has to be stored so that it can be accessed easily. Lastly, there will be costs resulting from using a call-provider like Skype for Business or Discord. These costs might increase, as REXPERTISE will deploy VR technology as a means of contact in the near future.

**Hardware costs:** Depending on the preferences of the customer, also hardware – such as mobile devices and 360-degree cameras – can be leased for little money from REXPERTISE. In the near future, VR-Glasses can also be leased out to customers. Depending on current customer demand, they are ordered as needed and can thereby also be provided according to fluctuations in demand.

### Scenario Fit:

**Renaissance 2.0:** REXPERTISE fits well in this scenario, as the personal and professional life are closely intertwined. Since maintenance workers close to retirement see work as an integral part of their life, they will not abruptly stop from one day to another. Therefore, they will be more likely to become a Rexpert. In this case, there might also be less need for manual maintenance work since AI is capable of making reasoned decisions. This would allow to develop and use maintenance robots. The REXPERTISE knowledge database, that has been generated by past Rexpert sessions, can also be accessed and further enhanced by such robots. It can be the main data source for their decision-making processes and is therefore highly valuable. Very complex maintenance problems might not be solvable by robots and would require maintenance workers who have more expansive skills. The comprehensive REXPERTISE knowledge platform and the Rexperts can empower such employees.

**New Age of Reason:** Unlike in the scenario above, humans will have to make loads of manual decisions even if AI can make suggestions and robots could execute simpler maintenance tasks. Thus, there is still a demand for many employees in the field of maintenance. However, the employee fixing the machine might not have to be physically present at the maintenance site but rather operate remotely. The digital knowledge platform of REXPERTISE can be accessed from anywhere at any time and provide profound suggestions for human workers to make the final decisions. REXPERTISE sets up the means to communicate with them remotely. Furthermore, REXPERTISE could also offer a service where the Rexperts make these final decisions, which could be used if



there are not enough employees available. Since professional and private life are fully merged in this scenario, maintenance workers are more likely to be interested in working as a Rexpert on work-related topics after retirement.

**The Golden Thirties:** In the scenario "The Golden Thirties", REXPERTISE would have to ensure to keep private and professional life clearly separated. This is challenging, as retirement does not always include a professional life in general. However, the separation between these two does not mean that there will not be any motivation to work as a Rexpert. To keep up the separation, Rexperts cannot be contacted outside their clearly specified working hours. In addition, REXPERTISE can also equip the facilities with the necessary hardware (e.g. laptop and VR glasses) to take part in a Rexpert session because Rexperts might not want to use private devices or even be unwilling to bring such work-related devices back home. Like in the "New Age of Reason", REXPERTISE could also offer a decision-making service with its pool of Rexperts.

**De-enlightened Romanticism:** With the decision-making process centered around the machines, the encompassing knowledge database of REXPERTISE generated through many Rexpert sessions will have the highest value for users. Machines need a profound foundation to base their decision on. This is exactly what REXPERTISE offers. In case of very specialized maintenance tasks, there would still be a need for competent maintenance workers. Similar to "Renaissance 2.0", REXPERTISE is able to support them with knowledge and a possibility to contact experienced Rexperts. However, REXPERTISE must set up facilities for the Rexperts where they can work for a specified amount of time to ensure that there is no convergence of private and professional life, much like in the scenario "The Golden Thirties".

## Challenges:

- Digitizing and structuring knowledge automatically
- Integration of knowledge for newly implemented systems
- Motivation of Rexperts to work after retirement
- Ensuring that Rexperts are available on short notice in case of urgent problems
- Making interfaces easy to use for people who are not digital natives

## Outlook:

The goal of REXPERTISE is to offer an overall solution to retain and digitize expert knowledge within a company. This is not only applicable to maintenance related areas, but to any business setting where the lifetime of systems is very long. Therefore, it is crucial that expert knowledge does not get lost when employees retire. In the future, REXPERTISE can automatically provide extensive help when employees face a problem. Maintenance workers will be offered a wide variety of input methods for their problems (e.g. by describing it with their voice or by taking a picture) and the REXPERTISE app will immediately respond with a profound solution since the platform has extensive digitized knowledge at hand. In very few instances, there will be a need for further clarification. In this case, the employee can either browse through the profound knowledge graph or contact one of the Rexperts. Through extracting digitized knowledge within that very session and the following evaluation of knowledge, the platform gets more comprehensive with every completed Rexpert session. With the developments in AI, such structured data will be highly relevant. Further technological advances in the fields of VR and AR enable the Rexperts to not only be connected to the employees via audio, but also to see the problem they are facing clearly. Additionally, AR glasses could enable the maintenance workers to see relevant information on the maintenance process from the REXPERTISE database right next to the concerning part while they are working on it.

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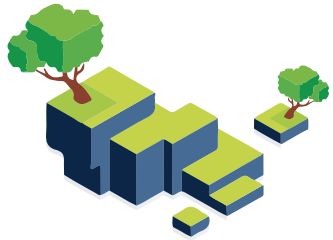
Wilson.



# WILSON

## Never Get Cast Away on Your Smart Production Island.

Top-down communication between factory workers and their team leaders is already optimized extensively in modern factories. Yet, a meaningful segment of communication is not effectively addressed: Workers lack means to share information among themselves. Thus, an overhead of approximately 20% of each worker's time in the factory is used on expedient tasks such as the hand-over of shifts and the adaption to new production lines and goals. Additionally, best practices specific to production islands, reports about frequent problems during shifts, and information on maintenance schedules are communicated inefficiently or not at all from worker to worker. Wilson tackles the problem of incomplete information exchange among workers: By equipping the immediate working environment of operators with a voice, ears, and intelligence, the production island itself becomes the medium for asynchronous communication between workers. Henceforth, operators can prompt their environment for any relevant information when beginning their shift. Wilson will prompt operators to share information about their specific working process at the machines. An incentive for information sharing is the building of a company-wide knowledge base, from which each worker will benefit themselves. Since Wilson is based on a voice-interface, storing information has the lowest possible participation barriers, making existing information exchange smoother. While primarily focused on voice interaction with its users, Wilson will also offer displays, dashboards and other information panels to simplify information exchange. Furthermore, data on occurred processes and changes made to the production line, as well as any errors, are collected automatically, increasing quality assurance and efficiency of production. Optical tracking is combined with data collection from smart tools. The system tracks processes without storing any associated personal data and ensures anonymity. With this new way of interacting with production islands, operators will reevaluate their current relationship with their place of work. Production islands will be appreciated as smart co-workers by humans, focused on the sole purpose of helping and supporting them.

## Business Model

### Key Partners

- Industrial manufacturing companies with large-scale production facilities
- Workers unions to get operators on board
- Sensor and actuator hardware providers

### Key Activities

- Development of voice interaction and ML algorithms
- Setting up hardware at customer site
- Further customization services for individual customers

### Key Resources

- AI expertise for ML and information structuring
- Manufacturing experience for product design
- Voice user experience expertise for interaction model
- Industry contacts for sales and product development

### Value Proposition

#### For workers

- Less administrative tasks resulting in overhead work
- Dedicated information access at point and time of use
- Ongoing, updated information sharing between workers through automated information gathering (e.g. on production processes and environment)

#### For plant managers

- Less management overhead
- Increased plant productivity
- Precise and easy production forecasting

### Customer Relationships

- System customization
- Change management support
- Key account management for customer-specific issues
- Co-creation of Wilson with customers' factory workers for system tailored to their needs

### Channels

- Website: information on products, use cases and change management
- Industry fairs: detailed product information, showcases and networking with potential customers
- Key account managers as direct sales contacts with a clear responsibility and trusting relationship to

### Customer Segments

- Industrial manufacturing companies:
- Operational factory managers
- Strategic change managers
- Operators

### Cost Structure

#### Fixed Cost

- Product development
- Key account management
- Development of a customer base
- Industry expert consulting fees

#### Variable Cost

- Direct sales efforts
- Product customization cost

### Revenue Streams

- Set-up charge hardware
- Customization service fee
- Licensing fee (per user)
- Hardware sales commission

## Value Proposition

**Operators:** Wilson simplifies the information exchange between operators to reduce unnecessary overhead. Small changes throughout a production run need to be communicated across all shifts and temporal workers alike. Often, information gets lost because it is assumed to be collectively known and thus not communicated, resulting in production errors and inefficiencies. With Wilson, production information can easily be accessed in the relevant production island directly, through a simple voice interface. Operators can attach information snippets to locations, machines, and processes. Additionally, Wilson uses optical sensors together with AI to autonomously recognize process and machine changes. As soon as a different worker enters the production island they will be notified of new available information which can then be retrieved. This relieves the operators from stress to pull this information from multiple people during time-constrained shift handovers and reduces the working overhead used for meetings.

In addition to facilitating easy, asynchronous communication between the workers, with Wilson, the production island becomes a digital co-worker: Wilson sets the basis for identifying best practices and ensuring the quality of production procedures. Finally, Wilson knows everything a worker wants to know: it guides the worker to find required tools and connects him with responsible people for solving concerns.

**For plant managers:** Wilson offers to increase factory efficiency and productivity by reducing overhead time workers spend on administrative tasks. On average, a factory worker spends about 20% of their time on administrative tasks, hand-overs, process improvements, and production adaption. Since Wilson provides valuable information concerning recent changes in the production process on the fly, time spent for overhead tasks is significantly reduced. Thus, workers can spend more time on producing products rather than communicating changes.

Moreover, Wilson makes plant management easier and more efficient by making all information flows within and across production islands transparent. This allows to anticipate required changes to the manufacturing process and enables preemptive island adjustment – a crucial element of flexible production cycles.

## Customer Relationships

Early on, key account managers take a proactive role in establishing a direct relationship with major industrial manufacturers: the customer remains the center of attention, their needs and visions become the basis for Wilson's design and features. Thus, even before the smart island is installed, the key account manager engages directly with the plant manager and operators to incorporate their needs into Wilson's design.

Once installed, Wilson accompanies the plant manager in introducing the smart islands to the operators and helps with change management to ensure a smooth transition with all workers on board. Introduction sessions and on-boarding workshops ensure that every operator appreciates Wilson as a supportive co-worker and understands its potential for creating the simplest information exchange.

Operators are the core users of Wilson. To know how they evaluate their experience with Wilson, the smart island provides a direct channel of communication between users and designers. Through the system, they can provide feedback on the fly – this can be taken up and directly integrated into ongoing software updates to continuously improve information exchange with Wilson.

## Key Resources

An essential component of the system will be an accessible voice user interface, which will enable workers to easily share information. Wilson's voice interface will play a vital role in user engagement. Therefore, experts in the field of voice user experience are needed. For Wilson to become a valuable digital co-worker, rather than a simple dictation device, it must make use of the latest AI technology within the field of Speech Recognition. Experts in the fields of Natural Processing, Speech Recognition, and information retrieval will be required to successfully complete the task.

Wilson will be highly integrated into the data and software processes of the production environment. Therefore, knowledge about the working and management processes in manufacturing plants is vital. The development and continuous improvement of Wilson will therefore be built largely on the knowledge and experience of industry experts and operators, resulting in improved adoption rates and value add for Wilson's users.

Lastly, acquiring customers in the field of industrial manufacturing is a question of personal industry contacts. Especially with a high-impact system such as Wilson, a relationship of trust needs to be established with the customers. For this reason, it is essential to acquire first-hand contacts in the industry, who will not only be a point of information exchange between the customer and Wilson, but ultimately also the first point of sales.

## Key Activities

Wilson creates a unique working environment for every employee and facilitates smart plant management by providing the simplest information exchange among all stakeholders. To attain this goal, Wilson ensures an effective set-up of the smart plant, customized to the manufacturer's priorities, and regular updates and adjustments of the smart plant through direct customer support.

To set up the hardware at the customer site, a pre-assessment of the current factory will provide a basis for software customization and help identify, which resources are required to be sourced and allocated efficiently. Crucial information includes details about production processes, knowledge management, production goals and quality assessment routines as well as the number of employees working in a factory. A smooth transition towards establishing the hardware for Wilson will be facilitated through mediating between customers and hardware providers.

Secondly, the software is developed, making use of cutting-edge AI expertise. The following features are included: A smart voice interface allowing effective and efficient communication between the workers and their environment as well as an AI-agent continuously monitoring a central database containing production activities, Wilson's interactions, and process changes for anomalies. Each worker receives currently relevant information, such as notifications on recent production changes, malfunctions, and tool placements through a smart audio-visual software system. Continuous software updates are part of the product.

Finally, support service accompanies the plant manager and workers throughout their joint Wilson experience. Effective 24/7 customer support provides initial capacity training and workshops, facilitates efficient maintenance service and a direct contact to the manufacturers of production equipment. While ensuring continuous software upgrades and integration of the latest AI expertise, Wilson's smart plant components can be adjusted to the company's needs at any time.

## Revenue Streams

Since Wilson only targets businesses in the manufacturing industry, revenue streams are numerous and growing. Wilson will be sold as an add-on unit to equip a production island and the customer can choose to install multiple Wilson instances throughout the factory. Therefore, the revenue breakdown will be conducted per Wilson instance. All percentages mentioned are an approximation.

**Set-up fees:** Wilson comes with hardware components that will need to be installed and integrated into production island. The customers pay an additional set-up fee to have it installed efficiently by the Wilson company. As part of the business development strategy, this price is highly discounted and forms around 5% of the total revenue.

**Product customization:** As is standard industry practice, B2B software is built to be customizable from the bottom up with very few standardized workflows built in. That is because the processes, workflows, and policies vary significantly across companies, making selling an off-the-shelf B2B software to multiple companies prohibitively difficult. Wilson will charge a markup for the bespoke development and customization to suit the factories' special needs. This price is not considered to be part of the initial costs of Wilson. Product customization forms another 5% of the total revenue for Wilson.

**Hardware commission:** The hardware for Wilson will be off-the-shelf third-party products. This makes Wilson an attractive sales channel for those hardware manufacturers. A possible future revenue source is charging a percentage commission on each hardware component sold through Wilson.

**Licensing fees:** The licensing fees form the main revenue component for Wilson. Customers will be charged a license fee per worker seat in the island, not a fixed cost per island. Licensing fees form approximately 80% of the revenue stream.

## Key Partners

Industrial manufacturing companies. They are the main customers, but close cooperation with manufacturing companies as partners will also be needed. Since Wilson is tackling high-level issues within the production environment, its development will require input and feedback from factory owners. Simultaneously, the optimization of the system will inevitably rely on test phases within the actual application domain, i.e. running factories. This includes close communication with machine operators, since they will ultimately be the ones using Wilson. As a young startup, product development advances in close cooperation with manufacturing companies, enabling the optimization of the product with real-world input.

Workers' unions. Wilson is a meaningful improvement for people employed in factories. However, it also means a new level of transparency and knowledge transfer – aspects that workers might perceive negatively in the face of rising automation. Due to the need for involvement of operators in the

product development process, as well as the dependency on their acceptance and usage of the final product, Wilson's success depends on its acceptance among the working force. It will hence be critical for a sustainable information-sharing system to involve workers in product development from beginning to end. Furthermore, when the system is up and running, operators can directly give feedback to Wilson's system to continuously maintain close contact and jointly improve its operation. All of this will be done through close collaboration with workers' unions, which will facilitate ongoing user-focused customization and improve the system based on the workers' needs.

Hardware suppliers. Even though its main component is software, Wilson in part depends on hardware components such as microphones, cameras, screens, and smart tools to provide its full value. As a young startup, Wilson will neither buy, nor store or manufacture its own hardware. Wilson will rely on a commissioning scheme to provide customers with the latest hardware for their systems. Through Wilson, the startup provides hardware suppliers the opportunity to use our sales channels with manufacturing companies, taking up the role of a mediator between the two key parties.

## Customer Segments

**Industrial manufacturing companies:** While the targeted main user group are machine operators on the factory shop floor, the main paying customers are industrial manufacturing companies. Especially plant and change managers of factories hold the organizational power to implement Wilson within their facilities. It will be key to success to make them aware of Wilson's value and the impact it has on the factory of the future. For plant managers, the most tangible criteria for success manifest themselves in a production facilities' profitability. This implies that everything increasing productivity, quality, and the reduction of time-consuming errors facilitates the fulfillment of company KPIs while maintaining the same output quantity. As automation and the use of machines is a central element in any production line, managers are aware of the human employees' importance. This is due to the low adoption of automation in highly dynamic work environments. Shift work provides factories with non-stop productivity, but as shifts change, team leaders must make sure that relevant information is shared across shifts among all workers. Wilson enables the successful exchange of information between the operators within production islands across time. As Wilson is be designed to be highly flexible, a broad variety of industry branches can be addressed.

**Operators:** The main users are machine operators on the factory shop floor. Generally, the operator's work is designed to be as simple and self-explanatory as possible. Yet, there are moments where information exchange between workers is paramount to successful production. A significant part of an operator's duty consists of overhead tasks, highly affecting the employees' and island's productivity. Those are often caused by changes in the production process, best practices and machine settings. By effectively providing every worker with the information they need to carry out their work successfully, Wilson would emerge as a digital companion, becoming an essential element to operators' everyday work.

## Cost Structure

As a cutting-edge technology product focused on the B2B market, Wilson will be capital intensive to develop and sell. We break down our costs into fixed and variable costs, which form about 80% and 20% of the total costs respectively. The percentage breakdown of the cost given henceforth are approximations.

**Fixed costs:**

**Industry experts:** Manufacturing experts from the industry will be hired as consultants to guide the development of Wilson. They will help answering questions such as which processes are customizable and to what extent. What are industry standards? What are industry best practices? As expected, such expert consultancy will come with a price tag and would form about 5% of the fixed costs.

**Business development:** As with any B2B company, Wilson will require a considerable amount of resources on business development in the beginning, namely on prototyping and forming partnerships with industrial manufacturers. This high cost will pay off later with vendor lock-in and high profit margins in the enterprise sector. Most of the business development will take place in the form of prospecting by sales

people or attending tech fairs. It is expected to account for 25% of fixed costs.
**Product development:** Wilson's core value lies in the unique and cutting-edge voice interface, tracking system and IoT ecosystem support. This will require months of research and development in technologies like NLP and Speech Recognition. This includes the cost of hiring voice user experience experts, AI researchers, high quality software engineers and few years of development budget. It is expected to form at least 70% of the fixed costs.

**Variable costs:**

**Direct sales:** As Wilson targets enterprise customers, the most effective marketing and sales channel is direct sales. This is an elaborate and time-consuming process. Therefore, it will form about 60% of the variable costs for the Wilson company.

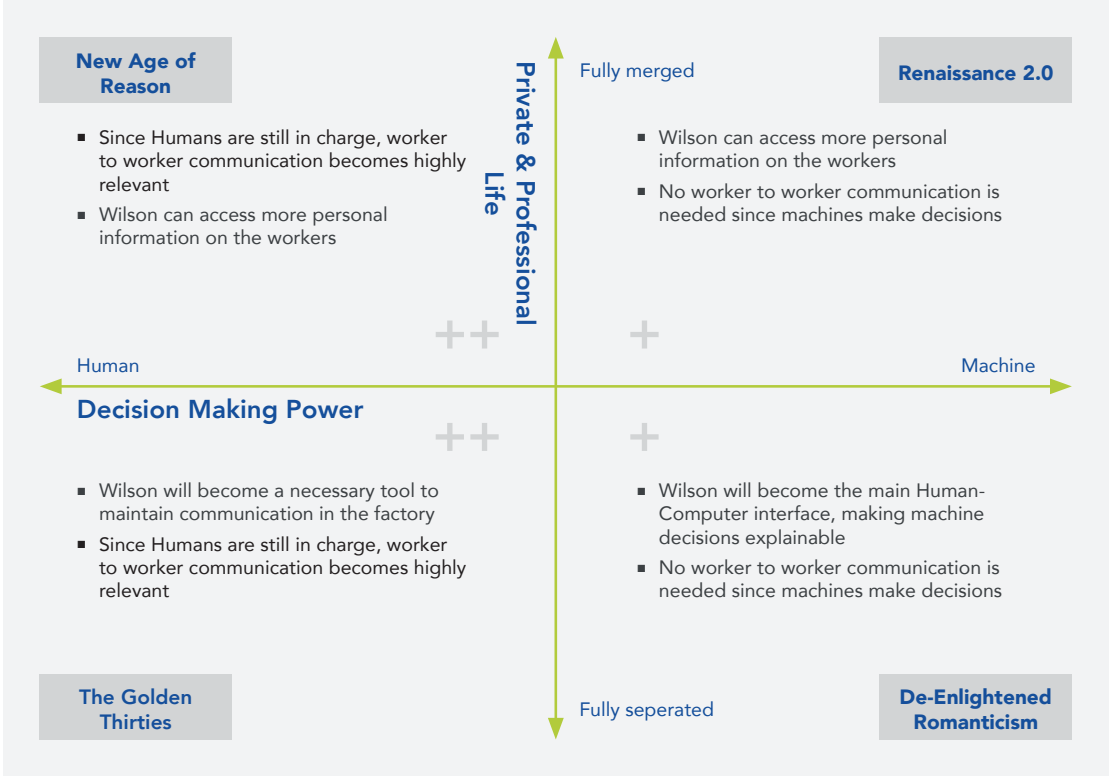
**Product custo**
**mization:** Since Wilson needs to be tailored for every individual customer, it will require additional development effort. It is expected to form a smaller 40% share of the total variable cost.

## Scenario Fit:

**Renaissance 2.0:** Wilson, as a digital companion, stands to benefit greatly from a future where machines make decisions. The personal assistance of Wilson can extend beyond just conversing when prompted, to proactively measuring the emotional state of the worker and to provide a user experience tailored to each worker. In a future where work and private life are completely merged, the possibility of Wilson not being restricted to the island itself can also be considered. It will be available in your home, as a digital assistant and use deeper knowledge of the worker as a person to serve them better at the workplace. However, the merger of work and personal life means workers can be contacted off-shift and information can be accessed with ease. That goes against one of the core values of Wilson: to provide information when needed. The company must consider that the job description of an operator will have changed drastically in such a scenario, nevertheless the job might exist in some form and Wilson will continue to cater its target users.

**New Age of Reason:** Humans remain in control of making decisions in this scenario, therefore the problems that Wilson was built to solve still exist. Wilson continues to be a valuable companion in the Factory of the Future, providing information when and where it is needed, while being a personal companion for the workers in their day-to-day job. In fact, the personal assistant aspect is augmented with the merger of work and personal life. Wilson can be taken home by the worker and assist at their homes, at the same time learning more about the worker. Therefore, Wilson ends up being a better assistant in both work and private life (in a merged future, one may just call it life). As with the other merged work-life scenario, this future also provides easy access to workers outside of their shift.

**The Golden Thirties:** In the future scenario of the Golden Thirties, where decisions are human centered and private and professional life are completely separated, Wilson is going to be a powerful tool to maintain productivity within the manufacturing sector. While humans make all important decisions, there will be the need for a reliable log of all decisions and changes made. Once workers leave the production facilities, they will not be reachable by their colleagues. Any information they might have aggregated during the shift will be refined and provided by Wilson. This information will help



to streamline processes by reducing unnecessary production stops due to poor comprehension of earlier decisions and changes. Wilson will not only be a nice-to-have but rather the indispensable colleague which will always be on site, unlike human workers.

**De-Enlightened Romanticism:** In the era of De-Enlightened Romanticism, decisions are machine centered. Simultaneously, private and professional life are fully separated. As decision making shifts from humans to machines, so will Wilson's main value-add. While previously being focused on enhancing human-to-human information flow, this peer interaction will now be largely redundant. The new communicative sparring partner for humans will now be machines. With Wilson's functionalities being easily adaptable to human computer interaction, it will still serve as the smart voice of any exchanged production information. In fact, a future of empowered machines will require even more communication between humans and computers.

## Challenges:

- **User adoption:** With Wilson being a holistic digital assistant, user adoption problems might apply. Its end-users, blue collar workers, are characterized by little technology affinity, and fear of automation. At the same time, the quality of our product will depend on the amount of people using it, as well as their willingness to share their thoughts and ideas with it. If these interaction processes do not take place due to lacking trust in the system, its value proposition cannot be fulfilled. Hence, the company will work in close collaboration with workers unions when developing the system. Additionally, the customer's operators will be kept in the loop while tailoring Wilson to specific production facilities. This way, workers will be able to recognize the value-add that Wilson can provide to them.
- **Voice-user interface:** Wilson's voice interface must me impeccable. Since its main value proposition is the reduction of inefficiencies in knowledge transfer, using the system may not result in any additional overhead work for the operators. Any failure of Wilson to understand spoken language, misinterpretation of orders or simple system downtime will reduce the level of interaction with the workers. While current personal assistants are offering a variety of voice services, Wilson will be focused on a limited number of industrial use cases. It is crucial that it excels in these limited domains. For the product development, it is essential to focus on quality, not quantity of services.
- **Dynamic Industrial environment:** The industrial manufacturing industry is highly dynamic and innovative. Especially, in the age of Industry 4.0, new software applications and systems are introduced to company ecosystems on a frequent basis. This dynamic poses a challenge to Wilson, since changes in its soft- and hardware's surrounding requires constant system updates. To ensure that Wilson is always perfectly integrating with the factory equipment, customers will need to keep Wilson's engineers in the loop concerning platform changes or newly introduced equipment in the factory. However, innovation in the production equipment often means competitive advantages for industrial companies. Hence, this information is frequently considered confidential by manufacturing companies, and it will be a challenge to convince them that Wilson needs access to it to provide its best value.

## Outlook:

Within the next 24 months, Wilson aims at establishing itself as a start-up and acquire seed investment. It develops a first prototype, in close cooperation with an industrial manufacturer to build up the expertise required to strengthen the genius island.

In 5 years, the business aims to grow and offer its services to key industrial manufacturers, first focusing on Germany, Austria, and Switzerland. Expanding the team within the next five years is essential in order to build a strong foundation of intellectual capacities and building on latest AI expertise.

Within the next 10 years, Wilson aims at becoming the number one in providing integrated digital companion systems in the industrial context. As an established service provider for key industrial manufacturing suppliers even beyond European borders, Wilson proactively drives the advancement of the digital factory forward. In a future version of Wilson, one can imagine that it serves as a constant feedback collector or provides operators with elemental contextual information, providing a bigger picture of their work. Fostering intra- and inter-company information sharing, Wilson envisions to become a smart way to communicate and share information, resources and best practices. Even beyond a company's borders, Wilson will be a means to foster innovative change.

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# EVA

## Real-Time, Direct, AI-Supported Feedback within the Company

While many companies claim the embodiment of an 'open' corporate culture, few take proactive steps to ensure continuous internal transparency. One consistent challenge is in the area of feedback. Companies often lack an 'open-door' policy, where feedback is not encouraged. Even if there is abundant feedback, inappropriate action is often taken by management, as managers may not fully understand the feedback. Therefore, when feedback is provided in an environment that is not fully receptive, the value of feedback is lost and may even lower motivation and productivity.

However, this does not have to be a problem. Eva is revolutionizing peer-to-peer as well as work-related feedback. Eva is a smart, intuitive, AI-based feedback companion that collects, aggregates, synthesizes, and delivers feedback between employees in a company. As a push and a pull system, Eva asks for and can also be provided with feedback about peers, managers, workplace environment, and internal processes. Uniquely, Eva allows for situational feedback from proximity-based interactions between employees. Eva knows who you have met, where you have been, and what you may have done according to your calendar. Eva then offers potential feedback options based on these situations. For example, if you have just met with your boss for an extended period of time, Eva may inquire about how you felt during the meeting. Feedback will be available for viewing through a web or mobile application. The feedback collected will be data mined, synthesized, and displayed in an interactive interface in real-time and updated in predefined intervals. Through integration with Learning Management Systems (LMS), suggestions on coaching and training can be provided. The aggregated feedback of different areas in the company can be linked with other datasets to identify patterns and create important insights. This enables Eva to become a strategic tool that can support managers in real-time in the decision-making process.

By combining the power of NLP and Machine Learning, Eva provides a comprehensive feedback and coaching platform.

## Key Partners

- Pilot customers in the manufacturing industry to verify minimum viable product
- Device manufacturer to address hardware needs
- Experts in organizational psychology to understand and interpret data
- Established Human Resource Management (HRM) platform providers to ensure real-time synchronization of employee data

## Key Activities

- Software development to provide the most accurate and constructive feedback
- Integration into existing corporate structures
- Customization and after-sales support

## Key Resources

- Software developers and data scientists
- Intellectual property of software to create a competitive advantage
- Personal feedback and process data

## Value Proposition

- Higher level of productivity and performance
- Reduced HR costs
- Increased employer attractiveness
- Full-service solution from problem recognition to implementation and consulting/training services
- Customization to the companies' requirements

## Customer Relationships

- Personal relationships with clients via dedicated personal assistance
- Co-creation relationship for initial software development and continuous improvement

## Channels

- Raising awareness through fairs, events, industry summits, pitches at client's site and established HR platform providers
- Product sales mainly offline via sales representatives
- After-sales services provided by key account management through all relevant channels

## Customer Segments

Diversified (manufacturers, corporations, and government agencies)

## Cost Structure

### Fixed Costs

- Software development costs
- Wages
- Office space

### Variable Costs

- Customer acquisition costs
- Product integration costs
- Customer care and support costs
- IT infrastructure and maintenance

## Revenue Streams

- Subscription fee (incl. hardware device rental)
- Advanced services to support customers in integrating Eva

## Value Proposition

**Higher level of productivity and performance:** One of the main values provided by Eva is a higher level of productivity and performance. Eva creates and fosters an open feedback culture. Based on the feedback provided by oneself and by others about oneself, Eva can recommend actionable steps for areas of self-improvement, such as being punctual. If serious problems or areas of improvement exist that cannot be resolved by Eva, individuals' managers can be notified by Eva. Similarly, an interactive 'heat-map' will highlight the performance, satisfaction, and engagement levels of the various physical regions (e.g. parts of a large factory) or departments within a company to provide managerial insights. As a result, employees have the chance to reflect, learn and grow, thereby increasing their own satisfaction and engagement and the company's bottom line.

**Reduced HR costs:** Since Eva does not only point out improvement areas, but also takes appropriate actions to address them, human resource cost reductions can be realized. A more welcoming and engaging environment is expected after the implementation of Eva, lowering employee turnover and increasing employee retention. Furthermore, as the happiness level of employees increases, the number of sick-days will also be reduced.

**Increased employer attractiveness:** As an indirect consequence of a happier, more satisfied, and high performing workforce, the attractiveness of an employer using Eva will increase. Through word of mouth and employer review platforms, potential candidates will become aware of this newly established and attractive open company culture. Eventually, companies using Eva might have a competitive advantage in recruiting the most qualified employees.

**Full-service solution:** The underlying promise of Eva is to provide its customers with a carefree full-service solution. The only responsibility that Eva's customers have, is a willingness to tweak their corporate culture; otherwise, all other tasks can be addressed by Eva. From problem recognition, to implementation and consulting/training services, every step along the customer lifecycle will be supported by representatives from Eva. Customers do not need to have specific capabilities or company structures. The status quo of a customer is assessed and the appropriate service provided accordingly.

**Potential for customization:** On top of the standardized platform, Eva offers limited, value-added customization options. In kick-off workshops, Eva representatives discuss specific needs and wishes with the customer. The AI will then be trained with different datasets and therefore adapt automatically or be adapted to the different work environments. While key aspects of Eva will remain the same, other aspects of Eva can be customized manually. For example, the intervals for which feedback reports are delivered to the user can be changed. Similarly, the extent to which Eva proactively asks for situational feedback or sends real-time feedback can be customized. Calendar integrations, news updates, and other personalized services are also expected to be easily integrated within the Eva ecosystem.

## Customer Relationships

**Personal relationship:** Eva maintains personal relationships with its customers. Each key account manager supports a limited number of customers and provides them with personalized customer service. To establish long-term business relationships, personal visits to the customer's site on an annual basis are an important aspect of Eva's relationship and retention management. By frequently asking for customer feedback, potential pain points or uncertainties are identified and resolved. Moreover, the communication channels between key account managers and customers are always open. Long-term customer relationships built on trust, reliability, and success are established.

**Co-creation:** Initial development of the software is highly dependent on data provided by corporate partners. As such, Eva will have co-creation relationships with potential customers, even before the product is launched. In exchange for providing the anonymized user data, corporate partners will have unrestricted access to Eva's services. Once the most promising relationships are selected, further negotiations will be conducted to convert them into long-term customers and partners. Co-creation partners are the first to receive any new updates or product launches, as well as concessions on pricing.

## Channels

**Raising awareness:** The sales team is the first point of contact. Initially, sales representatives will raise public awareness of Eva at fairs and industry trade shows, as well as presenting at potential client sites. Partnerships and reselling agree-

ments with established HRM providers are another effective channel to increase awareness of the product. In exchange for HRM providers marketing Eva as a viable add-on, profit sharing plans will be used to incentivize these partnerships.

**Selling the product:** The sales team will expand the business through direct sales, by contacting individual business connections, or making cold calls. While offline channels are key, online sales will also be a primary channel. SMEs that require little to no degree of consulting may directly purchase Eva online. Depending on customer size and value, subsequent steps such as the integration of Eva into the existing corporate structure will still be conducted on-site.

**After-sales services:** Personal relationships with customers are maintained through dedicated key account managers. With the help of implementation consultants, account managers will organize the rollout of the software and continuously interact with their clients via personal visits, phone, or email.

## Key Resources

**Talented employees:** Software developers, data scientists, and cybersecurity experts are key resources that propel Eva to the next level. The Eva algorithm satisfies highly complex requirements, which range from intuitive ML, to advanced text-based and voice-based NLP. As Eva matures, health, personality, and mood monitoring will need to be implemented to increase the users' benefits while also considering privacy regulations. Furthermore, strong and well-connected sales representatives and account managers are essential to generate revenue and value for the company.

**Intellectual property:** The process of how Eva collects, aggregates, synthesizes, and interprets data is unique. Thus, by applying successfully for a patent, a significant competitive advantage is realized. Specifically, patents of various data-mining and analysis techniques help to ensure the longevity of Eva's competitive advantage. Due to the intensity of R&D activities, protecting the Eva technology and brand is key for commercial success. Similarly, intellectual property in advanced AI will also attract additional investors and shareholders thereby, further increasing Eva's value.

**Data:** Eva will evolve over-time into a data-driven company. The employee data available will help to train Eva's capabilities and is a key resource to further add functionalities to the core product. Thus, the safety and privacy of external data is of the utmost importance. The internal cybersecurity experts will therefore consistently ensure the security of Eva's platform to protect sensitive user data.

## Key Activities

**Software development:** The main asset of Eva is the software including the AI technology. Thus, the continuous development and maintenance of the software is the primary task. Creating a user-friendly, easy-to-use software is an iterative process. Ensuring continued adoption of users requires external AI software development and input from psychology experts. Over time, the software will be optimized for the Eva wristwatch, as well as other common mobile devices. Moreover, software development should not only be limited to product development, but also exploring the different possible avenues of integration with other software platforms, as integration is key for mass adoption.

**Implementation of Eva:** Kickoff workshops are conducted for major customers before a contract is finalized, where specific needs and desires are identified. The existing software and hardware ecosystem is assessed and the product offering is tailored accordingly. A roll-out strategy is developed with the customer before the introduction of Eva within a company and additional support is provided. Change management workshops are conducted with managers to ensure a smooth transition for the company.

**Customization and after-sales support:** As Eva is a full-service solution, customer support is of high importance. Individual customer wishes are respected and software customizations or adjustments depending on organizational changes are provided whenever possible. Similarly, customer care provides 24/7 support for common issues and questions, such as lost Eva wrist-watches or malfunctioning software.
**Customer acquisition:** Customer acquisition is done through

three key channels. The main customer acquisition channel is through search engine results. SEO will be the main tool, as potential clients looking for software and support in performance, feedback, or happiness-related corporate issues will see Eva at the top of the list. Second, customer referrals are another key acquisition channel. Eva is expected to deliver above customer expectations and current clients could be used as key references. Cold calls and lead generation from sales people is another acquisition channel. This acquisition style targets mainly SMEs that may not be aware of Eva's offerings.

## Revenue Streams

**Subscription fee:** A monthly subscription fee is Eva's primary source of revenue. A full-service solution is provided and thus, the subscription fee includes the product, initial implementation and after-sales support. The price of the subscription is differentiated based on the number of employees and the complexity of the client's organization. Depending on the type of subscription, wristwatches are leased to the customer. In work environments where employees do not own corporate personal mobile devices or would like a device to complement their existing device, an Eva wristwatch can be provided. The Eva device offers additional features; as such, customers are incentivized to equip all their employees with an Eva wristwatch.

**Advanced services:** Although Eva offers a full-service solution, some customers may demand services that are beyond the standard offerings. These customers are aware that their needs are special and thus are willing to pay additional fees for advanced services. For instance, some customers do not have the capacity to integrate Eva within their companies. Thus, Eva representatives can manage the implementation process and mediate the changes within the client's company.

## Key Partners

**Pilot customers:** In the development stage of Eva, partnerships with potential corporate customers are essential. Such collaborations are key to ensure varied testing environments for Eva, both in terms of physical corporate setups as well as business models. The high volume of data generated is used to develop and ensure Software flawless functionality. Similarly, the hardware device is tested in real-life scenarios to ensure its efficacy in all situations. As a result, the minimum viable product can be verified and key customer references can be created for the future.

**Device manufacturer:** The Eva platform can be accessed via existing corporate infrastructure such as workstations, stationary PCs, laptops, tablets, smartphones, and smartwatches. A prerequisite for unleashing the full potential of Eva is to ensure that every employee carries a portable device that is always available to the employees. While most corporate smartphones fulfill this requirement, many employees, especially blue-collar workers are not afforded such a luxury. Therefore, the Eva software will be complemented by a small, portable wristwatch. For the development and manufacturing of the watch, a partnership with an original equipment manufacturer (OEM) is required. The OEM can address potential future needs of the device as well, such as fitness and health tracking. The hardware will be shipped directly from the OEM to Eva's customers.

**Experts in organizational psychology:** Aggregation and synthetization of data are at the heart of Eva. Close collaboration with organizational psychologists – in practice and academia – is crucial for Eva to be able to provide accurate interpretation, predictions, and recommendations. Particularly, during the software development phase input by psychologists is required to provide actionable results for our beta customers.

**HRM platform providers:** Partnerships with existing HRM software providers, in the ranks of SAP, Workday, and Ultimate Software, are pivotal in ensuring the success of Eva. Given the large customer-base of these giants, the integration with one or all of these Software-as-a-Service companies will not only provide additional value for their customers, but also help ensure a sustainable revenue stream and mass adoption of Eva. Similarly, as most organizations use HRM platforms to manage personal information, integration of data collected by Eva into established HRM platforms will help organizations understand employees better.

## Customer Segments

**Diversified (manufacturers, corporations, and government agencies):** Eva aims to reach and serve corporations, institutions, NGOs, and government agencies with more than 50 employees. The customer needs will differ depending on the type of devices and software employees of these companies have access to on a daily basis. As such, two groups can be subdivided: corporations that provide their employees with a personal mobile device and corporations that do not provide or cannot provide a mobile device to their employees. By segmenting our customers into these two groups, Eva is able to customize its solution according to the kind of hardware and data that will be available. Most institutions have employees in both subgroups and the number of employees in each segment determines how Eva should acquire them as customers. For employees who do not have constant access to a phone, computer, digital work calendar, and email, it would require Eva to deliver digital devices, such as smartwatches or feedback tablets, to integrate the feedback software into the corporate environment. For employees who have access to digital devices at work, Eva is primarily delivering the necessary software for these devices. Regardless of

the type of implementation, all customers will have access to the same functionalities.

### Cost Structure

**Fixed costs:** Software development makes up the majority of fixed costs. It is a crucial upfront investment prior to product launch. Similarly, continuous software development is required to improve existing features and implement new product features. The success of the software depends on the expertise and skills of the software developers and data scientists. To work together with the highest qualified developers, above-average salaries need to be paid. Human resource costs are significant and include shares for sales representatives and key account managers. Common fixed costs such as the rent of the office space or other administration are also necessary.

**Variable costs:** Variable costs are mainly related to interactions with potential or existing customers. This includes customer acquisition costs, costs of tailoring Eva to the customer, as well as customer care costs. Variable costs will increase with the number of customers. Moreover, the costs of the IT infrastructure and its maintenance cannot be neglected.

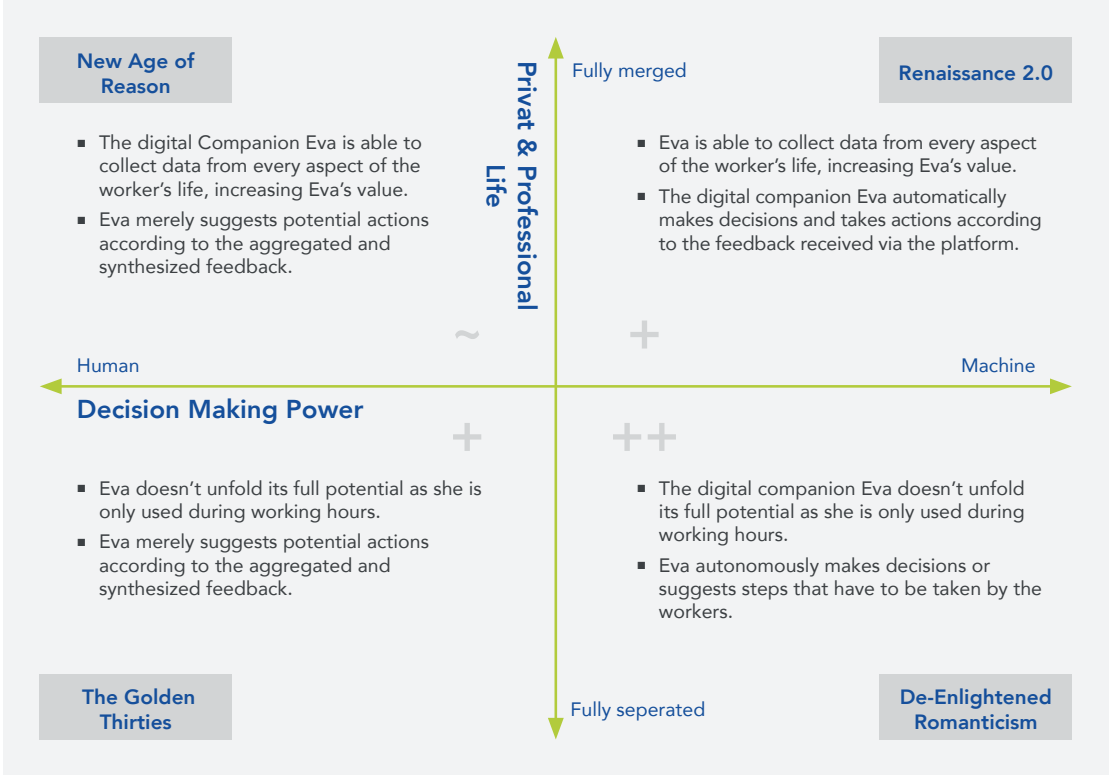
### Scenario Fit:

**Renaissance 2.0 (++):** A society where personal and professional lives are fully merged and decisions are primarily made by machines, creates the most ideal future for Eva. The digital companion can automatically make decisions and suggest actions according to the feedback received via the platform. Eva can then ensure that the product is fully utilized within the company and users reap its benefits due to network effects. HR managers now have the opportunity to focus on more value-added tasks and to integrate the data-driven insights from Eva within the company. Additionally, a merged lifestyle gives Eva access to more employee data and can offer additional services in the employee's private life.

**New Age of Reason (+):** In a society where private and professional life are fully merged and where humans are the main decision makers, Eva is still of great value. The digital companion assists humans in their daily life by only suggesting actions according to the aggregated and synthesized feedback. Since the decision-making power still lies with humans, the value of Eva would depend on how often the user utilizes it. Moreover, a fully merged lifestyle gives Eva the opportunity to collect data from all aspects of the user's life, thereby, further increasing Eva's value.

**The Golden Thirties (+):** In a society where personal and professional life are fully separated and the decisions of the digital companion are based on human command, Eva lacks the ability to realize its full potential. A larger portion of the employees' workday is now centered around decision-making, and the employee may lack the motivation or habit of utilizing the companion. Similarly, because workers only use this system during work hours, not only is Eva's use-case limited, but also the data that can be collected is reduced.

**De-enlightened Romanticism (+):** A society in which the decisions are machine-centered gives Eva the opportunity to achieve a high utilization rate and act on feedback provided by employees. Eva has the capability to autonomously make decisions or suggest steps that can be taken by the user. Eva will become an important part of a company's DNA, mainly through providing autonomous feedback on both a personal and aggregated level. However, because of the separation between work and life, the use-cases and data collection opportunities are limited to work related topics.




## Challenges:

- Adoption rate of Eva within companies to ensure a high level of Return on Investment (ROI) for our customers
- Privacy concerns regarding the collection, synthesis, and utilization of relevant personal data
- Cultural acceptance of an AI-based platform as a first interaction point when providing, receiving, and acting on feedback
- Misuse of the platform e.g. cyber bullying of certain colleagues
- Competition with established HR Management or other software companies that already have an existing knowledge and customer base
- Efficient and effective development in relevant areas of AI to ensure the success of growth plans

## Outlook:

The best predictor of future behavior is often past behavior. Given the successful advancements in AI technology in the past decade, the potential to expand on Eva's current offering is tremendous. Technological capabilities of AI will be easier to implement and more feasible on a larger scale. Within the next five years, Eva will be able to offer accurate and intuitive feedback by itself due to advances in ML algorithms, NLP, as well as other adaptive capabilities. Similarly, Eva will be able to utilize unbiased metrics and predictive analytics to evaluate and provide practical coaching itself or register employees in more advanced training sessions. Over time, Eva is expected to take on the role of a virtual manager. Besides providing suggestions, the digital companion is expected to monitor performance in blue-collared verticals (e.g. manufacturing), as well as to provide live-feedback and real-time guidance while one works. This could even branch into automatic compensation management based on performance. On a more personal side, Eva is expected to be able to provide feedback and aid depending on the tone and pitch of the user's voice and of the interactions, for example, when one is mad or sad.

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# QUALIT

## A Quality Inspection Data Platform Connecting B2B Suppliers and Buyers

Producing at the highest possible quality is one of the key objectives of manufacturing companies in order to please clients and maintain trustful relationships. To attain this goal, produced goods usually have to go through a rigorous quality control process. A supplying company makes sure that goods sold and shipped to a purchaser, such as an original equipment manufacturer (OEM), are flawless and meet required quality criteria. To ensure this, each product's quality is assessed via means of visual inspection of simple mechanical parts as well as highly specific inspection of more complex parts. Once the product arrives at the buyer end, the quality is assessed again. In extreme cases, such as working together with a new supplier, every single produced part is inspected. Overall, this process inherits inefficiencies and redundant quality inspection work. On one hand, lack of information and trust regarding the supplier's quality assurance practice leads to redundant quality inspection work for the buyer. On the other hand, the quality process on the supplier side can often be improved through further automation because manual quality inspection based on a human's visual input that is prone to error is still a common practice in the industry. QUALIT attempts to solve this problem by offering a platform connecting buyers and suppliers with the value proposition of increasing trust between these two parties. In order to do so, QUALIT provides a quality inspection ecosystem with multiple components. First, QUALIT helps to automate the supplier's quality inspection systems by authenticating existing automated systems or providing new, automation-ready hardware equipment. Second, each produced good will be tagged with a unique identifier before it goes through the quality inspection process. The processed inspection data will then be transmitted along with the unique identifier within a data container to the QUALIT cloud where analytics and monitoring capabilities are offered to both suppliers and buyers. Third, by applying a cryptographic hash function to each data container and saving the hash into a blockchain, the integrity and immutability of the quality data on the cloud can be verified. With this process, an overall higher quality of inspection, improved trust, as well as cost savings can be ensured.

## Business Model

### Key Partners

- Testing equipment manufacturers
- IT service providers
- Existing quality control institutions

### Key Activities

- Customer acquisition
- Brand establishment as a trusted company
- Inspection and authentication of existing machines
- Renting of additional inspection hardware
- Collection and processing of testing data

### Key Resources

- Human capital and expertise
- Server and IT infrastructure
- Training material

### Value Proposition

- Trust and transparency
- Higher quality of inspection
- Time and cost savings
- Root cause analysis

### Customer Relationships

- Dedicated key account managers
- Neutral middle-manning to establish trust
- Operative support for supplier
- Customer support for buyer

### Channels

Online

- Newsletter marketing
- Direct customized emails
- Search engine advertisement

Offline

- Trade fairs
- Manufacturing magazines
- Direct sales

### Customer Segments

- Supplier: Manufacturing company producing parts at any tier of the supply chain
- Buyer: Any manufacturing company buying intermediary components

### Cost Structure

**Initial Investments**

Development of platform

**Fixed Costs**

- IT maintenance and infrastructure
- Salaries
- Office rent

**Variable Costs**

- Installation and setups of QUALIT machinery
- Sales, marketing, and PR
- Customer service and support

### Revenue Stream

**Supplier**

- Setup and inspection fee
- Commission fee from hardware rental
- Platform subscription fee

**Buyer**

Platform subscription fee

## Value Proposition

**Trust and transparency:** The QUALIT platform automatically collects, processes, and analyzes quality inspection data and transfers it from the supplier to the purchaser in real time. This enables the purchaser to gain direct insight into the quality inspection procedure of the supplier. Thus, QUALIT establishes transparency between suppliers and purchasers resulting in more trustful relationships.

**Higher quality of inspection:** QUALIT eradicates manual quality inspection procedures, which means that there is no human error in the process, resulting in higher quality of inspection and minimized loss in terms of faulty parts. The automated inspection procedure will be applicable for both simple mechanical parts through 3D scanning and complex products like circuit boards through specific systems that measure performance and functionality.

**Time and cost saving:** Increased trust between purchaser and supplier due to reliable quality inspection data will ensure that purchasers reduce their involvement in internal quality procedures to the minimum. This will reduce redundancy in the form of double checking and save time and costs on the purchaser end as they will not need to further invest in internal quality checking procedures. Also, on the supplier side there are less costly product returns as a higher quality of inspections leads to cost savings in terms of transport.

**Root cause analysis:** QUALIT will capture detailed quality inspection data that will be fed into the QUALIT platform and transformed into analytics. Suppliers will receive data not only on defects but also on the structure of the defects and the possible reasons behind them. This will empower the suppliers to trace the root cause of defects and improve faulty production processes, resulting in an overall better quality of production. Furthermore, purchasers will be enabled to trace back quality issues and can identify liabilities for defects.

## Customer Relationships

**Personal customer relationship through dedicated key account managers:** To build a strong customer base, it will be imperative for QUALIT to establish strong personal relationships with suppliers and buyers by providing them with dedicated key account managers. Continuous advice, sharing of training material, service support, and troubleshooting are some of the key activities to be undertaken by key account managers.

**Trustful and neutral partner:** As a mediating body that builds trust between purchasers and sellers, QUALIT will have to establish itself as a trustworthy, neutral partner. The credibility will be built on QUALIT's reputation as an independently acting and financed business, its partnership with other well recognized certification bodies, as well as the success stories of its well performing existing clients. Furthermore, from a technical perspective, there needs to be transparency in terms of data sharing and safe data storage mechanisms for both the sellers and the buyers. Thus, QUALIT leverages Blockchain technology to prevent data manipulation in the cloud and hence ensures a secure system from end-to-end.

Supplier support: QUALIT will be highly involved with suppliers as it initially needs to connect and integrate the quality inspection systems to the QUALIT cloud infrastructure. Thus, suppliers will have to be given high attention in terms of continuous support and intense relationship building efforts. Constant customer support through telephone hotlines and chatbots will be key in maintaining this relationship.

**Purchaser support:** The purchaser relationship will be rather intermittent in comparison to suppliers, as purchasers will only require support in the form of onboarding to the QUALIT data analytics platform and periodic troubleshooting. Acquisition of buyers will be based on direct sales pitches and later the purchaser relationship will be maintained through the aftersales efforts by key account managers.

**Customer support for platform:** Customers, both suppliers and purchasers, will be trained before the installation of the system in order for them to get the most utility out of the product. Constant customer support and troubleshooting will be offered to the supplier end of the customer base through dedicated key account managers in order to ensure maximum efficiency and minimum loss of time on the cus-

tomer end.

## Channels

**Channels for awareness generation:** QUALIT is an innovative product that is new to the manufacturing industry. As a result, there needs to be intensive initial drive to create awareness for the product and communicate its attributes, benefits, and use cases. Offline methods such as cold calling and direct pitches (e.g. at B2B manufacturing fairs) and features in popular manufacturing industry magazines will be essential. Online marketing channels such as newsletters, direct customized emails, and search engine optimization (SEO) are some ways through which awareness will be generated. The website will act as the front face for all kinds of information dissemination for QUALIT. Turning existing satisfied customers into brand ambassadors will help generate positive word of mouth (WOM) and further add to the process of awareness generation.

**Channels for product and service delivery:** On the supplier end, QUALIT will provide direct integration of the platform and installation of hardware. It will also offer inspection and authentication of existing testing systems. All of this will be done through direct connection between the supplier and the QUALIT key account managers. QUALIT will also provide continuous support through the website and mobile app. It will periodically connect through PR channels like events and trade fairs and keep customers updated on QUALIT news through online channels such as newsletters.

## Key Resources

**Human capital and expertise:** The main selling efforts for QUALIT will be driven by direct sales personnel. Previous knowledge of hardware and certification methods will be key in setting up the base of the business. Thus, experts in the roles of sales, marketing, key account management, technical development, data analysis, maintenance, and support will be crucial in establishing and running the business successfully.

**Server and IT infrastructure:** The QUALIT platform is a software-based interface that will transfer large quantities of quality inspection data and analytics from the supplier to the B2B purchaser in real time. Thus, a robust server system and

IT infrastructure will be key in providing the computing capacity and data storage space for the QUALIT data analytics platform, including periodic investments in maintenance and troubleshooting. The IT infrastructure will initially be rented from a third-party IT partner.

**Training material:** Since QUALIT is a new product on the market, awareness generation regarding its usability will be crucial. Thus, training materials on how to use the platform and continuous support to enhance customer experience and troubleshoot will be essential. Online video tutorials, a customer support portal, direct hotline to connect with dedicated key account managers, chatbots, and digital companions as part of the platform interface are some of the key resources to support this.

## Key Activities

**Brand establishment as a trusted company:** QUALIT is a B2B2B platform, the middle B being the QUALIT platform that acts as a mediator in order to build trust between buyers and suppliers and reduce redundancy in quality inspection procedures. Thus, it is essential that the platform itself projects trust and reliability as strong values. In order to do that, Public Relations (PR) will play a major role. Some key activities will include getting featured in major manufacturing related publications, collecting recommendations and buy-ins from key opinion leaders in the industry, and providing incentives to existing customers to spread positive word-of-mouth.

**Inspection and authentication of existing machines:** For suppliers that have automated inspection systems in place installed already, QUALIT will provide authentication in besides relevant quality assurance bodies.

**Renting of additional inspection hardware:** For supplier that have a very low level of automation in their inspection system, QUALIT offers the opportunity to rent out automat-

ed quality control hardware produced by our partners.
**Collection and processing of testing data:** The robust QUALIT platform and interface will transfer real time quality inspection data analytics from the supplier end to the purchaser end. The interface will be presented in a way that will aid the purchaser in deriving quality status of the supplied parts from the automated inspection data, even before the parts are shipped.

## Revenue Streams

**Supplier:** QUALIT will charge service fees for inspection and authentication of inspection machines approximately every two years. Additional paid inspections can be organized on demand in case of any changes in the inspection equipment. For suppliers that have quality inspection hardware that is incompatible with the QUALIT platform or has manual inspection procedures, QUALIT offers the possibility to rent out automated quality inspection equipment delivered by equipment manufacturer partners. In this case, QUALIT receives a commission fee from the partners. An annual subscription fee will be charged for access and usage of the QUALIT cloud platform.

**Purchaser:** Annual subscription fees will be charged for the access to in depth quality inspection data and data analytics, which can be customized to individual needs of the buyers.

## Key Partners

**Testing equipment manufacturers:** As a part of the business model, QUALIT will provide a complete ecosystem for quality inspection, including state of the art hardware that is individually designed to test different parts. Thus, suppliers of the hardware will be crucial in maintaining the business model as the quality of the service will be dependent on the hardware that tests and evaluates the product. Selection of the hardware supplier will be based on reputation, cost, and quality of service.

**IT service provider:** The QUALIT platform for data analytics will require robust servers as neither QUALIT nor its customers will have enough capacity in their data centers to store the data. Thus, an investment is required to collaborate with an IT partner that would be responsible for establishing and maintaining the servers in order to provide the massive computing power required for platform operations. The IT partners will be responsible for operating the servers and QUALIT will collaborate with them to provide strong data security through Blockchain technology.

**Existing quality control institutions:** QUALIT will rely on the support and expertise of existing certification institutes like Deutsches Institut für Normung (DIN), the German ISO member body. Having partners such as DIN will give QUALIT credibility which is crucial for its success.

## Customer Segments

**Suppliers:** Supplying companies that manufacture parts at any tier of the supply chain are considered a customer for QUALIT. For suppliers who are running quality inspection procedures that are mostly manual and prone to human error, QUALIT will provide the entire ecosystem of its quality inspection platform. For suppliers that already have state-of-the-art sophisticated quality inspection systems, QUALIT will integrate these into the QUALIT data analytics platform.

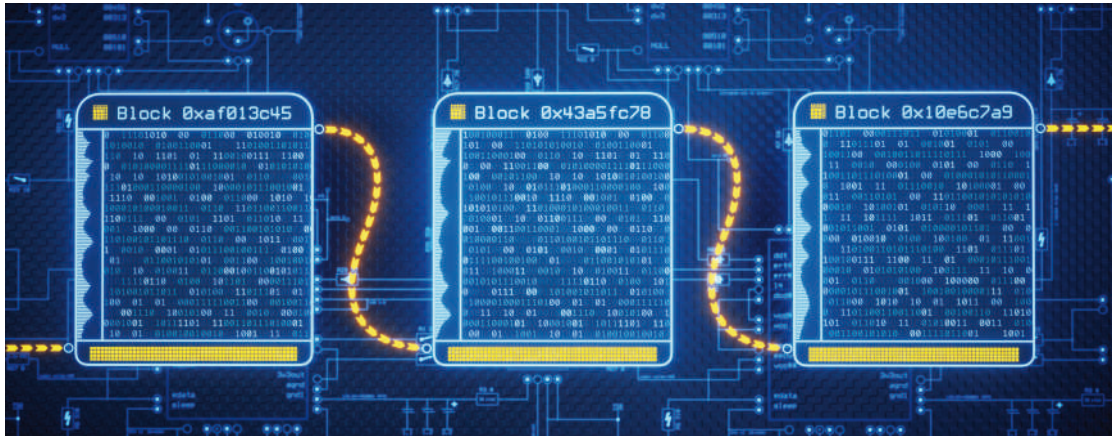
**Purchasers:** Any manufacturing company buying intermediary components is a potential client for QUALIT. This includes multiple stages of the supply chains up to OEMs. QUALIT will reduce redundancy in the quality inspection process along with costs as buyers do not have to maintain an extra layer of quality inspection of ordered parts. Integration of the QUALIT data analytics platform will be enough to give them real time insight into the quality status of the incoming parts.

## Cost Structure

**Initial investment:** A substantial amount of money needs to be dedicated towards building QUALIT's minimum viable product (MVP). This will include establishing servers for the storage and processing of data as well as front-end and back-end development of the QUALIT platform.

**Fixed costs:** Office rent, maintenance of IT infrastructure and salaries are some of the main fixed costs of QUALIT. A substantial part of the cost will be invested in the area of human resources as a lot of developers and inspection workers are needed to deliver the value proposition. Moreover, maintenance costs of IT infrastructure will also be significant, due to the vast amount of data and data processing requirements. Another important segment of fixed costs that will recur on a continuous basis is customer service, an essential part of the business model to retain customers and create positive WOM.

**Variable costs:** QUALIT will introduce a novel and unique



platform centered around quality inspection for manufactured parts in the market. The novel and unique nature of the product needs to be communicated effectively to potential customers alongside the benefits it will bring about. This will result in high sales, marketing, and PR-related expenditures

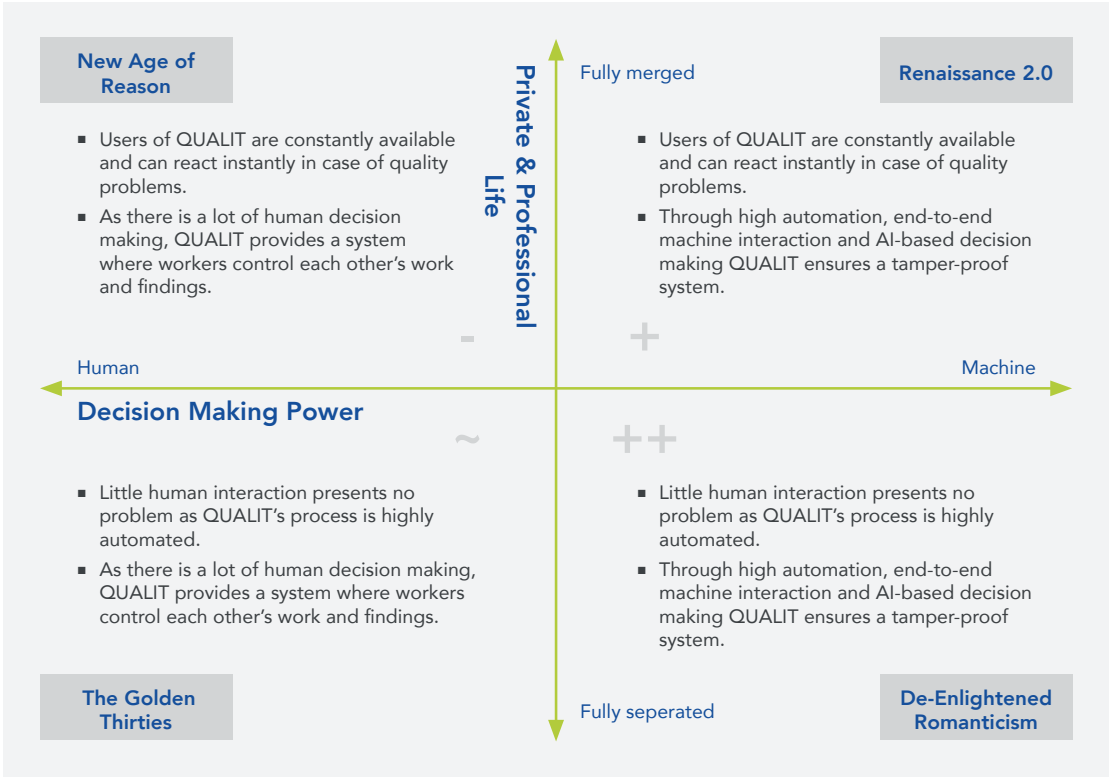
## Outlook:

**Renaissance 2.0:** A world where decision-making is centered around machines and private and professional lives are merged is an ideal one for QUALIT. An increase in automation minimizes human involvement in production and quality assurance. This minimizes trust issues between supplier and purchaser since end-to-end machine inspection eliminates the potential of test data manipulation by any of the involved parties. In the ideal case where all products are fault-free, there is no need for human involvement. If quality problems in production appear, the system can find a solution by analyzing the faulty parts and adapting the manufacturing process. This requires a knowledge base which connects an error pattern to its root cause. Only in rare incidents where a solution by the system is not possible external quality experts need to be immediately consulted.

**New Age of Reason:** Even though the quality assurance process is not fully automated and a lot of decisions are human-centered, the QUALIT platform still provides value to suppliers and buyers. Because the professional and private life of humans are merged, they are always available and can immediately react when quality problems appear. In contrast to Renaissance 2.0, there will be higher human involvement in the quality control process. There needs to be supervision for every worker by a second worker or an assisting system to prevent illegal modification of data and to correct errors so that the proposed quality assurance system will be trustworthy and reliable. In case of quality issues, the solution of the problem is not part of QUALIT anymore. Instead, an external quality expert who can remotely assess the situation, e.g. by inspecting a digital twin of the factory in VR, is requested on demand. Those external experts can be drawn from a vast network of specialists which offer services on demand.

**The Golden Thirties:** Very similar to the New Age of Reason, human-centered decision-making creates the need for quality experts to solve quality problems when they are detected by the QUALIT platform. The separation of private and professional life poses a major problem as experts might not always be readily available for instant problem solving. Instead of highly-specialized external experts, every factory has to have at least one dedicated quality expert with general knowledge about the system. In order to be able to solve problems during the absence of internal experts, a knowledge base of quality problems is required which offers information about the root cause and solution. In this way, a substitution worker can adjust production to immediately fix the problem if the regular quality expert is not on-site. In this future, humans do not fully trust the reliability of machine intelligence which leads to additional selective product and process controls to double-check any automated machine related controls.

**De-enlightened Romanticism:** In a future where machines mostly make decisions and the private and professional lives of people are separated, QUALIT is the optimal tool for quality control because of full automation in production. Once the platform is installed with the help of humans, a fully automated production chain is created, including automated quality testing and resolving of quality issues. Since humans are not involved in the process after the installation, there is no need for a human-computer interface of QUALIT. Instead,



all machines in the production chain are connected directly. Production data as well as test data is then fed into one database so that every individual part is traceable throughout the production process.

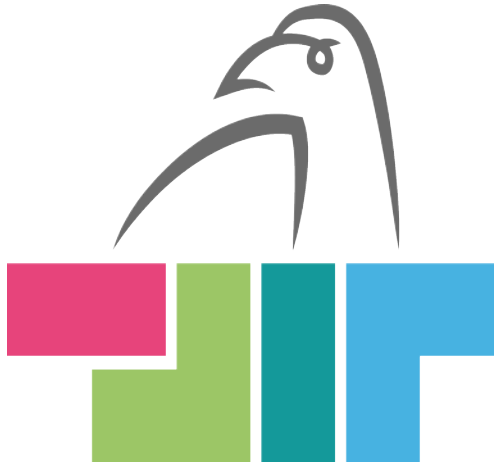
### Challenges:

- Extension of automated quality control system, especially regarding liability, to delivery and shipping phase
- Exhaustive protection against manipulation of data
- Prevention of (unintended or intended) changes to product tags
- Full automation of the testing of complex parts
- Onboarding of a critical mass of suppliers to the platform
- Minimization of initial installation and setup effort on supplier side
- Elimination of 100% of inspection work of incoming parts on buyer side

### Outlook:

Looking forward, in 20 years, advancements in sensor technology will make it possible for components to be inspected with very high accuracy. With greater accuracy and scalability, QUALIT's systems will become an emblem of industry standard. QUALIT will also greatly benefit from the rampant advancements in AI which will allow the platform to predictively determine the root cause of production-related This is enabled by the increasing data collection of similar components in an ever-growing knowledge base. Root cause prediction will also open up the possibility of optimizing critical manufacturing steps by analyzing the most frequent mistakes in the production line. All this knowledge, combined with predictive AI-based technology, will enable QUALIT to establish itself as a well-regarded expert in industrial quality inspection. This will give QUALIT the authority to implement a Score system for suppliers which will rate and rank suppliers based on the quality of their output. The separation of private and professional life poses a major problem as experts might not always be readily available for instant problem solving. Instead of highly-specialized external experts, every factory has to have at least one dedicated quality expert with general knowledge about the system. In order to be able to solve problems during the absence of internal experts, a knowledge base of quality problems is required which offers information about the root cause and solution. In this way, a substitution worker can adjust production to immediately fix the problem if the regular quality expert is not on-site.

Awais Shafique, Florian Kirchgeßner, Konstantin Adrianowytsch, Louisa Mayr, Tomislav Tomov



# SIMON

## Draft for the Future

Digital and smart factories are the powerhouses of our future economy. To have an optimal factory layout is essential to achieve maximum product output, flexibility, and cost-efficiency. Today, factory planning and portfolio shifting are long and complex processes, involving several steps with different activities, periods, and requirements for significant time and financial capital.

The process starts when the factory planner has to collect relevant information from multiple data sources like PowerPoints, Excel tables PDFs etc.. Using this information, the whole factory planning process is done manually using basic tools. The factory planner has to consider all these different factors which makes it very difficult to satisfy every single one of them and exhaust all possible layout solutions manually. Due to the lack of progress tracking and insufficient documentation, the planner has to start from scratch when designing factories, even if he is dealing with similar projects.
To address these problems, we propose SIMON, a revolutionizing factory layout planning software with the potential to reduce the required time up to 80%. SIMON is a collaborative cloud-based tool that analyzes data, optimizes layout designs, and keeps track of the project progress to dramatically facilitate the life of factory planner. SIMON will drastically simplify repetitive tasks enabling the factory planner to focus on higher-level decisions and complex client interaction to create more value. The factory planner's tasks will be centered around customer and stakeholder interactions. The initial version of SIMON mainly focuses on data collection and generates optimized drafts by iteratively considering basic, previously defined constraints. On top of that the software will be capable to document project information of past and present planning projects and store them in such a way that this information can be used in later projects.

In the near future, we will be able to leverage the power of Knowledge Graphs and Genetic Algorithms in order to automatically consider complex constraints for layout optimization. Integration with existing tools, such as material flow simulations will reduce the process time and further improve efficiency. Further along, we envision that the system is integrated completely with a digital companion, a smart coworker software (like an industrial Amazon Alexa), taking over labor-intensive tasks and reducing the whole factory planning time drastically. Within a few years, SIMON will completely redefine the way factories are being designed.

In conclusion, SIMON is an intuitive and interactive layout planner that captures expertise from every stakeholder, reduces iteration loops and cuts down planning time significantly.

## Business Model

### Key Partners

#### Experts

- AI experts
- Chatbot and Virtual Private Assistant (VPA) developers
- Cloud developers
- Application developers

#### Factory stakeholders

- Factory planners
- Key stakeholders for data input (e.g. plant manager, operators)

### Key Activities

- Developing algorithms to extract, summarize, and structure data
- Developing and integrating the digital assistant
- Developing algorithms for optimization under constraints
- Designing an optimal user experience in collaboration with our end users

### Key Resources

- Data science expertise to implement several data sources
- Factory planner expertise to identify specific constraints
- Workflow knowledge to implement SIMON into internal IT infrastructure

### Value Proposition

Facilitating Data Management for the Factory Planner and His Stakeholders

- Save factory planners' time by providing single access to project information
- Simplify backtracking in planning steps by documenting and storing of layout development

Support the Factory Planners' Decision-Making Process

- Providing initial and subsequent drafts based on pre-defined constraints
- Optimizing layouts based on pre-defined constraints

### Customer Relationships

- Working closely with the pilot customer in order to train the algorithms and refine the models and user experience (UX)
- B2B customers that license the software will receive an extensive training and will have 24/7 access to our customer service

### Channels

- Trade shows
- Social Media like Facebook, Instagram etc.

### Customer Segments

- Pilot customer
- B2B in the manufacturing industry
- B2B in the construction industry

### Cost Structure

#### Fixed costs

- Wages
- Initial setup of hardware infrastructure (includes PCs, Laptops, GPU-clusters for training)

#### Variable Costs

- Running costs for cloud service infrastructure
- Licensing fees for 3rd party software services and frameworks

### Revenue Streams

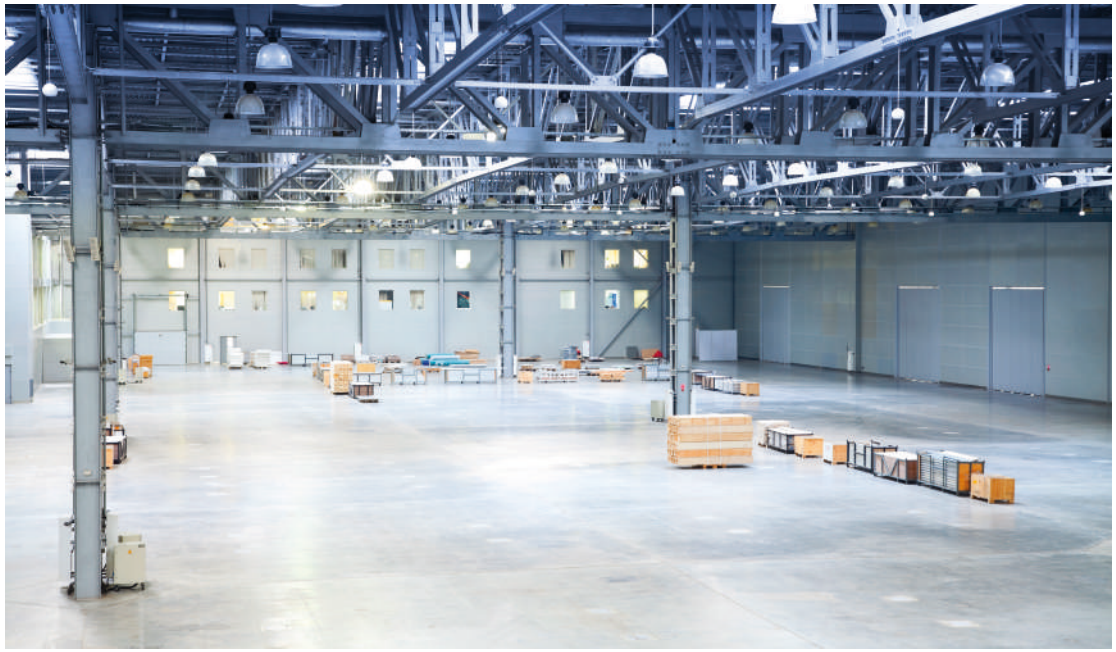
- As intrapreneurs: focus and project time savings and thereby cost reduction
- Licensing fees on a pay-per-use basis

## Value Proposition

**Save time by providing single access to project information:** One major task for the factory planner is to collect data from different stakeholders to get an overview of the project. SIMON will facilitate this data management by offering a single collection point to store all the project information. On top of that, the cloud will also summarize and validate the input from the different data sources so that the factory planner is able to quickly dive into the new project without losing time for gathering data.

**Simplify backtracking by documenting and storing of layout development:** To come up with the optimal solution, factory planners must iterate over several possible layouts to find the best one. Currently, there is no system that stores all the iterations as well as the project progress. SIMON will store all the different versions to generate a progress overview for the factory planner. This overview enables the rating of different layouts and the final decision on the one optimal solution.

**Providing initial and subsequent drafts based on pre-defined constraints:** As the factory planner must keep track of an extensive number of factors, it is rather difficult to come up with layouts that satisfy even a minor subset. In this case, algorithms can vastly outperform human capabilities in a fraction of the otherwise needed time. For SIMON to provide initial drafts, the planner must define relevant factors as constraints. This allows SIMON to suggest layouts which can be improved and tweaked through additional input from the factory planner or the involved stakeholders. Instead of a human coming up with designs over the span of multiple weeks, the process can be reduced to mere days by continuously optimizing the layout with the support of SIMON.



**Seamless tool integration:** SIMON will be able to export all generated layouts or documented information into the most commonly used file types. This will allow the factory planner to integrate SIMON into his existing workflow without having to learn new tools. Moreover, he can easily share his progress with colleagues or his superior, who might not use SIMON but is familiar with tools like Microsoft Excel or Microsoft Visio.

## Customer Relationships

SIMON is produced through an open, co-creation process with factory planners, so staying in touch with the factory planners is important to continuously get feedback from their work experiences. This feedback forms the basis for the ongoing improvements of features that will manifest in the advanced versions of SIMON. A SIMON training demo software along with user manuals will be rolled out to smoothen the onboarding process for factory planners. Once SIMON is being used in factory planning, it will document the process and quantify the results in terms of increased efficiency of factory planning, this quantified comparison of factory planning results before and after use of SIMON will help create company-wide acceptance for SIMON. For licensed software, dedicated SIMON expert consultants could help other companies set up SIMON for their factory planning projects. A challenge will be to convey that SIMON is a support software for the factory planners with the aim to facilitate their daily work life instead of a replacement technology.

## Channels

SIMON offers a business-to-business solution. Therefore, classic mass marketing and sales channels would be ineffective. As SIMON is a highly complex system, the benefits of using it can be best conveyed in a personal interaction. Tradeshows offer the advantage that businesses and decision makers of target industries and companies can specifically approached. Moreover, SIMON´s tradeshow appearance can be modified depending on the industry and the required solutions: in a manufacturing context, SIMON 1.0 could already be presented as a factory planning tool solution of the future. In a construction setting, advanced versions of SIMON can be presented as an advanced project management tool. As SIMON has the potential to revolutionize the factory planning industry, (professional) Social Media channels like

XING or LinkedIn can be used to push its knowledge among industry professionals.

## Key Resources

**Data science expertise to implement several data source:** SIMON's main advantage is that it will facilitate information supply. It will combine several decentralized data sources into one central cloud and automatically summarize and validate the most important information such as the dimensions of machines and the layout of the production floor. To set up this single source of information, data science expertise is needed to merge several data inputs into only one accessible cloud. The main challenge is summarizing the most relevant information while not omitting important data.

**Factory planner expertise to identify specific constraints:** The expertise and experience of factory planners will play a crucial role, since this knowledge will be needed to feed the algorithms with meaningful constraints in different situations. As several projects are varying from each other and layouts are becoming very complex with the additions of more production machines, factory planners are required to identify and name crucial constraints for SIMON. Additionally, secondary constraints like climate or factory location, which are not easily quantifiable but based on experience, must be integrated into SIMON.

**Workflow knowledge to implement SIMON into internal IT infrastructure:** To simplify the use of SIMON as much as possible for the factory planners, an implementation of the software into the existing, internal IT infrastructure will be necessary. The goal is that SIMON is fully integrated with the work tools of all planners to easily make use of this supporting application.

## Key Activities

**Developing algorithms to extract, summarize and structure data:** Extracting relevant information from machine specification sheets is a prerequisite for creating visual and easily comprehensible summaries and structuring semantically linked documents in a graph overview. While classical text analysis techniques may provide help or serve as benchmarks, the most promising approaches currently lie within the family of DL models. Different approaches for summarization


and semantic analysis need to be researched, trained, tested, and compared against each other. It is crucial to come up with the necessary amount of data for training a viable model and find a way to adjust for the technical terminologies found in specification sheets.

**Developing and integrating the digital assistant:** The digital assistant is central to SIMON. Initially, it is conceptualized to serve as a smart search engine via a Chatbot interface allowing to find relevant information quickly. This can be implemented today once document analysis and summarization is successfully running. The companion can be integrated as a Chatbot in the web application, but it needs to be able to handle varying queries input by natural language (either text or voice). Later, the companion will need to leverage Knowledge Graphs to handle more complex requests by users and be interfaced with existing tools like material simulation software. Finally, to be able to guide and moderate whole factory planning workshops in the future, the digital assistant needs to be able to understand context and comprehend everything that is being said. This will be achieved by continuously training the companion with observed actions of human factory planners and stakeholders.

**Developing algorithms for optimization under constraints:** SIMON is helping factory planners to devise nearly optimal layouts under consideration of machine dimensions and process sequences based on production flow. To realize this vision, an appropriate way needs to be identified to encode and input constraints into the system (extracted automatically or manually provided by the user) and feed them into the respective algorithms. A capable constraint satisfaction solver, Genetic Algorithms based solutions or Reinforcement Learning approaches must be researched, adopted, and tested to find the best optimization scheme possible for the targeted use case.

**Designing an optimal user experience in collaboration with our end users:** It is crucial for SIMON's success that the targeted factory planners are met with the optimal user experience. The software is designed to accelerate their work and therefore should be perfectly fitted to suit the factory planner's needs. A lean product development process should be utilized to quickly iterate trough versions by building rapid prototypes, collecting feedback, and subsequently improving the usability of the product. This cycle should be repeated in close collaboration with the targeted users until the

desired quality is achieved to enable for maximum efficiency and barrier-free adoption of the new solution.

## Revenue Streams

**Cost savings through improved productivity and efficiency:** SIMON is a product designed around the standard factory planning processes and focuses on optimizing this internal process to improve efficiency and productivity while reducing the time and in turn saving cost during factory planning. The ease of use of SIMON, because of its intuitive user interaction interface, would speed up and smoothen the onboarding process for new factory planners which would also reduce the time and money spent on the onboarding process. Since the system will be increasingly smarter and smarter, SIMON will be able to autonomously provide potential solutions, which the factory planners can improve upon. This will drastically reduce the project duration.

**Licensing:** Aside from use of SIMON to reduce cost and time inside a company, the technology could also be licensed to other manufacturing companies at a later stage. The proposed licensing model would be pay-per-use, such that companies can buy instances to create layout plans and pay proportionally for their stored layout and machine data on the cloud. Additionally, pay-per-use will reduce initial entry barriers for the customers. Thereby, the pilot customer could not only generate economic value by reducing costs but generate revenue with the technology.

## Key Partners

**AI engineers:** Since SIMON is powered by intelligent algorithms, AI expertise is required to develop a system capable of NLP, parsing and analyzing the semantics of text documents. Applicable ML and DL models need to be researched, identified, adapted, and trained. For the key supervised learning application areas like NLP, critical success factors are the training data sets, which engineers will extract and pre-process before feeding it into the learning models. Additional know-how in Knowledge Graphs, Genetic Algorithms, DRL, Generative Models and others are of crucial importance for realizing the full set of SIMON's capabilities.

**Chatbot and VPA developers:** Voice as a modality for human-machine interaction is gaining momentum, as people get accustomed to talking to VPA in their everyday lives. SIMON embraces this trend by initially incorporating a Chatbot interface, which allows users to ask and retrieve relevant project information, as well as input additional basic constraints. In the near future, factory planning with SIMON will be simplified to a series of workshops with the stakeholders – completely guided and moderated by a smart digital companion. Chatbot and VPA experts are required to develop these functions from the start and extend them further over time.

**Cloud experts:** Modern applications and software services are powered by the cloud – easily deployable, quickly scalable and incredibly flexible. Since these benefits are of central importance to the vision of SIMON, the required IT-infrastructure will be driven by cloud technology. The domain expertise will be needed for the development of the backend services, deployment of the application, and ensure SIMON's ability to scale according to the usage by customers. Additionally, an option to use the cloud to quickly train ML models and efficiently go through product feature iterations allows for a lean process and removes the requirement of owning training hardware and managing capacities.

**Application developers:** SIMON's first iteration comes in form of a web application, which is powered by AI technology and is hosted in the cloud. Factory planners interact with the intelligent software through this application. Therefore, app developers play a vital role in the product's success. A close collaboration between all developers is required to build the backend, integrate Chatbot capabilities, and deploy production ready AI algorithms. Capable application developers are needed to ensure the proper implementation of SIMON's features and the resulting delivery of their envisioned added values.

## Customer Segments

**Pilot customer:** SIMON is a factory layout planning software which is tailored towards the pilot customer's processes based on the feedback from factory planning experts inside the company. The solution focuses on making the pilot customer's factory planning processes faster and more efficient by improving the existing methodology and even completely redefining certain parts of the processes.

**B2B in the manufacturing industry:** Even though each factory is unique in terms of design and output requirements, they can still be broadly clustered into a few major groups and the layout planning process can be generalized according to these clusters. Considering the drastic effects of this technology, it would be beneficial to license this technology to manufacturing companies of all types which have their own factories and might need to re-plan factory layouts due to portfolio shifts.

**B2B in the construction industry:** Since SIMON generates layouts while optimizing certain desired parameters (such as area) based on predefined constraints by stakeholders (such as the area of each machine, the positioning of machines), an extended version of SIMON could be further generalized and implemented in any kind of large-scale construction project. For example, SIMON could be used in home architecture by considering the number of rooms as input constraints and the software would provide a layout for optimal position and orientation of rooms with a maximum area for a living room as required by the client.

## Cost Structure

**Fixed costs**
The development and implementation of SIMON will require substantial manpower from experts of different fields like AI and application development. With the introduction of SIMON 1.0, we will simultaneously start the development of SIMON 2.0 and 3.0 as soon as the required technology is available for commercial usage. Consequently, wages required for R&D experts will be comparatively stable over the first years as the number of experts required will remain relatively stable. Form a hardware perspective, the initial hardware structure, including PCs, laptops, and GPU-clusters for training will be a necessary investment at the beginning of SIMON's journey. Once SIMON is licensed to other companies in the industry or even outside industries, the respective licensees will bear the cost of the initial hardware setup.

**Variable costs**
Variable costs will initially concern mainly the running costs for a cloud service infrastructure. Additionally, licensing fees for 3rd party software services or software frameworks may apply. As soon as the AI is technically ready it will be incorporated into SIMON to enable continuous learning. This will incur running costs for experts that train the AI and exper-

imenting with models. These costs will mainly concern the human resources required to train the AI.

### Scenario Fit:

**Renaissance 2.0 (machine & merged)** In this scenario machines have a very large influence on our lives, automating decisions and suggesting possible actions. Traditional nine to five jobs no longer exist and leisure activities are completely intertwined with professional life. Because of the high degree of digitalization, SIMON will be capable to collect all the required information from different data sources itself to autonomously plan the factory layout. All these sources will constantly enable the planning software to consider all necessary parameters to come up with the optimal solution for individual projects. The long-term vision is that the entire planning process is autonomously handled by SIMON, which will change the job requirements of factory planners.

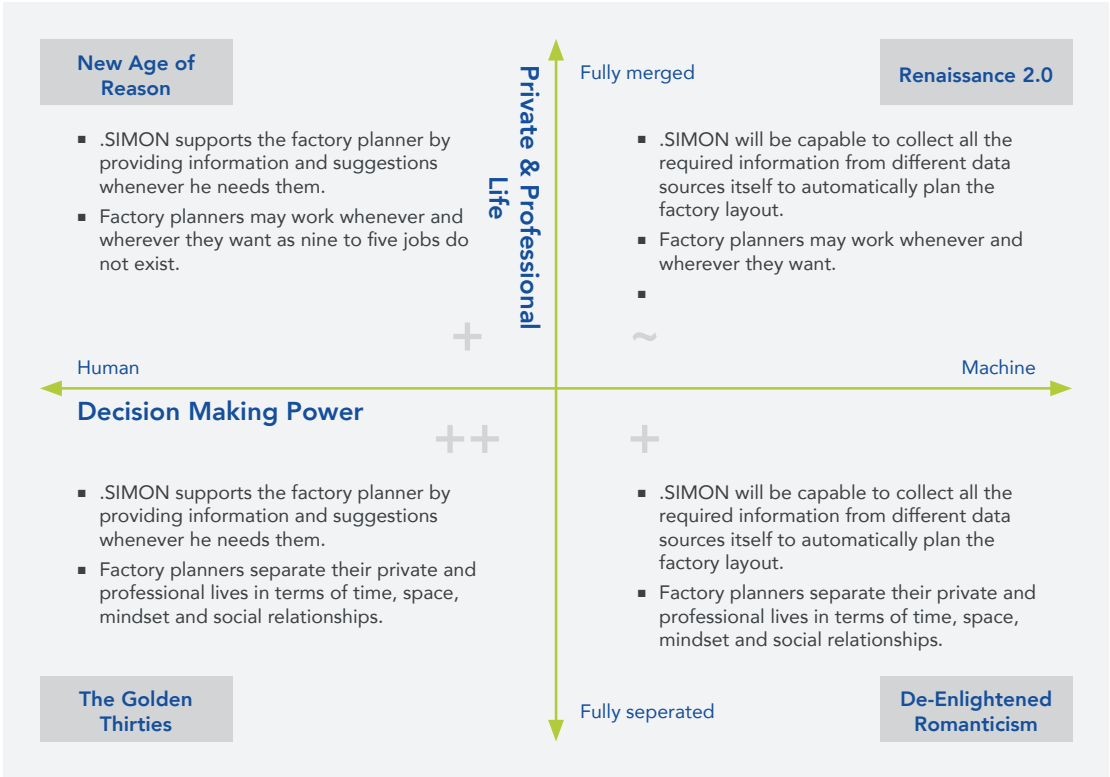
**New Age of Reason (human & merged)** Kant's "sapere aude", "dare to think for yourself", marks the reincarnated motto of this future, where humans oversee decision-making because most physical work has been automated. The factory planner pulls information from SIMON whenever he needs further clarifications. He also validates and chooses the optimal suggestions of SIMON as his expertise is necessary to deal with unexpected individual cases. Since the professional and private life is completely merged, traditional employment from nine to five does not exist any longer. Factory planners can work whenever they want from wherever they want and do not have to be present at the client's side when using SIMON.

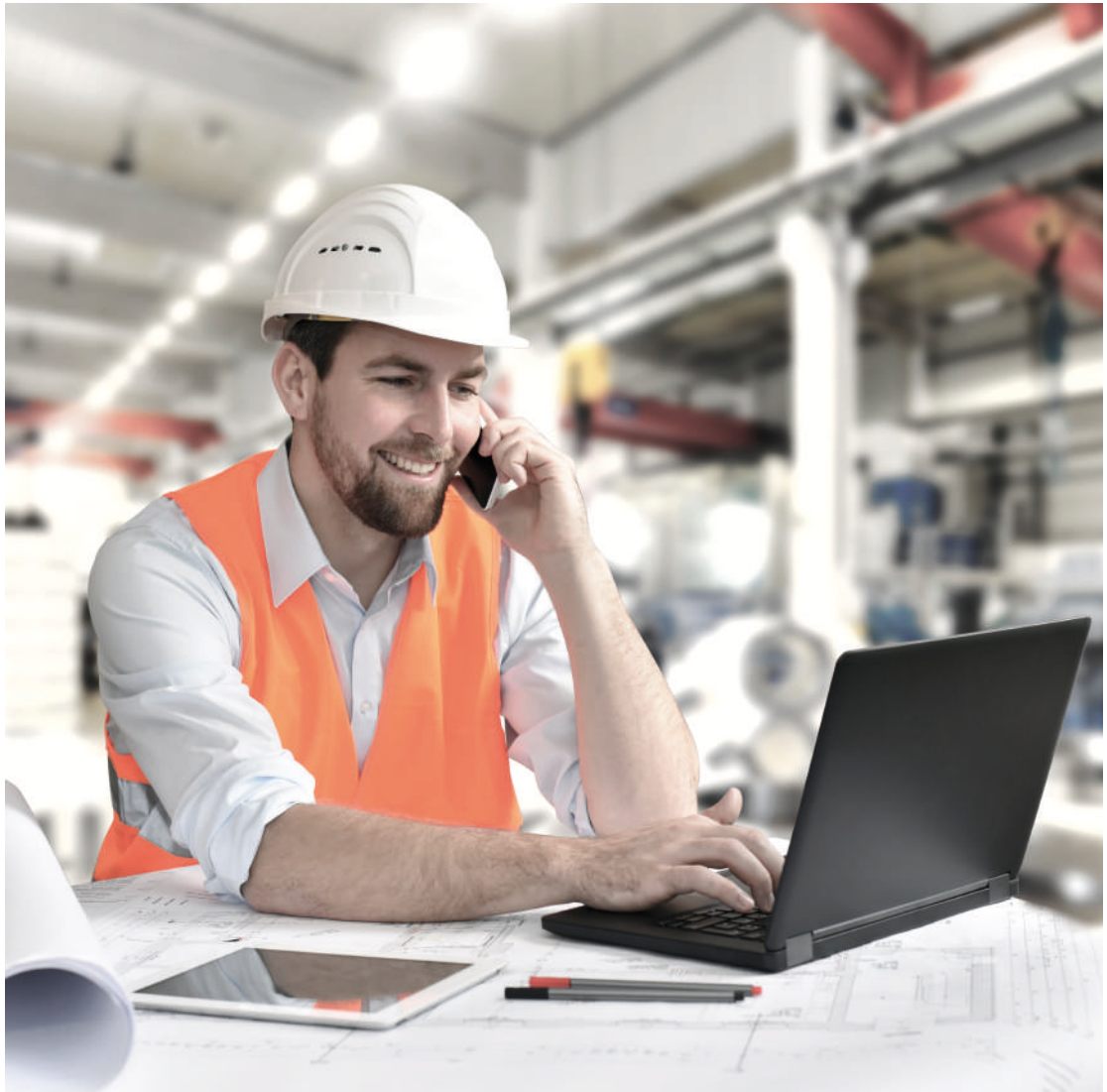
**The Golden Thirties (human & separated)** In this future, private and professional life are completely separated. Since AI is highly capable but inexplicable, human work is centered around decision-making. At the same time, automation has allowed humans to increasingly focus on leisure activities, leading to an improved quality of life. The factory planner pulls information from SIMON whenever he needs further information or assistance. He will also validate the information and draft proposals provided by SIMON and choose the optimal suggestions as his working expertise is necessary to deal with unexpected individual situations. Since professional and private life are completely separated the factory planner will have only access to SIMON when he is at the job site. Accessing SIMON remotely will not be possible.

**De-enlightened Romanticism (machine & separated)** In this scenario machines have the capability to autonomously make explainable decisions and dominate actions in multiple human spheres. Individuals totally separate their private and professional lives in terms of time, space, mindset, and social relationships. Due to the high degree of digitalization in any aspect of work (and private) life, SIMON will be able to autonomously search for all required project information. The 24/7 accessibility of all available information will enable the planning software to consider all necessary planning parameters at all times in order to come up with the optimal solution for each individual project. The SIMON long-term vision is that all planning processes are autonomously handled by SIMON, which will change the job requirements of a traditional factory planner.

### Challenges:

- Uploading and summarizing all required data
- Handling various formatted data sources
- Establishing a user-friendly human-computer interface
- Managing the high complexity of planning project
- Computing highly customized solutions
- Creating value before having access to large datasets





## Outlook:

SIMON has a very bright future with the potential to revolutionize and digitize the traditional factory layout planning which relies on a limited and segregated tool set. Regarding the different development stages, the next step will be to implement a single cloud that summarizes, validates information from various data sources. This system will facilitate data management and save the planners' time as well as effort to gather the required information. In a further step, SIMON will create and suggest rough drafts of the production floor layout based on constraints related to machine specific characteristics such as electricity supply, required maintenance access etc. Looking even further into the future, the software will constantly keep track of the layout changes and store the optimal solution, which can be validated by cooperative stakeholder review sessions. The database of optimal layouts enables SIMON to learn from previous projects by recognizing certain patterns in the machine allocation on the production floor. Our long-term vision is that SIMON builds the factory software of tomorrow as it will autonomously generate optimized layouts within highly complex environments.

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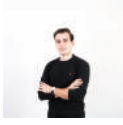

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# SOURCES


[1] J. Bughin et al., "A Future That Works: Automation, Employment, and Productivity," McKinsey Glob. Inst., no. January, pp. 1–28, 2017.

[2] B. Prescott, "Better Together: Artificial Intelligence Approach Improves Accuracy in Breast Cancer Diagnosis," Harvard Medical School, 2016. .

[3] "Artificial Intelligence in Stock Trading - Future Trends and Applications," techemergence.com, 2017. .

[4] "EY, Deloitte And PwC Embrace Artificial Intelligence For Tax And Accounting," Forbes, 2017. .

[5] "Lawyer-Bots Are Shaking Up Jobs," MIT Technology Review, 2017.

[6] D. M. Katz, M. J. Bommarito, and J. Blackman, "AI in Law and Legal Practice - A Comprehensive View of 35 Current Applications," PLOS ONE, Apr-2017. .

[7] "Human-Robot Collaboration: The Technology," KUKA AG, 2018. .

[8] "Machine Learning in Manufacturing - Present and Future Use-Cases," techemergence.com, 2018. .

[9] S. Mahroum, "AI Raises Lots of Questions. These Are the Ones We Should Be Asking," World Economic Forum, 2018. .

[10] D. Varadharajan, "CB Insights: State of AI," 2018.

[11] "AI & Deep Learning Academic Papers Published," Scopus, 2018. .

[12] Y. Shoham, R. Perrault, E. Brynjolfsson, J. Clark, and C. LeGassick, "Artificial Intelligence Index, November 2017," no. November, p. 101, 2017.

[13] Kumba Sennaar, "Machine Learning for Medical Diagnostics - 4 Current Applications -." [Online]. Available: https://www.techemergence.com/machine-learning-medical-diagnostics-4-current-applications/. [Accessed: 07-Mar-2018].

[14] "The Democratization of AI Is Putting Powerful Tools in the Hands of Non-Experts," Singularity Hub, 2018. .

[15] "2018 Will Mark the Beginning of AI Democratization," Gartner, 2017. .

[16] K. He, G. Gkioxari, P. Dollár, and R. Girshick, "Mask R-CNN," Mar. 2017.

[17] J. Johnson et al., "Inferring and Executing Programs for Visual Reasoning," May 2017.

[18] N. Dvornik, K. Shmelkov, J. Mairal, and C. Schmid, "BlitzNet: A Real-Time Deep Network for Scene Understanding," Aug. 2017.

[19] C.-C. Chiu et al., "State-of-the-art Speech Recognition With Sequence-to-Sequence Models," pp. 3–7, 2017.

[20] J. Shen et al., "Natural TTS Synthesis by Conditioning WaveNet on Mel Spectrogram Predictions," pp. 2–6, 2017.

[21] A. van den Oord et al., "Parallel WaveNet: Fast High-Fidelity Speech Synthesis," Nov. 2017.

[22] "The Exponential Growth of Data," insidebigdata.com, 2017. .

[23] "42 Percent of US Smartphone Owners Use AI Personal Assistant Monthly," voicebot.ai, 2017. .

[24] "Sluggish Adoption of AI-Driven Personal Apps," Verto Analytics, 2017. .

[25] "Uses of Virtual Assistants in the U.S. 2017," Statista, 2018. .

[26] "Virtual Digital Assistants Familiarity in U.S. 2016," Statista, 2016. .

[27] "Virtual Digital Assistant Market Worldwide 2015-2021," Statista, 2018. .

[28] "Eight ways AI will change your business in 2018," PricewaterhouseCoopers, 2018. .

[29] "Facebook's AI Boss: 'In Terms of General Intelligence, We're Not Even Close to a Rat'," Business Insider, 2017. .

[30] "Evolving from Narrow Artificial Intelligence to Cognitive Artificial Intelligence," medium.com. .

[31] "Artificial Intelligence Data Privacy Issues on the R ise," techtarget.com, 2017. .

[32] "Big Data, Artificial Intelligence, Machine Learning and Data Protection," ICO, 2017. .

[33] Y. De Montjoye, A. Farzanehfar, J. Hendrickx, and L. Rocher, "Solving Artificial Intelligence 's Privacy Problem," no. 17, 2018.

[34] "Artificial Intelligence Poses Data Privacy Challenges," Bloomberg Law, 2016. .

[35] "Microsoft Says AI Advances Will Require New Laws, Regulations," Bloomberg, 2018. .

[36] F. O. R. I. Release, "Home Automation Device Market Grows Briskly, to 27 Million — Consumer Intelligence Research Partners," 2017.

[37] S. A. Grandhi, G. Joue, and I. Mittelberg, "Understanding naturalness and intuitiveness in gesture production," in Proceedings of the 2011 annual conference on Human factors in computing systems - CHI '11, 2011, p. 821.

[38] Verto Analytics, "Rise of the Machines: How AI-Driven Personal Assistant Apps Are Shaping Digital Consumer Habits."

[39] "Virtual Reality, Chatbots to Dominate Brand Interactions by 2020." [Online]. Available: https://www.oracle.com/uk/corporate/pressrelease/oracle-report-can-virtual-experiences-replace-reality-vr-chatbots-for-cx-20161206.html. [Accessed: 28-Feb-2018].

[40] Digi-Capital, "Augmented/Virtual Reality Report and Deals Database Q1 2018."

[41] Gartner, "Forecast: Wearable Electronic Devices, Worldwide, 2017."

[42] Slashgear, "BMW i Inside Future concept makes the dashboard a tactile hologram." [Online]. Available: https://www.slashgear.com/bmw-i-inside-future-concept-makes-the-dashboard-a-tactile-hologram-05470426/. [Accessed: 07-Mar-2018].

[43] "Harman, Ultrahaptics team up for mid-air haptic feedback - ExtremeTech." [Online]. Available: https://www.extremetech.com/extreme/244660-harman-ultrahaptics-team-mid-air-haptic-feedback. [Accessed: 28-Feb-2018].

[44] "Speech recognition faster at texting | Stanford News." [Online]. Available: https://news.stanford.edu/2016/08/24/stanford-study-speech-recognition-faster-texting/. [Accessed: 28-Feb-2018].

[45] S. Choi, K. Jung, and S. Do Noh, "Virtual reality applications in manufacturing industries: Past research, present findings, and future directions," Concurr. Eng., vol. 23, no. 1, pp. 40–63, Mar. 2015.

[46] L. Freina and M. Ott, "A Literature Review on Immersive Virtual Reality in Education : State Of The Art and Perspectives."

[47] E. Bastug, M. Bennis, M. Medard, and M. Debbah, "Toward Interconnected Virtual Reality: Opportunities, Challenges, and Enablers," IEEE Commun. Mag., vol. 55, no. 6, pp. 110–117, 2017.

[48] MarketsandMarkets, "Volumetric Display Market by Component (Projector, Motor & Position Sensor), Technology (DLP and LCOS), Display Type (Swept and Static), Application (Medical, Aerospace & Defense and Oil & Gas), Geography - Global Trend & Forecast to 2015 - 2020."

[49] A. Murphy, "Industrial: Robotics Outlook 2025," Loup Ventures, 2017. .

[50] L. S. Terrissa, "Towards a New Approach of Robot as a Service (RaaS) in Cloud Computing Paradigm," 2016.

[51] M. Brambilla, E. Ferrante, and M. Birattari, "Swarm robotics : A review from the swarm engineering perspective IRIDIA – Technical Report Series Technical Report No .," Swarm Intell., vol. 7, no. 1, pp. 1–41, 2012.

[52] "Opinion: Why 'Robotics as a Service' is on Its Way," Cloud Tech News, 2017. .

[53] "How Robots Will Redefine Competitiveness," Boston Consulting Group, 2015. .

[54] G. Wisskirchen et al., "Artificial Intelligence and Robotics and Their Impact on the Workplace," IBA Glob. Employ. Inst., no. April, 2017.

[55] K. Panetta, "Top Trends in the Gartner Hype Cycle for Emerging Technologies, 2017 - Smarter With Gartner," 2017. .

[56] R. van der Meulen, "Gartner Says 8.4 Billion Connected Things Will Be in Use in 2017, Up 31 Percent From 2016," Gartner, 2017. .

[57] J. Manyika et al., "The Internet of Things: Mapping the Value Beyond the Hype," McKinsey Glob. Inst., no. June, p. 144, 2015.

[58] S. Heng, "Industry 4.0: Huge potential for value creation waiting to be tapped.," 2014.

[59] C. Curran, D. Garrett, and T. Puthiyamadam, "A Decade of Digital - Keeping Pace With Transformation," 2017.

[60] "The Internet of Things: a Movement, Not a Market," IHS Markit, 2017. .

[61] R. van der Meulen, "What Edge Computing Means for Infrastructure and Operations Leaders - Smarter With Gartner," Embedded Innovator, 2016.

[62] V. Turner et al., "IDC FutureScape: Worldwide IoT 2018 Predictions," 2017. .

[63] "Global Sensors in Internet of Things (IoT) Devices Market, Analysis & Forecast: 2016 to 2022," 2017.

[64] M. Beijia, S. Nahal, and T. Felix, "Future Reality : Virtual , Augmented & Mixed Reality ( VR , AR & MR ) Primer," 2016.

[65] mCube, "The Advantages of Integrated MEMS to Enable the Internet of Moving Things," no. June, pp. 2–6, 2014.

[66] "5G: The Internet for Everyone and Everything," Natl. Instruments, 2016.

[67] L. Gupta and R. Jain, "Mobile Edge Computing – An Important Ingredient of 5G Networks - IEEE Software Defined Networks," 2016. .

[68] K. Rose, S. Eldridge, and L. Chapin, "THE INTERNET OF THINGS: AN OVERVIEW. Understanding the Issues and Challenges of a More Connected World.," Internet Soc., no. October, p. 80, 2015.

[69] P. Richards and B. Goretkin, "Mesh Sensor Networks Bridge IoT's Last Mile," 2016.

[70] J. Holdowsky, M. Mahto, M. E. Raynor, and M. Cotteleer, "Inside the Internet of Things," Deloitte Univ. Press, p. 54, 2015.

[71] Ahmed Banafa, "Three Major Challenges Facing IoT - IEEE Internet of Things," 2017. .

[72] Arxan, "Study on Mobile and IoT Application Security," no. January, 2017.

[73] R. Geissbauer, S. Schrauf, V. Koch, and S. Kuge, "Industry 4.0: Opportunities and Challenges of the Industrial Internet," PricewaterhouseCoopers, p. 52, 2014.

[74] "Winning with the Industrial Internet of Things," Accenture, 2015. .

[75] "Meet Manufacturing's Digital Twin," The Wall Street Journal, 2017. .

[76] R. Geissbauer, S. Schrauf, P. Berttram, and F. Cheraghi, "Digital Factories 2020: Shaping the future of manufacturing," 2017. .

[77] "CAD Trends 2016 - worldwide survey results," Business Advantage, 2016. .

[78] "Digital Twin Market by End User: Aerospace, Defense, Automotive Transportation, Home, Commercial. Forecast 2023," Markets And Markets, 2017. .

[79] "The Shifting Economics of Global Manufacturing," Boston Consulting Group, 2014. .

[80] "The Cheap, Convenient Cloud," The Economist, 2015. .

[81] "Data Management Reality Check: IDC Survey Finds Organizations Need a More Centralized Data Strategy," Commvault, 2015. .

[82] G. Krempl et al., "Open Challenges for Data Stream Mining Research," ACM SIGKDD Explor. Newsl. - Spec. issue big data, vol. 16, no. 1, 2014.

[83] C. Pettey, "Prepare for the Impact of Digital Twins," Gartner, 2017. .

[84] Zukunftsinstitut, "Generation Y. Selbstverständnis der Manager von morgen," 2013.

[85] J. H. G. B. Joseph Pine, The experience economy: past present and future. Edward Elgar Publishing, 2016.

[86] Deloitte, "Making it personal. One in three consumers wants personalised products," 2015.

[87] Deloitte, "Made-to-order: The Rise of Mass Personalisation.," 2015.

[88] PwC, "The shift from ownership to access. How will the automotive industry respond to new consumption models in China?," 2014.

[89] PwC, "Share Economy. Repräsentative Bevölkerungsbefragung," 2015.

[90] Allianz, "Global Wealth Report," 2017.

[91] World Economic Forum, "The Global Information Technology Report," 2015.

[92] Prognos, "Arbeitslandschaft 2040," 2017.

[93] BCG, "Profiting from Personalization," 2017.

[94] EY, "Global generations. A global study on work-life challenges across generations," 2015.

[95] Deloitte, "The Growing Power of Consumers," 2014.

[96] International Labour Organization, "Working anytime, anywhere: The effects on the world of work," 2017.

[97] J. Bughin et al., "A Future That Works: Automation, Employment, and Productivity," McKinsey Glob. Inst., no. January, pp. 1–28, 2017.

[98] Deloitte, "The Future of the Workforce Critical drivers and challenges," pp. 1–15, 2016.

[99] E. Velinov and I. Denisov, "The Relationship between Contemporary Holacratic Models of Management and Company Performance: Evidence from Global Corporations in the World," Glob. J. Bus. Soc. Sci. Rev., 2017.

[100] McKinsey Global Institute, "Independent Work: Choice, necessity, and the Gig Economy," 2016.

[101] OECD, "Average annual hours actually worked per worker," 2018. [Online]. Available: http://stats.oecd.org/viewhtml.aspx?datasetcode=ANHRS&lang=en#. [Accessed: 03-Jul-2018].

[102] L. Greiner, "So haben die Millennials die Arbeitswelt verändert," Spiegel, 2018.

[103] Deloitte University Press, "Rewriting the rules for the digital age - 2017 Deloitte Global Human Capital Trends," 2017.

[104] European Parliament, "Temporary contracts, precarious employment, employees' fundamental rights and EU employment law," 2017.

[105] National Intelligence Council, "Global trends. Paradox of Progress," 2017.

[106] P. Figgis and C. Walters, "Changing demographics demand healthcare reforms," PwC , 2017.

[107] OECD, "Chapter 1: Families are changing," Doing Better Fam., pp. 17–53, 2011.

[108] I. Hoßmann et al., "Europe's Demographic Future," IThe Berlin Inst. Popul. Dev., p. 368, 2008.

[109] OECD, "Gender equality and women's rights in the post-2015 agenda: A foundation for sustainable development," 2015.

[110] O. Solon, "CES 2018: less 'whoa', more 'no!' – tech fails to learn from its mistakes at annual pageant," The Guardian.

[111] National Intelligence Council, "Global Trends 2030: Alternative Worlds," 2012.

[112] United Nations, "Economic & Social Affairs: World Population Ageing," 2015.

[113] V. Bengler, K and Knott, "Ergonomic User Interface of an Exoskeleton for Manual Handling Tasks - An Evaluation Study," in Proceedings of the 4th International Digital Human Modeling Symposium, 2016.

[114] Mckinsey Global Institute, "MGI: Digital Globalization: The era of global flows," 2016.

[115] RAND Europe, "Trends in connectivity technologies and their socioeconomic impacts," 2009.

[116] Internet Society, "Global Internet Report," 2017.

[117] UK Government Office, "Foresight Future Identities, Final Project Report," 2013.

[118] Cisco, "The Zettabyte Era: Trends and Analysis," 2017. [Online]. Available: https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/vni-hyperconnectivity-wp.html. [Accessed: 02-Mar-2018].

[119] eMarketer, "Worldwide Internet and Mobile Users: eMarketer's Updated Estimates and Forecast for 2017-2021," 2017.

[120] S. Genner, ON/OFF Risks and Rewards of the Anytime-Anywhere Internet, 1st ed. vdf, 2017.

[121] IHS Markit, "The Internet of Things : a movement , not a market," p. 9, 2017.

[122] UN, "International Migration Report," 2017.

[123] UNHCR - The UN Refugee Agency, "Global Trends Forced Displacement," 2016.

[124] McKinsey, "Delivering through Diversity," 2018.

[125] PwC, "CEO Action for Diversity & Inclusion." [Online]. Available: https://www.ceoaction.com/about/. [Accessed: 07-Mar-2018].

[126] J. A. Patsiurko, Natalka; Campbell, John L.; Hall, "Measuring cultural diversity: ethnic, linguistic and religious fractionalization in the OECD," Ethn. Racial Stud., pp. 195–217, 2012.

[127] M. Czaika, Mathias; de Haas, Hein; Villares-Varela, "The global evolution of travel visa regimes," 2017.

[128] M. Saxon, Steve; Weber, "A better approach to airline costs," McKinsey, 2017.

[129] UN, "Development and Globalization - Facts and Figures 2016," 2016.

[130] "Global Peace Index 2017," Inst. Econ. Peace, 2017.

[131] K. Brett, Jeanne; Behfar, "Managing Multicultural Teams," Harvard Business Review, 2006.

[132] A. Green, Kelli; López, Mayra; Wysocki, "Diversity in the Workplace: Benefits, Challenges, and the Required Managerial Tools," University of Florida.

[133] "13 benefits and challenges of cultural diversity in the workplace in 2017," Hult News, 2017.

[134] C. M. Riordan, "Diversity Is Useless Without Inclusivity," Harvard Business Review, 2014.

[135] IPCC, "Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change," 2014.

[136] UNEP, "Frontiers 2017. Emerging Issues of Environmental Concern," 2017.

[137] Daniela Selloni, New Forms of Economies: Sharing Economy, Collaborative Consumption, Peer-to-Peer Economy CoDesign for Public-Interest Services. Cham: Springer, 2017.

[138] OECD, "Seeing Paradigm Change," 2015.

[139] D. Haski-Leventhal, Strategic Corporate Social Responsibility. Tools and Theories for Responsible Management. London: SAGE, 2018.

[140] European Economic and Social Committee, "Civil society networks to take circular economy to next level," 2018. [Online]. Available: https://www.eesc.europa.eu/en/news-media/news/civil-society-networks-take-circular-economy-next-level.

[141] World Economic Forum, "The Global Risks Report 2018. 13th Edition," 2018.

[142] R. Guha-Sapir, Debarati, Hoyois, Philippe, Wallemacq, Pascaline, Below, "Annual Disaster Statistical Review 2016," 2016.

[143] World Health Organization, "World Health Statistics," 2015.

[144] F. J. Brauer, M, Freedman G, "Ambient Air Pollution Exposure Estimation for the Global Burden of Disease," Environ. Sci. Technol., vol. 50, no. 1, pp. 79–88, 2016.

[145] UNDP/UNRISD, "Global Trends. Challenges and Opportunities in the Implementation of the Sustainable Development Goals," 2017.

[146] R. M. T. McCaul, "H.R.3359 - Cybersecurity and Infrastructure Security Agency Act of 2017." Washington DC, 2017.

[147] Deloitte, "The General Data Protection Regulation." 2018.

[148] Freshfields, "China's New Cybersecurity Law - What International companies should know." 2017.

[149] BSI, "Kooperation mit BSI: NRW-Digitalminister erklärt Cyber-Sicherheit zur Chefsache." Bonn, 2018.

[150] D. Dollasse, "Collaborative research," KOWi, 2017. [Online]. Available: http://www.kowi.de/kowi/verbundforschung/Partnerschaften/cppps/fof/ppp-factories-of-the-future-fof.aspx. [Accessed: 07-Mar-2017].

[151] International Federation of Robotics, "Robot density rises globally," International Federation of Robotics, 2018. .

[152] G. Zwakman, M. Aslett, J. Stamper, J. Curtis, and K. Roy, "Total Data market expected to reach $132bn by 2020," 451Research, 2016.

[153] Hitachi, "'Industry 4.0', the 'connected factory', the 'Industrial Internet of Things': all these terms refer to a vision of the future where products are manufactured within a system of networked people, assets and machines.," Hitachi, 2017. .

[154] EFFRA, "Joint Declaration on Boosting Europe's Future Competitiveness as Key Priority for FP9 Published," EFFRA, 2018.

[155] Ducker Worldwide, "SMART FACTORIES – MAJOR CHALLENGES FOR THE FUTURE OF EUROPEAN INDUSTRY," Ducker Worldwide, 2017. .

[156] Europa, "Factories of the Future," Europa, 2017. .

[157] EFFRA, "Factories 4.0 and Beyond," 2016.

[158] H. Krcmar, Einführung in das Informationsmanagement. Springer, 2011.

[159] A. Hern, "North Korea is a bigger cyber-attack threat than Russia, says expert," The Guardian, www.theguardian.com, 2018.

[160] Accenture and P. Institute, "Cost of Cybercrime," 2017.

[161] A. Greer and N. Montierth, "How Are US-China Cyber Relations Progressing?," The Diplomat, 2017.

[162] J. Brenner, "The New Industrial Espionage," Am. Interes., vol. 10, 2014.

[163] strategy&, "Industrie 4.0 - Chancen und Herausforderungen der vierten Industriellen Revolution," 2014.

[164] D. A. Duisberg, "No Title." 2018.

[165] U. of St. Gallen, Ed., Recht im Digitalen Zeitalter. St. Gallen, 2015.

[166] DHS, "Law Enforcement and Cybersecurity," 2010.

[167] VdS, "VdS-Studie zur Cyber-Security: KMU bewerten eigene Schutzmaßnahmen als nicht ausreichend." Vertrauen durch Sicherheit, Cologne, 2017.

[168] J. Germano, "Proposed NY Cybersecurity Regulation: A Giant Leap Backward?," Forbes, 2016.

[169] EU, "Home Page of EU GDPR," EU GDPR Terminal. 2016.

[170] European Union, "Regulation 2016/679 of the European parliament and the Council of the European Union," Off. J. Eur. Communities, vol. 2014, no. March 2014, pp. 1–88, 2016.

[171] EU GDPR.org, "Key Changes with the General Data Protection Regulation." .

[172] "The Democratization of AI Is Putting Powerful Tools in the Hands of Non-Experts." [Online]. Available: https://singularityhub.com/2018/02/19/the-democratization-of-ai-is-putting-powerful-tools-in-the-hands-of-non-experts/#sm.0013j9jvw14jidywrxu2jnrk35nfm. [Accessed: 28-Feb-2018].

[173] R. 09 US EPA, "What are the Challenges?" .

[174] "IDC Studie."

[175] H. Meeker, "Open source licensing: What every technologist should know | Opensource.com." 2017.

[176] B. Golden, "Succeeding With Open Source." p. 242, 2005.

[177] "Facebook, Google, IBM and Red Hat team up on open-source license compliance - SD Times." .

[178] "_'Big four' Linux companies shift open-source licensing policies _ ZDNet." .

[179] "EU pledges support for open source government solutions _ Opensource." .

[180] K. Schleife and B. Beckert, "Summary The Economic and Social Impact of Software & Services on Competitiveness and Innovation –." 2016.

[181] B. Duck et al., "2017_BlackDuck_Open source security and risk analysis.pdf."

[182] T. H. E. Power and O. F. Open, "ICT Standardisation in a Digital world," no. December, 2017.

[183] "Open Standards, Move Over - OpenForum Europe." .

[184] A. Mohamed, "Open source software security," Computerweekly.Com. 2008.

[185] "Lawsuit threatens to break new ground on the GPL and software licensing issues _ Opensource." .

[186] S. M. Bastian Best, "No Title," 2018.

[187] "How open source makes software more secure _ Opensource." .

[188] R. Clarke, D. Dorwin, and R. Nash, "Is open source software more secure?," , Univ. Washington, http//courses. cs. …, 1999.

[189] S. David, "Opening the sources of accountability." 2004.

[190] P. De Hert, V. Papakonstantinou, G. Malgieri, L. Beslay, and I. Sanchez, "The right to data portability in the GDPR: Towards user-centric interoperability of digital services," Comput. Law Secur. Rev., 2017.

[191] Council of the European Union, "Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on addressing geo-blocking and other forms of discrimination based on customers' nationality, place of residence or place of establishment within the internal market and amending Regu," 2016.

[192] European Data Protection Supervisor, "Accountability on the ground: Provisional guidance on documenting processing operations for EU institutions, bodies and agencies Summary," 2018.

[193] F. Doshi-Velez et al., "Accountability of AI Under the Law: The Role of Explanation," p. 15, 2017.

[194] J. Boag-Thomson, "GDPR: the implications for business," 2017. [Online]. Available: https://www.icas.com/ca-today-news/gdpr-the-implications-for-business. [Accessed: 03-Mar-2018].

[195] Union European, "Geo-blocking: unlocking e-commerce in the EU," 2018. [Online]. Available: http://www.consilium.europa.eu/en/policies/geo-blocking/. [Accessed: 05-Mar-2018].

[196] European Commission, "Free flow of non-personal data," 2017. [Online]. Available: https://ec.europa.eu/digital-single-market/en/free-flow-non-personal-data. [Accessed: 03-Mar-2018].

[197] European Commission, "Free flow of non-personal data," p. 2, 2017.

[198] L. Rainie and M. Duggin, "Privacy and Information Sharing," Pew Res. Cent. Internet Proj., vol. 15, no. December 2015, p. 47, 2016.

[199] M. McFarland, "Why We Care about Privacy," 2012. [Online]. Available: https://www.scu.edu/ethics/focus-areas/internet-ethics/resources/why-we-care-about-privacy/. [Accessed: 03-Mar-2018].

[200] J. Podesta, P. Pritzker, E. J. Moniz, J. Holdren, and J. Zients, "Big Data: Seizing Opportunities, Preserving Values," Exec. Off. Pres. USA, no. May, pp. 1–79, 2014.

[201] Nature, "More accountability for big-data algorithms," 2016. [Online]. Available: https://www.nature.com/news/more-accountability-for-big-data-algorithms-1.20653. [Accessed: 03-Mar-2018].

[202] P. Turner, "Fuhgettaboutit: the GDPR 'Right to Erasure,'" 2017. [Online]. Available: https://www.scality.com/blog/fuhgettaboutit-the-gdpr-right-to-erasure/. [Accessed: 03-Mar-2018].

[203] DSI Analytics, "DATA SCIENCE AND EU PRIVACY REGULATIONS: A STORM ON THE HORIZON," 2015. [Online]. Available: https://dsianalytics.com/data-science-and-pending-eu-privacy-regulation-a-storm-on-the-horizon/. [Accessed: 03-Mar-2018].

[204] "Accelerating Workforce Reskilling for the Fourth Industrial Revolution. An Agenda for Leaders to Shape the Future of Education, Gender and Work," World Economic Forum, 2017. .

[205] J. ; A. K. Bhargava;, "How the Internet is Fueling the Growth of Creative Economies," 2017.

[206] J. Lucker et al., "Navigating the future of Work: Can we point business, workers, and social institutions in the same direction?," Deloitte Rev., no. 21 (Special Issue), p. 202, 2017.

[207] A. Berg, "Digitale Schule – vernetztes Lernen," no. November, p. 6, 2016.

[208] A. Berg, "Arbeit und Qualifizierung in der digitalen Welt," no. November, pp. 1–15, 2017.

[209] K. Lavelle, M. Lyons, and D. Smith, "Gen Z Rising," Accenture, p. 10, 2017.

[210] "Digital Factories 2020: Shaping the Future of Manufacturing," 2017.

[211] I. S. Wolfe, "6 Critical Skills for Tomorrow's Workplace," 2017. .

[212] P. Illanes, S. Lund, M. Mourshed, S. Rutherford, and M. Tyreman, "Retraining and Reskilling Workers in the Age of Automation," p. 6, 2018.

[213] ManpowerGroup, "Recruiting a Competitive Workforce: Should Needed Skills be Built or Bought?," 2016.

[214] R. Rasmus and J. Nichols, "Digital factory: Cracking the Code to Success," pp. 1–9, 2016.

[215] McKinsey & Company, "Job Lost, Jobs Gained: Workforce Transition in a Time of Automation," no. December, p. 160, 2017.

[216] ATOS, "Smart Factory," Ascent, pp. 1–16, 2014.

[217] E. Gezgin, X. Huang, P. Samal, and I. Silva, Digital Transformation: Raising supply-chain performance to new levels. 2017.

[218] K. Alicke, D. Rexhausen, and A. Seyfert, Supply Chain 4.0 in consumer goods. 2017.

[219] J. Bughin, L. LaBerge, and A. Mellbye, "The case for digital reinvention," McKinsey Q., 2017.

[220] B. Kreutzer, M. A. Meyer, and F. Puertas, "Liberating the Supply Chain Workforce," Accent. Insights, 2017.

[221] E. Hannon, M. Kuhlmann, and B. Thaidigsmann, "Developing products for a circular economy," no. November, pp. 1–4, 2016.

[222] "Mapping the Benefits of a Circular Economy," McKinsey Quarterly, pp. 1–11, 2017.

[223] Ellen MacArthur Foundation, "Growth Within: a circular economy vision for a competitive europe," Ellen MacArthur Found., p. 100, 2015.

[224] D. Bové, Anne-Titia, S. D'Herde, and Swartz, "Sustainability's Deepening Imprint," McKinsey & Company, 2017. .

[225] "Mapping Resource Prices: the Past and the Future," European Commission - DG Environment, 2012. .

[226] McKinsey & Company, "Why the Circular Economy is All About Retaining Value," no. October, pp. 1–9, 2016.

[227] "Making the Most of Corporate Social Responsibility," McKinsey & Company, 2009. .

[228] V. Ramaswamy, "Are You Ready for the Resource Revolution?," Tech. Commun., vol. 49, no. 2, pp. 162–170, 2009.

[229] UNCTAD, World Investment Report 2017 - Investment and the Digital Economy. 2017.

[230] M. Hallward-driemeier and G. Nayyar, Trouble in the Making? - The Future of Manufacturing-Led Development. World Bank Group, 2017.

[231] GOWLING WLG, "Global Protectionism," 2017.

[232] J. Furman, J. Holdren, C. Munoz, and M. Smith, "Artificial Intelligence, Automation, and the Economy," no. December, 2016.

[233] C. Darwin and R. D. Keynes, On the origin of species by means of natural selection, or, The preservation of favoured races in the struggle for life / Charles Darwin ; introduced by Richard Keynes. 2006.

[234] A. Lewis and D. McKone, "To Get More Value from Your Data, Sell It," Harvard business review, 2016. [Online]. Available: https://hbr.org/2016/10/to-get-more-value-from-your-data-sell-it.

[235] D. Parkins, "The world's most valuable resource is no longer oil, but data," The Economist, 2017. [Online]. Available: http://www.economist.com/news/leaders/21721656-data-economy-demands-new-approach-antitrust-rules-worlds-most-valuable-resource.

[236] McKinsey, "Fueling growth through data monetization," 2017.

[237] V. Turner, J. F. Gantz, D. Reinsel, and S. Minton, "The Digital Universe of Opportunities: Rich Data and Increasing Value of the Internet of Things," IDC White Paper, 2014. [Online]. Available: https://www.emc.com/leadership/digital-universe/2014iview/index.htm.

[238] Dimitrios Pavlakis (ABI Research), "IoT data exchanges , brokerage and mone za on services : the next IoT evolu on," pp. 2–4, 2018.

[239] T. G. Toca, "Data brokers," 2014.

[240] J. Holdowsky, M. Mahto, M. E. Raynor, and M. Cotteleer, "Inside the Internet of Things ( IoT )," Deloitte Univ. Press, p. 54, 2015.

[241] H. Nicolaus et al., "The age of analytics: Competing in a data-driven world," 2016.

[242] B. M. Lake, T. D. Ullman, J. B. Tenenbaum, and S. J. Gershman, "Building Machines That Learn and Think Like People," 2016.

[243] B. M. C. Beezy and S. A. Lucas, "Compliance with the eu's general data protection regulation and us discovery law," pp. 1–17, 2018.

[244] McKinsey & Company, "Big data: The next frontier for innovation, competition, and productivity," 2011.

[245] M. Najjar and W. Kettinger, "Data Monetization: Lessons from a Retailer's Journey," MIS Q. Exec., 2014.

[246] A. Lewis and D. McKone, "To Get More Value from Your Data, Sell It," Harv. Bus. Rev., 2016.

[247] D. Opresnik and M. Taisch, "Int . J . Production Economics The value of Big Data in servitization," Int. J. Prod. Econ., vol. 165, no. 4, pp. 174–184, 2015.

[248] D. J. Smith, "Power-by-the-hour : the role of technology in reshaping business strategy at Rolls-Royce Power-by-the-hour : the role of technology in reshaping business strategy at Rolls-Royce," Technol. Anal. Strateg. Manag., vol. 7325, no. September, pp. 987–1007, 2017.

[249] D. Wee, R. Kelly, J. Cattel, and M. Breunig, "Industry 4.0 - how to navigate digitization of the manufacturing sector," 2015.

[250] The Manufacturer, "Intelligent Digital is here for manufacturing," 2018.

[251] I. The Manufacturer, Barclays, Columbus, DELL, "Annual Manufacturing Report 2017," 2017.

[252] C. Raddats, T. Baines, J. Burton, V. M. Story, and J. Zolkiewski, "Motivations for servitization: the impact of product complexity," Int. J. Oper. Prod. Manag., vol. 36, no. 5, pp. 572–591, 2016.

[253] N. Dubruc, S. Peillon, and A. Farah, "The impact of servitization on corporate culture," Procedia CIRP, vol. 16, pp. 289–294, 2014.

[254] N. J. Barnett, G. Parry, M. Saad, L. B. Newnes, and Y. M. Goh, "Servitization: Is a Paradigm Shift in the Business Model and Service Enterprise Required?," Strateg. Chang., vol. 22, no. 3–4, pp. 145–156, 2013.

[255] C. Nyce, "Predictive Analytics White Paper," 2007.

[256] S. Ryu, "Book Review: Predictive Analytics: The Power to Predict Who Will Click, Buy, Lie or Die," in Healthcare Informatics Research, vol. 19, no. 1, 2013, p. 63.

[257] M. Young, D. Pollard, E. Taylor, C. Boyd, and H. Mitchell, "What businesses can learn from big data and high performance analytics in the manufacturing industry - Big Data Insight Group," 2012.

[258] Industrial Internet Consortium, "Smart Factory Applications in Discrete Manufacturing," 2017.

[259] D. Lechevalier, A. Narayanan, and S. Rachuri, "Towards a Domain - Specific Framework for Predictive Analytics in Manufacturing," 2014.

[260] markets and Markets, "Predictive Analytics Market by Type (Services, Solutions (Financial Analytics, Risk Analytics, Customer Analytics, Marketing Analytics, Sales Analytics, Web & Social Media Analytics)), Deployment, Organization, Industry Vertical - Global Forecast to 2022," 2017.

[261] KPMG, "Predictive analytics turns insight into competitive advantage for consumer brands," 2016.

[262] Vodafone, "IoT Barometer 2017/18," 2017.

[263] V. Grewal-Carr and C. Bates, "The three billion Enterprise crowdsourcing and the growing fragmentation of work," 2016.

[264] Forbes, "Crowdsourcing: Great For Your Business (A Handy Primer)," 2013. [Online]. Available: https://www.forbes.com/sites/netapp/2013/06/06/crowdsourcing-for-business/#61d62c317703.

[265] I. Borst, "Understanding Crowdsourcing Effects of Motivation and Rewards on Participation and Performance in Voluntary Online Activities," 2010.

## Sources


[266] Accenture, “People First : The Primacy of People in a Digital Age,” 2016.

[267] M. W. Van Alstyne, G. G. Parker, and S. P. Choudary, “Pipelines , Platforms , and the New Rules of Strategy y o r P os t No Pipelines , New Rules of Strategy,” 2016.

[268] “E-Platform.” [Online]. Available: http://www.sml.com/product-and-services/software-solutions/e-platform.

[269] World Economic Forum, “Digital Transformation Initiative : Unlocking B2B Platform Value,” 2017.

[270] European Commission, “Industrial platforms and large scale pilots,” 2016.

[271] M. Daugherty, Paul; Carrel-Billiard, Marc; Blitz, “Platform Economy: Technology-driven business model innovation from the outside in,” 2016.

[272] J. Manyika, S. Lund, J. Bughin, J. Woetzel, K. Stamenov, and D. Dhringra, “Digital Globalization : The New Era of Global Flows,” 2016.

[273] J. Byrne, “the Next Generation of,” 2016.

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# DIGITAL COMPANIONS IN THE FACTORY OF THE FUTURE

Digital technologies are constantly pushing us towards an ever more connected world and have a significant impact on our daily private life and business environment. Whereas we are already used to talking to our personal digital devices in the form of Siri, Alexa, or other voice and virtual assistants, our workplaces still heavily rely on non-personalized, manual processes. This is especially true for factory settings. Increasing complexity – due to individualized manufacturing – can be met with digital companion systems based on new technologies, such as Natural Language Processing and Artificial Intelligence. This opens up potentials for increased efficiency on the one hand and a more enjoyable working environment for employees on the other hand. But which technologies are best suited for digital companions? How are employees' needs best addressed? Which data is available or needed? Which use cases for digital companions offer tangible support for employees and will be accepted by them? And which digital companions can both make an impact now and sustain in future factory environments?

This report identifies current trends (political, economic, social, technological, environmental, and legal) in the field of digital companions in factory processes and derives four future scenarios as well as five related business ideas. The business ideas range from leveraging data mining for factory planning, digitally connecting current to retired maintenance experts, using NLP for increased efficiency in shift changes and feedback mechanisms, as well as using Blockchain technology for direct quality assurance.

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The Center for Digital Technology and Management (CDTM) is a joint interdisciplinary institution of education, research, and entrepreneurship of the Ludwig-Maximilians-University (LMU) and the Technical University of Munich (TUM).

Building on the strengths of two of the most prestigious universities in Germany, CDTM provides highly qualified and ambitious students with an excellent academic education in the field of emerging digital technologies. As a research institution, CDTM closely cooperates with the industry, concentrating on telecommunication, information technology, media, entertainment, health and energy sectors.

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