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Readiness of Companies in Relation to Industry 4.0 Implementation

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Abstract. First part of this paper theoretically describes the history of Industry 4.0 and its position in manufacturing companies. All four industrial revolutions are mentioned, also their impact on human society. Then the concept of Industry 4.0 is presented. Also, its characteristics and principles are mentioned here. In the next part readiness of companies in relation to Industry 4.0 implementation is analyzed. Several EU countries initiatives are described, their attitude to Industry 4.0 and successful preparation for the process, implementation and description is presented. The final part of the article summarizes all above mentioned

Keywords: Industry 4.0, Companies, Readiness, Implementation, Industrial Engineering, Initiatives, Internet of Things.

1 Four Industrial Revolutions

During its existence, humanity has undergone many important milestones in its development, including, for example, domestication of animals, which allowed people to move faster from collecting society to agriculture, bringing the appropriate food sources. As for other innovations or societal advances, human history can be considered as the origin of scripture, religion, political regimes, and ways of government, such as democracy or dictatorship, or discovery of a new world (American continent). All these steps represented only a grain of dust compared to what was yet to come [15].
The industry is an important sector of the world economy. It very quickly introduces scientific discoveries and technical inventions into production. Because Industry 4.0 is considered as fourth industry revolution, this introductory part details the historical course of each revolution. Here are listed here information on time slots and technologies that were key to each revolution, and what were the impacts on society at that time. Interestingly, the first three industrial revolutions first took place, or the world reached them, and have been named afterward. With the fourth revolution that is going on now, it's just the opposite. It can seem to have been enforced by force. This is because in the past technological changes took place sequentially. Always after a certain invention, it took many years to its influence began to manifest in the structure of factories and the labour market. Today it is different. Time is faster, thanks to

interconnectedness of the world. Changes around us happen instantly, they happen in parallel. According to [15] pace is 100 times faster than it was in the past

1.1 First Industrial Revolution

The first industrial revolution took place between the 18th and 19th centuries, and its so-called cradle was England, then the most advanced country in the world. The result was a shift from manual production to manufactories to factory machinery. The quality of the machines has been subject to increasing demands, thus developing a new field of engineering. The symbol of this first industrial revolution is referred to as a steam engine, the invention of which is attributed to James Watt. Factory production also required new energy sources, especially coal. The form of organization of production has changed completely, resulting in the emergence of a new social stratum - the workers. There has been a revolution in transport, especially the great development of rail and shipping. This facilitated free trade and, together with the emergence of large-scale factories, it can be considered as a prerequisite for market economy. Enterprises have tried to maximize profits, and labor wages have been minimal and working hours have been very long. Thanks to the workers' dissatisfaction, the workers' trade unions and, later, the workers' political parties emerged. There have been major changes in society - a drop in mortality (due to the development of science), which has led to population growth and rise of cities. People's lifestyle has also changed, education grew, part of people's life became culture. We also need to mention the changes in agriculture - progress has been made to improve agricultural machinery and to increase production.

1.2 Second Industrial Revolution

We also call the second industrial revolution a technical revolution. It is defined by the period from the 1980s to the 1930s. A characteristic feature is the use of electricity and an internal combustion engine. Industrial production in this period grew roughly threefold. There is a close interconnection of science and technology; the results of natural sciences are applied in industry. Due to the higher level of mechanization and division of labor (development of belt production), labor productivity has increased significantly. Significant progress has been made with the use of new energy sources - whether it was water-based energy, or, in particular, the energy of electric and internal combustion engines. The electric power was then used in lighting, machine drive, trams (significant development of public transport) and after the invention of the transformer also for the production of irons, washing machines, etc. Incineration engines were then used mainly to drive cars, motorcycles, motorized aircraft. There have been significant breakthroughs in the field of chemistry. As a result, new materials and materials have been developed - synthetic materials, organic compounds. A major change in industrial production was centralization and monopolization, which means pooling smaller businesses with an effort to control the market. Banking has become a major sector of the economy. Everything is accompanied by the growth of living standards, education,

and awareness of the population - the boom of newspapers and magazines, the invention of the phone, photography, and film.

1.3 Third Industrial Revolution

The Third Industrial Revolution dates back to the 1960s and is called the scientific and technological revolution because the industry is very closely associated with science, with significant advances in natural and technical sciences and research. The first changes did not start in Europe, as in the previous stages, but in the United States. The revolution in the industry is primarily driven by the development of cybernetics, a field that deals with the rules of information management in machines and self-regulating systems. Together with discoveries in electronics cybernetics is at the beginning of computer technology. The first computers were completed in the US in the 1940s, but they were very large devices, usually occupying several rooms. In the 1960s, computers were made smaller and more powerful, and in 1975, even the first personal computer was put on sale. Just improving efficiency and speeding up the operation of computers meant their great use in industrial production - especially robotizing and automating production. In the energy sector, a breakthrough occurs due to the use of the core, as nuclear power plants are characterized by high performance. Transportation has also changed - steam locomotives are replaced by electric and motorized, aircraft are able to overcome distances between different continents in a few hours, dense networks of roads and highways have been built in developed countries, and the most common means of transport is becoming a car. In the field of medicine, there have been such successes as the implementation of transplants or the eradication of certain fatal diseases due to vaccination. Since the above-mentioned 60s, there has been essentially continuous progress, with all the technologies being continually being refined, and a new invention can be made every day that will push humanity back a little further.

1.4 Fourth Industrial Revolution

Nowadays, and especially in the future, the Internet connects not only people but also machines and things. Virtual worlds are emerging to simulate the real world - we are talking about cyber-physical systems. Thanks to cyber systems, smart factories will be created where robots will take on monotonous and stereotypical activities that people have done so far. The fourth Industrial Revolution is spoken by 2011 and at least 30 years it will be discussed. This is where the term "Industry 4.0" is created [15]. Nowadays it is quite common to use internet where things, people and services are interconnected, and this is related to a generation of a huge amount of data (whether in human-human communication, machine-man-machine or machine-machine). The fourth industrial revolution, however, will not only concern industrial production but it will merge in other areas, such as the labor market, the social system, science and research, education system, legal framework, security, etc. It can be said that this is a new philosophy that brings society-wide change.

2 Characteristics of Industry 4.0 concept

Thanks to the rapid development of new technologies, a new philosophy is created that brings a whole society a change affecting a whole range of areas - from industry, through technical standardization, security, education, law, science and research, the labor market, the social system, The Industry 4.0 concept is considered to be the key to ensuring greater efficiency and flexibility for manufacturing companies in the future [8].

It becomes an integral part of human life, becoming an accelerator of production processes and with concepts such as the digital factory, internet stuff, internet services, people's internet make up the future, where engineering production and related branches will go. There are relative terms for Industry 4.0, such as "Industrial Internet" or "Digital Factory". None of these terms does provide a complete view of the situation. The Industry 4.0 concept focuses on the digitization of all physical assets and integration into the digital ecosystem, including business partners within the value chain.

Part of the Euro-American Grouping of Countries to Maintain Global Leadership in the World strategy is rapid realization of the fourth industrial revolution. This revolution would have come without these strategies, but the Euro-American group has put in place many measures for the speed of its deployment. The essence of this revolution is to achieve fully automated production, introducing a change in the way process management and revolutionary changes relate to the human resource requirements of these processes to introduce the changes and then work on them and try to develop them. The main idea of Industry 4.0 is the computer interfacing of production machines, machined products and semi-products, and other systems and subsystems of an industrial enterprise (including ERP systems, business systems, etc.) [16]. The idea of Industry 4.0 strongly supports and develops the idea of FoF (Factory-of-the-Future) which has resulted in CIM (Computer Integrated Manufacturing) generalization through computer development and communication technologies and methods of artificial intelligence.

2.1 Industry 4.0 Relies on the Following "pillars":

1. **Digitalization and integration of horizontal and vertical value chains**

Digitization and integration of vertical processes across the organization, from product development, purchasing, management, manufacturing, logistics, and services. Vertical processes will be linked with horizontal ones within corporate systems that will be a realistic time to respond to changing demand for products and services. Horizontal integration is connected with suppliers, customers, and other key partners. All data on operations and process planning can be performed in real time and use the support of expanded reality is perhaps the constant optimization of production processes.

2. **Digitization of products and services offered**

There will be so-called smart products that will be uniquely identifiable and localizable. The digitization of products is based on the expansion of existing products,

for example by adding smart sensors or communication devices that can be used with analytics data tools. Next, to create new digitized products that are targeted to a fully integrated solution. By integrating new methods to collect data and analyze data, companies are able to obtain information about the use of the product, this will not only know its history and current status but also alternative ways to improve the product to meet the growing needs of end products customers. This way, companies will put pressure on the consumer to be flexible and produce tailored products in a relatively short time. Software will help, where virtual prototyping will be possible – i.e. virtual designs not only of products but also of production means and processes.

3. Digitization of businesses and access to customers

These technologies are being used already today. Very closely this pillar is related to the Internet of Things (hereinafter referred to as IoT) and the Internet of Services (IoS). In the customer segment, for example, use Customer Relationship Management (CRM) systems that integrate social networks and data analysis, especially in e-commerce. Social networks and available information on the Internet has increased customer demand for delivery speed and product quality. Customers on social networks, among other things, evaluate company products and provide reviews. Offered services through internet marketing are very much - clothing, cars, travel, financial services, employment, electronics, etc. If companies do not catch up of this trend and do not use the opportunity to communicate with customers in this way, there is a great risk from the point of view of the relationship with the public or marketing obsolescence [4].

In order for the concept to be realized, it is necessary to realize these 3 pillars described in the previous paragraph: digitalization and horizontal integration and vertical value chains, product digitization, and services offered, and digitization businesses and customer access, with the help of smart technologies such as 3D printing, sensors, large data analysis, autonomous robots, communication infrastructure, data storage and cloud computing, virtual and expanded reality, position detection, mobile devices, advanced interface human-machine, authenticity, fraud detection, multi-level customer interactions, and profiling customers.

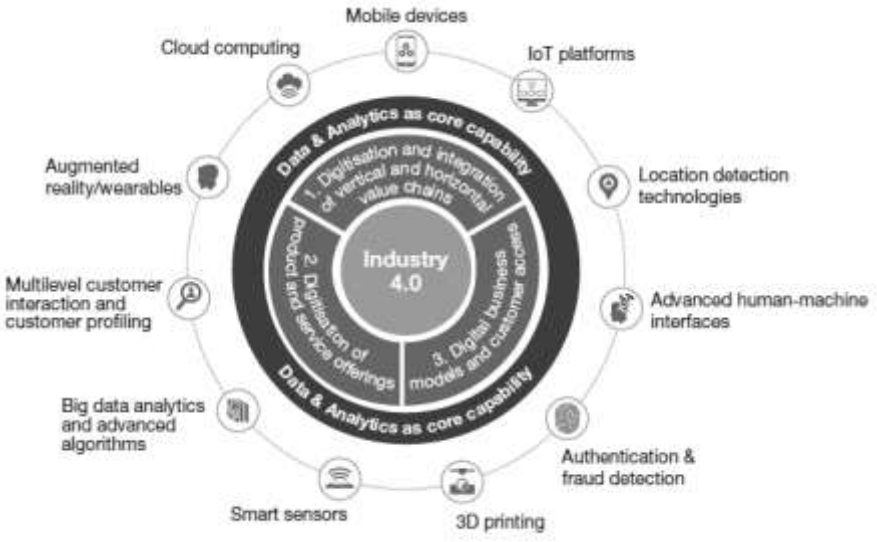

Fig. 1. Industry framework 4.0 and contributing digital technologies [4].

In other words, the transition from standalone automated units to fully integrated automated and continuously optimized production environment. A new global will emerge networks based on linking production facilities to cyber-physical systems - CPS (Cyber-Physical Systems). CPS will be the basic building block of "intelligent factories", they will capable of autonomous exchange of information, evoking the necessary actions in response to the momentary conditions and independent controls. Sensors, machines, parts and IT systems will be mutually linked within the value chain beyond the boundaries of an individual company [6]. This is why the CPSs will be mutually interconnected using standard Internet-based communication protocols to respond and analyze the data in order to predict eventual errors or faults, to configure themselves and in real time adapt to changing conditions [6].

2.2 Industry 4.0 Principles:

When building Industry 4.0, the following principles are required:

1. Interoperability = ability of CPS, people and all components of "smart factory" to communicate together through IoT and IoS.

2. Virtualization = ability to connect physical systems with virtual and simulation on the machine. Each physical unit can have its virtual interpretation in the form of an autonomous one piece of code, or model software.

3. Decentralization = decision-making and management take place autonomously and in parallel in the individual subsystems.

4. Ability to work in real time = adherence to the real time requirement is key a condition for any communication, decision making and control in real systems world.

5. Service Orientation = Preferences of Computational Philosophy offers and uses standard services, it leads to SOA (Service Oriented Architectures). Individually autonomous units call for services by other units, and this function also provides IoT and IoS.

6. Modularity and reconfigurability = P4.0 systems should be maximally modular and capable of autonomous reconfiguration based on automatic recognition of the situation. Modularity is to connect a new device to the relevant communication network components will provide information about yourself. Relevant components will record this information „and knows they can turn to this machine (for example, if another machine loses communication ability) [11]. Reconfigurability is that the system itself reconfigures itself, if any other machine is being written off (repair, disconnection).

For clarification, it is appropriate first to state what the nature of Industry 4.0 is and what it is different about from the current state of industrial production. Three industries are affected by Interpretation 4.0 interconnected factors such as Digitization and integration of manufacturing and business relationships and String, Digitization of Production and Services and New Business Models [3]. These are now activities interconnected by a number of different communication systems. In the future, it would however, should be the most progressive communication technology of Internet Things (IoT), Internet Services (IoS) and Internet people (IoP). Thanks to these technologies, all entities could all throughout life cycle to communicate with each other regardless of the borders of companies or states. All entities along the production chain will have the necessary data in real time. This can happen to bring such an advantage, for example, that machine manufacturers will be able to design their machines anymore with components that are still being developed by their manufacturers, or that they can do business predict the failure of their devices in advance. [3]

3 Readiness of a Company for Industry 4.0 Revolution

The advanced countries want to maintain their competitiveness and also expect to support new one's technology will increase the demand for specialists, i.e. professionals and hence better distribution paid positions. This should at least, as have expected, increase average wages and thus and living standards. The main reason is also their attempt to reduce the likelihood of others being mature countries will be faster in innovation [12].

A number of states are striving their industrial companies to innovate and invest in modern one's technology, so they offer, for example, accelerated depreciation or even tax holidays, all above all in order to keep their competitive ability against other countries. In Italy or France, is virtually immediate to write off two or a half times more than it was actually spent for Industry 4.0 technologies [13].

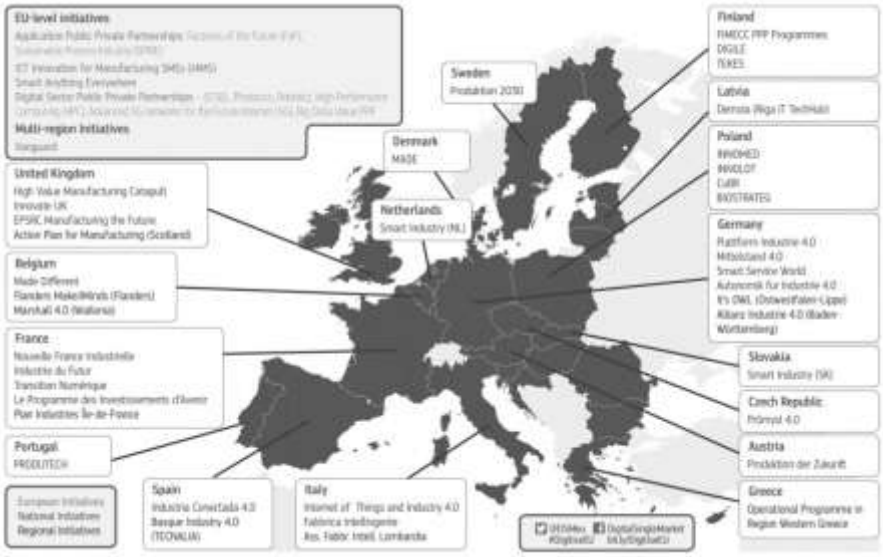

Fig. 2. Map of Industry 4.0 European initiatives.

3.1 Germany and its Initiative:

The fourth industrial revolution began in Germany. The initial vision of the Fourth Revolution was presented in 2011 at the Hanover Fair under the motto Computerization of industrial production. This document was created under the leadership prof. Henning Kagemann, prof. Wolfang Wahlster and prof. Wolf-Dieter Lukas. At the initiative of the German Government, this version was elaborated in more detail on the national strategy and also presented in 2013 at the Hanover Fair under the title Evolution from embedded systems to cybernetic-physical systems. In this document automation technologies are focused on the distributed systems in which it is calculated with methods of auto-optimization, self-configuring, self-diagnosis, machine perception and intelligent support for the labourer. In general, this document is called Industrie 4.0. Germany has spent more than 400 million euros on this initiative and is taking part in it German engineering and electro technical companies such as Siemens, Bosch or Volkswagen. The main idea of the German initiative is that the computer interconnection of production machines, machined products and semi-products, all people involved in processes and all others systems and subsystems is very beneficial to create an intelligent distributed network of heterogeneous entities along a chain that creates value in an industrial enterprise [8]. Further, it is advisable to these subsystems have been autonomously and paralleled as needed and evolved in parallel. Each physical system has a virtual copy or image in the virtual environment. By connecting the Internet of things and services have created cybernetic-physical systems, where borders are not quite clear between the real world and the virtual world. These borders can be moved as needed, so it is possible part of the system to simulate and the part is

already working realistically, it is a feature that helps to get started new production, or to help change the architecture of the production system [11].

Industry 4.0 calculates the robust inclusion of robots into industrial production, both standard intelligent manipulators, and especially full-motion autonomous robots, such as drones or trucks without drivers. Very important is the role of man as an integral one a cooperative component that cooperates in a network of autonomous units through terminal (computer, tablet...) and has the authority to initiate and stop running processes [15].

The first example of Industrie 4.0 is the Bosch pump producing factory in Hamburg, Germany. Its manufacturing, including assembly groups, carry it across the production RFID mini transponders that collect embedded information in digital form. These are active members communicate with both crates on the production belt and with transponders machining or assembly lines, warehouse manipulators and a logistics center [8]. Along the whole chain from the manufacturer to the final customer, they store additional information. Another example is the Siemens EWA plant in Amberg, which produces fully automated line of the Simatic programmable control unit. Each of these units bears in its production chip manufacturing, design, and business and user information. These the information is encoded by the optical QR code as the product collected during production and the carrier and the user are working with them [14].

3.2 Austria and its Initiative

In Austria there is an initiative "Industrie 4.0 Österreich - die Plattform für inteligente Produktion "and coordinates research projects and their funding in the Industry 4.0 area.

This initiative was founded as a platform by the following members:

- The Ministry of Transport, Innovation and Technology,
- Federal Chamber of Labor, Unions and Unions in Production.

3.3 France and its Initiative

In 2013, France also started the first phase of its Industrie du Futur project, which is also focused on the new direction of the industry using modern technology. The program was launched for 34 industrial projects [1]. The next phase of the project continued in April 2014, when the Minister for Industry and Digitization presented the program to the French general public. The French initiative focuses on a total of twelve strategic areas - the last of which were added later, being:

- new sources of energy and materials; ecomobility; future transport; future health; smart devices; digital safety; healthy eating; high-capacity drones; e-learning for schools; renewable energy sources

The strategic plan for these projects is planned until 2030 and some of the projects require a change in legislation both at national, and at European level. The main project of the initiative, as it may be seen from its name, is the so-called "factory of the future", which intervenes in all industrial sectors. French economists say the slow growth of the

French economy is mainly due to insufficient investment in modern technology, which, of course, leads to a decline in the country's competitiveness [15].

3.4 Italy and its Initiative

Italy has called its initiative to promote the development of the industrial revolution as Fabrica Intelligente, the Italian government is aware of the need to support development and research and investment in new technologies to increase the competitiveness of the country and thus creates tax incentives for companies as well as subsidy programs.

3.5 Switzerland and its Initiative

Switzerland owns the Industrie 2025 platform, like Austria. The leading figure is the president and founder, Mr. Robert Rudolph. In this respect, Switzerland remains state-owned and is convinced that it is well prepared for the fourth industrial revolution, mainly due to the good interconnection of education and industry, good contacts with other states and a sufficient number of well-trained experts.

3.6 USA and its Initiative

In USA in 2014 was founded The Industrial Internet Consortium, the five-nation multinational companies, is a platform linking the commercial, academic and government spheres to accelerate the development, adaptation and broad use of industrial Internet technologies. In addition, another broad, nonprofit platform, associating private companies, governmental, academic and research organizations, the Smart Manufacturing Leadership Coalition, was set up in 2012. It seeks to transform the industrial sector into a mutually interconnected, information-driven environment, enabling optimization of its own industrial processes and the whole value chain, increasing the productivity, innovation activity and quality of customer care. In the US, an Advanced Manufacturing Partnership 2.0 was also set up in the US, which in September 2014 defines 12 industry measures to boost innovation activity, support for education, and improve the business climate [8].

3.7 China and its Initiative

The Chinese government has also launched its own program to increase the competitiveness of its industry by making it "Made-in-China 2025". The program is largely inspired by the German industry initiative 4.0 and focuses on ten major segments, such as new advanced IT technologies, the aerospace industry, the production of automated machine tools and robots, etc. [8].

3.8 South Korea and its Initiative

South Korean government has developed its "Manufacturing Industry Innovation 3.0 "in July 2014, aiming to expand the use of modern technologies in industrial production and to support the construction of intelligent factories. Total private and public sector investment exceeds € 750 million and aims to build 10,000 new intelligent outlets by 2020 [8].

3.9 Japan and its Initiative

In Japan, in June 2015, a group of 30 Japanese companies launched an analogous initiative called the "Industrial Value Chain Initiative". It focuses primarily on the creation of technology standards for the interconnection of factories and their internationalization [8].

As we can see, different countries are “prepared“ for Industry 4.0 in different ways. It seems, that historical background of each country has played a significant role here. Countries with „engineering“ backgrounds or traditions seem to me more ready, that „agricultural“ countries. Also, preparedness depends on a lot of other factors (social, technical, economical, geopolitical) of each country.

4 Readiness of a Company for Industry 4.0 Revolution

The procedure of introduction of Industry 4.0 should correspond to the above mentioned Industry 4.0 Initiatives and its proposals for action across areas of the entire infrastructure state management. These suggestions lead to the conclusion that the focus should be on the areas in which they are at a weaker level than is appropriate to create an enabling and supportive environment introducing the idea of Industry 4.0. This is primarily about supporting science, research and innovation, that is, focusing more on funding innovation centres, the emergence of new centres with a focus on innovative technology, better interdependence with universities, support for emerging companies - start-ups, etc. Another benefit would be to inspire, for example, the German Fraunhofer Institute, which, is concerned with projects focusing on innovation and new technologies. An integral part of the aid Industry 4.0 is to spread his ideas to the wider society and also to include it into educational institute programs. It is precisely because of changes in education that there should be another Approaching the transition to Industry 4.0. These changes mean a change in methods teaching, content and extent of teaching. Consideration should be given to future developments and associated with them the fact that quite a few jobs will be lost and, on the contrary, a new one will emerge, and just that change education should also be addressed. At the same time, students are educated too narrowly focused on the given area, they should be educated in the future in a more general way and then narrow their focus later into practice. A key role is played by support for the digital economy and information and communication the technology through which the industry operates and is directly subject to these technologies.

4.1 Prediction of Industry 4.0 Further Development and Implementation

Czech Republic is not decisive in what can happen under Industry 4.0. implementation. Czech Republic can look around (what happens in others countries) and adapt appropriately to respond appropriately to Industry 4.0. To maintain competitiveness Czech Republic must be prepared as a co-operating partner able to absorb new technologies, integrate them and contribute adequately to innovation in global efforts. At the state level, it is necessary to prepare the infrastructure - high-speed broadband internet, legislation and human resources. In view of the above, it is difficult to expect further development of the implementation of Industry 4.0 elements. Every company will have a very individual process of implementing smart technologies, which are Industry 4.0. It depends on the digital maturity of the company and on the possibilities of ownership of companies.

5 Conclusions and Discussion

Previous steps must be the simultaneous creation of information documents and strategic materials that will be used to act and through which the Industry 4.0 concept will be further expanded. These are, in my opinion, some of the most important starting steps that have to be taken so that the principles of the new industrial revolution can work in practice. Of course Document Industry Initiative 4.0 contains many other terms and conditions, technological, legislative, ethical and other, which are very important for further development industry and the future functioning of society.

The great changes brought by the fourth industrial revolution cannot be hidden. World market will force the Czech industry to make fundamental technological changes, whether it will or not, another the choice is not. The starting situation of the Czech Republic is not bad, but at the moment it is necessary to spend a big piece work and efforts to keep the situation at a relatively good level. In this moment has an irreplaceable role to stand. The state must be responsible for creating a national technical infrastructure (broadband high-speed internet) and setting a suitable social environment to support the course of the Fourth Revolution, in particular by reconfiguring the education and legal system, system security support, etc.

The Fourth Industrial Revolution is not only about industrial production. The company is undergoing a change that is caused by the interconnection of three worlds: the physical world, the virtual world the world and the social world. Industry 4.0 ideas make a completely different picture of the company's life. For this reason, the name "Industry 4.0" is misleading. At first glance it may be wrong understood. Therefore, it might be more accurate to talk about Society 4.0.

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