OUTPUT 1

A research on innovative skills and best practices to enhance HE students employability, flexibility and transversal capabilities and develop effective digital workbased approaches

2022

Digital Transformation, Industry 4.0 and Human Resources Management: Innovative skills to enhance HE students' employability, flexibility and transversal capabilities

Ref. No. 2021-1-PL01-KA220-HED-000032182

Co-funded by the European Union

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INTRODUCTION

The Industry 4.0 concept is a highly topical issue, especially in the context of digitization and the use of ICT. *From the point of view of the project, it is necessary to monitor developments on how the content of work in new jobs is changing and how new knowledge is implemented in the curriculum in relation to the use of new technologies, digitization of business processes and public administration processes, as well as monitoring and evaluating possible impacts of the Industry 4.0 concept on increasing employability. It is clear that the results of the research will bring a number of factors that will affect the orientation and depth of the subsequent activities and outputs of the DigiWorks project. In this way, the project will create an educational platform with current topics for education in the field of digitization and Industry 4.0, on the basis of which the graduates of this course will become immediately applicable in practice.*

1 TO DIGITAL TRANSFORMATION AND INDUSTRY 4.0

1.1 FROM THE 1ST INDUSTRIAL REVOLUTION TO INDUSTRY 4.0

The term "Industrial Revolution" is explained as a technical progress that fundamentally changed the way of production as it was in the past. The industrial revolution brings new technologies that change the way people work and live. The changes of technological shifts that brought industrial revolutions are shown in fig. 1.

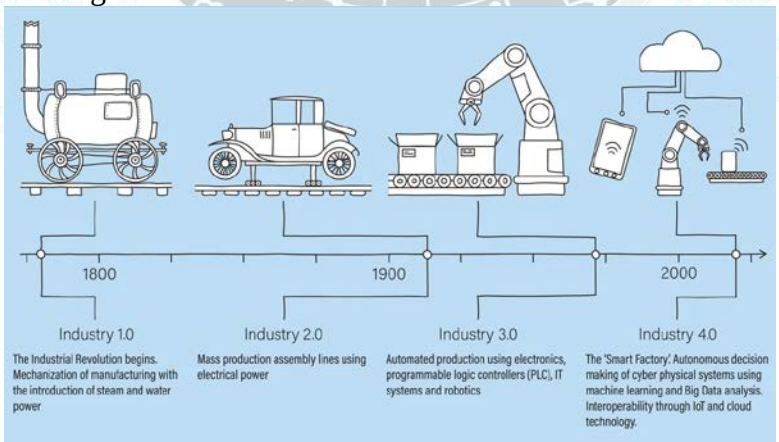

Fig. 1 Changes brought about by industrial revolutions

Over time, industrial revolutions generated more job opportunities, increased efficiency, and in many ways served to make people's lives easier in the long term.

The first industrial revolution

Before the first industrial revolution, most of the labor force was employed in agriculture, either as self-employed peasants as landowners or tenants, or as landless farm labourers.

The first industrial revolution was characterized by the transition from manual production methods to production with the help of machines using steam and water power. The introduction of new technologies took a long time. Its effects had consequences on textile production, which was the first to adopt these changes, as well as on the iron industry, agriculture and mining. The first industrial revolution began in England in the 18th century, more precisely from 1784, when Edmund Cartwright invented the first mechanical weaving machine. which then spread to Western Europe and later to North America. England was ahead of the rest of the world by half a century. It became the decisive power of the so-called "workshop of the world".

Thanks to the invention of steam engines, production was transformed into mechanized production. Mechanization was the reason why agriculture began to be replaced by industry as the backbone of the social economy. The impact of the industrial revolution on society was enormous, fundamentally changing all branches of the economy. This upheaval was comparable in meaning to the Neolithic revolution, which marked the transformation of society from hunters and gatherers to farmers. This was connected with the establishment of settlements, a complete change in lifestyle and the emergence of private property.

However, the old sources of energy were no longer sufficient for the mass use of new inventions in factories. Until then, the main source - the water wheel - was too dependent on the external environment. In the search for new sources of energy, the most successful designer was James Watt, Fig. 2, who In 1784 he created an improved steam engine - a machine working on the principle of compressed steam, which became a symbol of the industrial revolution and gave its name to the next, 19th century - the "century of steam". However, the first successful steam engine was first introduced in 1712 by Thomas Newcomen.

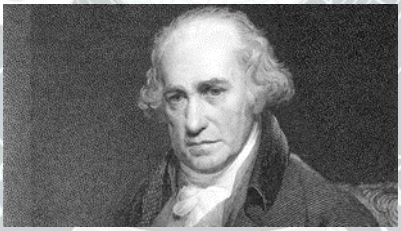

Fig. 2 James Watt, inventor of the steam engine

The use of steam energy for industrial purposes was the biggest breakthrough for increasing human productivity. Instead of weaving looms powered by the physical power of man, steam engines could be used for propulsion. For the first time in history, machines replaced human labor in one branch of human activity.

The development of the steamboat and the steam locomotive brought further massive changes as people and goods could be moved over long distances in fewer hours. At this time, new sources of energy began to be used en masse, primarily coal (or steam), which is why the steam engine is also a traditional symbol of the first industrial revolution. The key concept of this period is mechanization, fig.3.

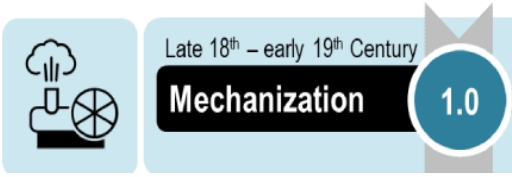

Fig. 3 Symbol of the 1st industrial revolution

However, iron was needed for the production of the steam engine and other useful inventions. However, this great demand required an improvement in the technological procedure for processing iron ore, as well as a fuel that could replace charcoal in blast furnaces, which was already in short supply in England at the end of the 17th century. The problem was solved by 1709 Abraham Darby, who started using coke instead of charcoal to smelt iron. Simplification and cheaper production of hardened iron - steel, however, took a long time to come.

The second industrial revolution

The second industrial revolution follows on from the first industrial revolution, i.e. that dates from the middle of the 19th century. The second industrial revolution occurred in the USA. The innovative technology was electric energy. It happened in the period 1850 - 1870, until the first half of the 20th century. In this new industrial revolution, some of the most important and biggest changes occurred in terms of technology and science. Innovative technologies were basically based on the latest sources of energy, such as fossil fuels, the use of new materials to improve machinery (such as iron), and new transport and communication systems (railroads and steamships). All these developments brought about changes regarding work, education, science and human consumption, which brought about the concept of mass production. Icons of this method such as Henry Ford,
However, it is mostly associated with the year 1870, when the Cincinnati company installed the first assembly line in its plant and started with the division of labor, later electrified, which brought further rapid development of mass production, which became a symbol of the 2nd industrial revolution fig.4.

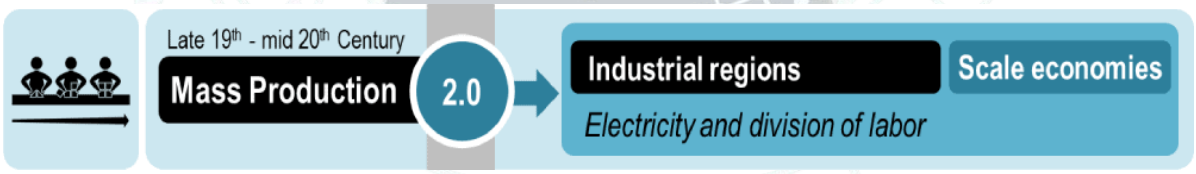

Fig. 4 Symbol of the 2nd industrial revolution

This revolution was focused on an economic and industrial model based on new large factories. Industries were driven by new organizational models of production, proposed by the American mechanical engineer Frederick Winslow Taylor and the American business magnate Henry Ford.
The pioneer of mass production methods, Frederick W. Taylor, in 1881 at the Midvale Steel Company in the United States began to study the organization of production operations, on the basis of which they subsequently created the basis of modern production planning. Henry Ford (1863 – 1947), fig.5 introduced the principles of mass production into automobile production and fundamentally changed it. Previously, the entire car production process was produced in one place,

now vehicles are produced in partial steps on conveyor belts. Production was significantly faster and at lower costs.

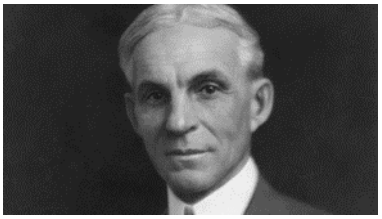

Fig. 5 Henry Ford. (born July 30, 1863, Wayne county, *Michigan*, US—died April 7, 1947, Dearborn, Michigan), American industrialist who revolutionized factory production with his assembly-line methods.

Henry Ford built his first car in 1896. The solution developed by the Ford Motor Company was a production line with machine tools and single-purpose machines that were systematically placed according to the work sequence. The whole process is called mass production. It was the first time in history that a large and complex product consisting of 5,000 parts in the hundreds of thousands per year was produced. Savings from mass production methods allowed the price of the Model T, Fig.6 to drop from $780 in 1910 to $360 in 1916. By 1924, 2 million T-Fords were produced and sold for $290.

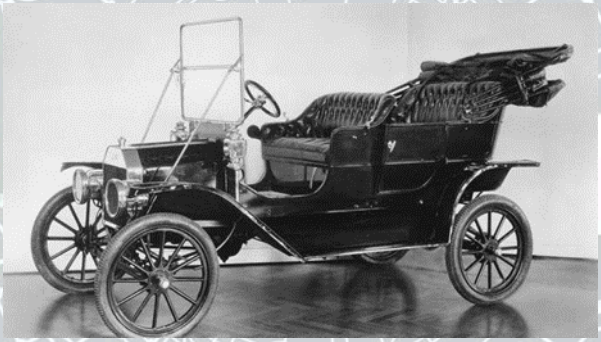

Fig. 6 The 1909 Model T.

Thus, the main driving force behind the second industrial revolution was the introduction of electricity and assembly lines in the automobile industry. The industrial sector accelerated exponentially as each employee concentrated on only one work activity. The application of the principle of mass production on assembly lines, which was able to increase production with higher coordination between work, tasks, processes and machines. Electrification also played an important role in supporting the emergence of modern telecommunications systems such as telegraphs, radios, telephones, and later televisions. Electrification has been called "the most important technical achievement of the 20th century."

The third industrial revolution

The third industrial revolution began in the 1950s and was significantly influenced by the development of semiconductors, personal computers (70s and 80s), computer networks (WLAN, LAN, MAN...), robots and the apparent birth of the Internet. It is referred to as the period of automation, Fig. 7.

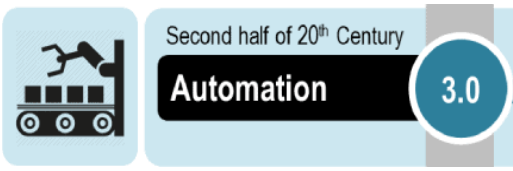

Fig. 7 Symbol of the 3rd industrial revolution

The most important change was the introductioncomputers, which enabled perfect production control. Production costs on lines modified in this way fell sharply. It was no longer necessary to produce large quantities of the same products for such a long time, for example the T-type Ford, because changing the product was no longer so expensive, and the quality of relatively cheap goods rose sharply. Computer technology has also led to faster and cheaper communication. The result was the emergence of global markets. It was easier for more and more countries to acquire new technology, investments could flow more easily to the most dynamic emerging economies.
In the industrial world, two major inventions, programmable logic controllers (PLCs) and robots, helped usher in the era of high-level automation. Indusry 3.0 introduces widespread automation of assembly lines to perform tasks with PLCs that were previously performed by humans. The year 1969 is most often cited as its beginning, when the first programmable logic automaton was produced. It is therefore a small industrial computer, a control unit, for real-time process automation. It is characteristic for PLC that the program is executed in the so-called cycles. Since the introduction of these technologies, we are able to automate the entire production process without human intervention, which has been replaced by robots. Robotics enables the humanization of human work, frees people from stressful and stereotypical activities, and also significantly increases work safety.
The term "robot" was first used in the play RUR published by the Czech Karel Čapek in 1921. RUR (Rossum's Universal Robots) was a satire, robots were made of biological beings that did all the unpleasant manual work. The game RUR replaced the popular use of the word "slot machine".
In 1941 and 1942, Isaac Asimov formulated the three laws of robotics and in the process coined the word "robotics".
Laws of Robotics by Isaac Asimov:
The robot must not harm a person or allow him to be harmed by his inaction.
A robot must obey a human, except when it conflicts with the first law.
The robot must protect itself from harm, except when it is contrary to the first or second law.
The history of industrial robotics is usually set in the 1950s, when Georg Devol proposed the "Programmable Article Transfer". Such a device was the basis for the development of the Unimate robot, which is considered the first "true" industrial robot in history. In 1954, Devol met the aerospace engineer Joseph Engelberger, fig. 8, and agreed to start a company that could produce robots for industrial applications. This led to the founding of a company called Unimaton, which produced the first Unimate robot in 1961, fig. 9.

Fig. 8 George Devol and Joseph Engelberger Fig.9 Unimate, the grandfather of industrial robots

The latest developments in robotics have led to robots capable of cooperating with humans, to cobots.
Cobots were invented in 1996 by J. Edward Colgate and Michael Peshkin, professors at Northwestern University. A 1997 US patent filing describes cobots as "a device and method for direct physical interaction between a person and a general-purpose computer-controlled manipulator." fig. 10.

Fig. 9 Cobots

At the beginning of the 20th century, the term humanoid robot was developed. Today, we can imagine human-sized robots that are capable of thinking and moving almost like a human.
The third industrial revolution focused on the development of digital technologies. The third industrial revolution brought a transition between analog and digital concepts; integrated circuits were invented to help reduce manufacturing costs. The use of communication technology and informatics is essential, enabling assisted computer use, the use of fiber optics, telecommunications, studies in genetics and the development of lasers.

Industry 4

The first industrial revolution used steam to mechanize production. The other has already used electricity and strip production to create mass production. The third has already applied electronics and information technology for production automation, including with the help of robots. Now the fourth industrial revolution is coming, based on the third and we can call it the digital revolution, fig. 11. It is characterized by the merging of technologies that blur the boundaries between the physical, digital and biological realms.

Fig. 10 Industry 4 concept

The fourth industrial revolution is the era of networks. Industry 4.0 takes the digital technologies of the past decades to a whole new level with interconnection through the Internet of Things, access to real-time data and the introduction of cyber-physical systems, fig. 12. Industry 4.0 offers a more complex, interconnected and holistic approach to production. It connects physical systems with digital ones and enables better collaboration and access between manufacturers, suppliers, products and people. Industry 4.0 enables companies to better control and understand all aspects of their operations and enables them to use real-time data to increase productivity, improve processes and drive growth. "Industry 4.0 is a label for the current digitization trend, the related automation of production and the changes in the labor market that it will bring.

Fig. 11 Symbol Industry 4

The term "Industry 4.0", abbreviated to I4.0 or simply I4, arose in 2011 from a project in the field of high-tech strategy of the German government, which supports the automation of production. The concept of "Industry 4.0" was publicly introduced in the same year at the Hanover Fair. Industry 4.0 is an information-intensive transformation of production (and related industries) in an interconnected environment of new technologies and big data, people, processes, services, systems and industrial assets with the support of the Internet of Things with the generation and use of actionable data and information as a way and means of realization smart industry and ecosystems of industrial innovation and cooperation. Technology really plays a key role, fig. 13: Internet of Things, Big Data, Simulation, Additive manufacturing, Cloud Computing, Augmented Reality, Autonomous Robots, Cybersecurity.

Fig. 12 Technological pillars Industry no

Principles of Industry 4.0

lndustry 4.0 contains eight design principles. These principles support companies in identifying and implementing Industry 4.0 scenarios.

1. **Interoperability:** Objects, machines and people must be able to communicate through the Internet of Things and the Internet of People. This is the most important principle that really makes the factory smart. This ability to connect everything in a company, everywhere and with everyone is essential to use the insights provided by data to increase efficiency and improve processes.
2. **Virtualization:**The ability to create a virtual view of operations or virtual copies of everything to see how new equipment or processes will affect operations. Digital twins or 3D models are used to optimize machine performance, allowing what-if scenarios to be run and the impact of new equipment to be tested.
3. **Decentralization:**The ability of cyber-physical systems to make decisions independently and perform their tasks as autonomously as possible. This creates a more flexible environment for production. In case of failure or conflict of objectives, the problem is delegated to a higher level.
4. **Real-time monitoring:**A smart factory must be able to collect data in real time, store or analyze it and make decisions based on new findings.
5. **Service orientation:** Production must be focused on the customer. People and smart objects/devices must be able to connect efficiently through the Internet of Services to create products based on customer specifications. This is where internet services become essential.
6. **Modularity:** In a dynamic market, the ability of a Smart Factory to adapt to a new market is essential.
7. **Transparency of information-** the transparency provided by Industry 4.0 technology provides operators with comprehensive information to make decisions. Interconnectivity enables operators to gather vast amounts of data and information from all points in the manufacturing process and identify key areas that can benefit from improvement to increase functionality.
8. **Technical assistance**- technological devices of systems help people in decision-making and problem-solving and have the ability to help people in solving complex or dangerous tasks.

9. **The key goal of Industry 4.0** is to be faster and increase production efficiency. The main technology used in the context of Industry 4.0 is Cyber-Physical Systems (CPS). CPS is considered a key enabling technology in the fourth industrial revolution.

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1.2 IMPACT OF COVID-19 ON INDUSTRY 4

Businesses and service firms are facing enormous challenges due to the development of the technology of the 4th industrial revolution, as well as the changing market caused by the Covid-19 pandemic. The spread of the COVID-19 virus has revolutionized the way customers and suppliers work, coordinate and interact. In some cases, this change has not been painless, especially when

there is a lot of rigidity and resistance to change.
Before the crisis, Industry 4.0 was an area of great interest for many manufacturers. It was an exciting topic with huge potential benefits and was generally seen as a 'positive' and forward-thinking topic.

The impact of Covid 19 on the implementation of Industry 4

The COVID-19 pandemic hit manufacturing companies and required adjustments to entire operations. The aim of this chapter is to highlight the main impacts of the COVID-19 pandemic on the manufacturing sector from the perspective of operational management, practical adaptation measures and future research opportunities.
The aim is to answer the following questions:
• What are the main effects of the COVID-19 pandemic on production?
• What measures have been taken to mitigate the effects of the COVID-19 pandemic?
• What are the main future research directions?
On the one hand, the spread of the corona virus has caused enormous obstacles for organizations; on the other hand, it presented opportunities for companies to recognize business model innovations in order to ensure business continuity or even survival. Unsurprisingly, in the unique circumstances of the pandemic, operational agility and flexibility emerged as the highest strategic priorities over increasing productivity and minimizing costs, which were often the primary goals. Likewise, technologies that enable remote work and collaboration have topped the list of priority Industry 4.0 use cases. The global supply chain has begun to experience changes that have never been seen before. Some manufacturers have stopped production completely, some have seen a significant decrease in demand, and others have seen a huge increase in demand.
The shock of the outbreak of the COVID-19 virus has forced local governments to implement strict measures to prevent further dangerous spread of the disease. These measures led companies to respond quickly and strategically to unexpected challenges. These restrictions not only affected production and marketing in local areas, but also led to factory closures and material shortages due to global disruptions in the distribution of goods. By the end of March 2020, almost the entire world had imposed radical lockdown measures, banning non-essential travel and ordering the closure of all non-essential businesses, while also shutting down schools and universities. As a result, there was a significant drop in production and employment. In particular, small and medium-sized enterprises (SMEs) experienced immediate adverse effects due to logistical problems,
The need to implement social distancing has led governments to consider the need for remote work for manufacturing businesses. These practices have expanded to limit contagion and have drastically affected consumer behavior in terms of consumption trends. Physical distancing and face masks have affected efficiency in some workplaces. These measures have required the establishment of work-from-home options, remodeling of offices and production spaces, and access to appropriate remote work technology and video conferencing tools, with social distancing and remote work continuing after the pandemic is over.
The COVID-19 pandemic boosted the structural changes that were already underway, especially to online services. This forced transition to online sales has required many manufacturing companies to reassess their inventory plans to ensure adequate inventory coverage for customers. The main measures implemented by manufacturing companies and future opportunities to mitigate the impact of the COVID-19 pandemic on production are shown in Fig. 1.

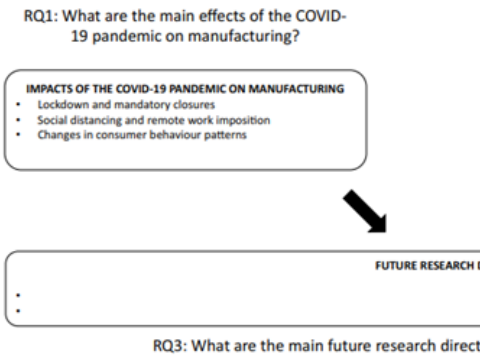

Fig. 13 Reference model – Actions and future opportunities to mitigate the effects of the COVID-19 pandemic on manufacturing companies

ICTs such as e-mail, video conferencing and cloud file management have made it possible for employees in many industries to do their work remotely. The transition to telecommuting generally went smoothly. Therefore, the feasibility of telecommuting has been confirmed in various industries and is generally seen as a potentially viable path in the future. Digital technologies such as cloud computing, the Internet of Things (IoT) and big data analytics can better enable remote and autonomous work. Likewise, adoption of visualization technology can assist in performing operations where face-to-face contact is not possible due to limitations.

Digital transformation has proven to be the key to moving up the value-added curve. Indeed, business models firmly based on digital technologies clearly indicate an opportunity to increase the flexibility of working time organization and create a competitive advantage for long-term growth in the so-called new normal. Similarly, servitization, the transition from a product-oriented business logic to a service-oriented business logic, is proving to be a justified and beneficial new activity.

Covid 19 accelerated Industry 4 processes by making companies more focused on implementing new technologies and choosing investments in information and operational technologies that will enable and help organizations solve problems and inefficiencies. The coronavirus pandemic has therefore highlighted the global shortcomings and weaknesses of automation and digitization in production.

Future research directions should certainly be oriented towards understanding how the skill set of employees must be configured to cope with strong external shocks and react quickly to better face the changed context.

Voice-over-Internet-Protocol (VoIP) software such as Zoom, Microsoft Teams and Google Meet have quickly become common tools for organizing business meetings and online classrooms, while e-commerce and home delivery supported by information and communication technologies (ICT) , increased in popularity.

The impact of Covid 19 on the educational processes of universities

In addition to 21st century skills, the development of the fourth industrial revolution, characterized by exponential technologies such as artificial intelligence, automation, bioengineering and others, has brought many challenges to teaching and learning in higher education. This has enabled universities to largely prepare students with the skills and competencies to adapt to the rapidly changing labor market and society in general. In addition to legislation, the trends in the digitalization of education were also helped to accelerate by the COVID-19 pandemic, with the creation of several portals aimed at making digital educational content available. Several teaching staff of schools as well as pupils had to learn to work with online education tools.

The main focus of this chapter is to examine how the COVID-19 pandemic has affected the development and management of higher education from the perspective of three key subthemes:

- student mobility,
- teaching and education of students a
- university management,

in order to understand and implement the knowledge gained in the project as well as to derive project recommendations for the future development of higher education.

The current global health crisis has opened up new opportunities for university teachers and leaders to explore innovative ways of teaching and student learning, moving beyond conventional models to develop new forms of inter-university collaboration.

Disruptions to regular education ranged from no school closures in a few countries to more than a year of closures in many countries. Lack of connectivity and equipment prevented at least a third of students from studying remotely. In addition to causing major disruptions to teaching, learning and research, the COVID-19 pandemic has also adversely affected many internationalization activities of universities, especially in terms of student and staff mobility. International student mobility is severely affected by these impacts, particularly due to the closure of many university campuses as well as restrictions on international travel. One immediate response was a large increase in interest and activity related to Virtual Student Mobility (VSM). VSM is the use of information and communication technologies (ICT) to create cross-border cooperation, which improves intercultural understanding and knowledge exchange. These activities can take place in a fully ICT supported environment and/or as a supplement to physical mobility.

The crisis has also disrupted research activities due to restrictions on the international mobility of researchers, resulting in barriers to research collaboration, the closure of laboratories and the transition to remote collaboration. The situation of researchers at the beginning of their career who were late in their projects was also critical.

Given that the situation was completely new, there was overall great interest in the exchange of experience, which, according to the institutions' plans, will continue in the future. One of the nagging concerns about online learning is whether the method is effective, especially when compared to in-person classes. For students who have access to digital devices and internet infrastructure, the rise of digital learning platforms provides an easy way out during the pandemic. This fortunate group of students can continue their education regardless of the growing challenges brought by COVID-19. That is why governments around the world have made great efforts to ensure access to education during the pandemic.

It has been shown that knowledge acquisition cannot be fully achieved through a transmissive approach alone, but through a participatory model with a strong collaborative knowledge creation process.

It is obvious that the pandemic has inevitably affected physical and mental well-being, and many negative factors such as reduced self-discipline, lack of personal contact and also eye strain have evidently manifested themselves. To address issues of student well-being in the context of the COVID-19 pandemic, universities should do more to help students improve their psychological well-being.

Today, despite the Omicron variant, schools are open in most countries thanks to the implementation of health protocols and vaccination programs. The implications for learning are

significant. It is therefore essential to make education a priority public good to avoid a generational catastrophe and enable a sustainable recovery.

However, conventional learning through face-to-face instruction is more effective in improving students' communication and interpersonal skills. In addition, face-to-face interactions in conventional classrooms offer immediate feedback from peers and instructors, which also promotes motivation to learn. Disciplines that require laboratory work, practical experience and external collaboration were more difficult to teach at a distance. In distance learning, students need to become highly independent and autonomous and able to self-monitor and maintain high motivation in order to progress at home.

In conclusion, when dealing with online education, university management must find a blended way of delivering education to improve teaching and learning. It turns out that there is no other option than to look for multiple methods to merge online teaching and on-site learning, along with other forms of educational activities, to enrich the learning experience of students and encourage students' intellectual thinking. Disciplines that require laboratory work, practical experience and external collaboration were more difficult to teach at a distance.

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1.3 WHAT WILL BE THE 5TH INDUSTRIAL REVOLUTION?

Ready or not, Industry 5.0 is here. While many manufacturers are still busy developing methods to connect new technologies to improve efficiency and productivity – a guiding principle of Industry 4.0 – the next phase of industrialization has already begun.
This part of the report draws attention to the trend towards the fifth industrial revolution (5IR) and highlights its potential due to the merging of digital, physical and biological technologies that promise to increase the well-being of society in all directions. The graphic presentation is shown in fig. 1. It further sets out a road map of how development is likely to progress and offers a set of key research questions that will emerge as a result in the near future. According to the consensus in this research, consumers, employees, and companies together will soon realize a future in which "people and machines work synergistically." This harmonious acceptance of human-machine collaboration distinguishes 5IR from the Fourth Industrial Revolution (4IR), which focuses primarily on achieving efficiency using technology.

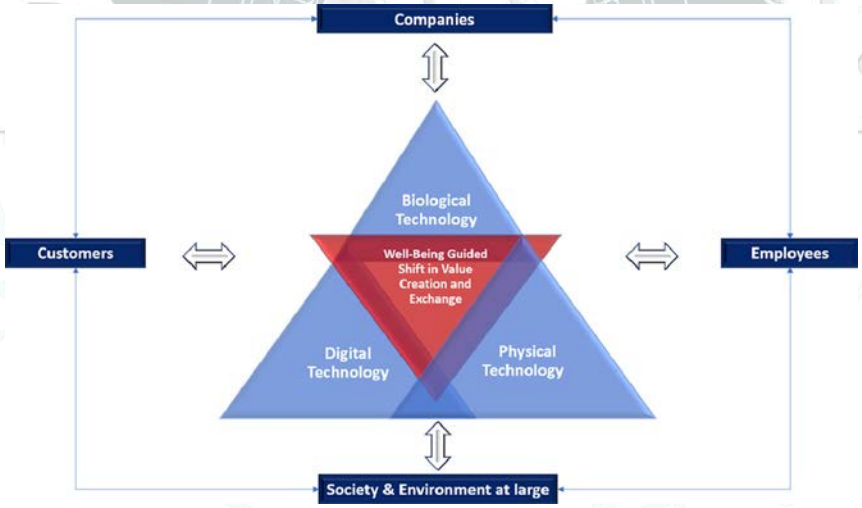

Fig. 14 Graphic presentation of the combined technologies of the 5 industrial revolution

Industry 5 in production

More than ten years have passed since talk of Industry 4.0 first appeared in manufacturing circles, but visionaries are already predicting the next revolution — Industry 5.0. If the current revolution emphasizes the transformation of factories into intelligent, IoT-enabled devices that use cognitive computing and connectivity through cloud servers, Industry 5.0 is supposed to focus on the return of human hands and minds to the industrial framework. Industry 5.0 is a revolution in which man

and machine harmonize and find ways to work together to improve the means and efficiency of production.

Industry 5.0 is the next step in the development of production. To understand the full picture of Industry 5.0 and its implications, we must first understand how the initiative is defined, Tab. 1.

Tab. 1

1st Industrial Revolution	2nd Industrial Revolution	3rd Industrial Revolution	4th Industrial Revolution	5th Industrial Revolution
Mechanisation	Electrification	Automation and Globalisation	Digitalisation	Personalisation
Occurred during the 18th and 18th centuries, mainly in Europe and North America	From the late 1800s to the start of the First World War	The digital revolution occurred around the 1980s	Start of the 21st century	2nd decade of the 21st century
Steam engines replacing horse and human power	Production of steel, electricity and combustion engines.	Computers, digitisation and the internet,	AI, robotics, IoT, blockchain and crypto.	Innovation purpose and inclusivity.
Introduction of mechanical production facilities driven by water and steam power	Division of labour and mass production, enabled by electricity.	Automation of production through electronic and IT systems	Robotics, artificial intelligence, augmented reality, virtual reality	Deep, multi-level cooperation between people and machines. Consciousness.

Within each revolution, there were changes in where people lived, what work they did, how people moved from place to place, and who developed wealth. The term Industry 5.0 refers to people working alongside robots and intelligent machines. These are robots that help people work better and faster by using advanced technologies such as the Internet of Things (IoT) and big data. To the technological pillars of Industry 4.0 is added the personal participation of people with their cognitive properties. The pairing of people and machines opens the door to countless opportunities in manufacturing.

To be ready for Industry 5.0 and its impacts, there are three key elements of the initiative that we need to understand:

1. Industry 5.0 is aimed at supporting – not replacing – people. Don't mistake the rise of robotics as an opportunity to eliminate headcount and replace workers who perform repetitive tasks on assembly lines.

2. Industry 5.0 is about finding the optimal balance between efficiency and productivity. The goal of Industry 4.0 is to connect machines, processes and systems for maximum performance optimization. Industry 5.0 takes such efficiency and productivity one step further. It is about improving cooperative interactions between humans and machines.

3. The expansion of robotic automation is essential. A European Union (EU) advisory body has acknowledged that Europe is lagging behind the United States and China in advanced technologies such as artificial intelligence (AI) and has called for accelerating the development of AI and robotics in the region. "The EU should fully embrace digitization for the sake of consumers, producers and employees alike,"

The fifth generation industry brings customer satisfaction and opens up a new market. IR 5.0 will feature collaboration between machines and humans with the ultimate goal of providing additional value to manufacturing by creating customized products capable of satisfying consumer demands. IR 5.0 focuses on humans working with machines. IR 5.0 will combine the precision and pace of industrial automation through the critical thinking of human workers. Thus, technology does not replace people, but improves their role in production. In Industry 5.0, collaborative systems (cobots) will be responsible for routine tasks such as drilling or data mining, while employees will take on higher-level tasks. They will manage and oversee such systems and then make real-time decisions and look for opportunities to improve quality and production processes. As a result, employees get more meaningful, useful and valuable jobs. IR 5.0 is expected to renew the push for more technologically advanced human-machine interfaces. This will improve integration, enabling faster and better automation coupled with the power of human intelligence. In addition, this shift, which combines the best of both human and machine, will also lead to increased efficiency. The idea of people and machines working together can be achieved by dividing the production line into two parts: a) Using people to adapt and think creatively. b) Using robots for monotonous and strenuous work. thus enabling faster and better automation combined with the power of human intelligence. In addition, this shift, which combines the best of both human and machine, will also lead to increased efficiency. The idea of people and machines working together can be achieved by dividing the production line into two parts: a) Using people to adapt and think creatively. b) Using robots for monotonous and strenuous work. thus enabling faster and better automation combined with the power of human intelligence. In addition, this shift, which combines the best of both human and machine, will also lead to increased efficiency. The idea of people and machines working together can be achieved by dividing the production line into two parts: a) Using people to adapt and think creatively. b) Using robots for monotonous and strenuous work.
Production workers can rest easy, automated systems will not replace them. At least for now. The most visible result is that IR5.0 provides collaboration between workers as well as automation, there will be no replacement of workers. It's about applying technology to accelerate human performance, freeing up workers to spend more time on valuable tasks like strategic planning. Professionals with critical thinking skills will be in demand. IR 5.0 uses cobots (collaborative robots) to achieve collaboration in the workspace. IR 5.0 also creates new production positions such as Chief Robotics

Officer (CRO). Such a position will require an expert who specializes in the interface between man and machine and will be responsible for all things related to technology.

In IR 5.0, everyday products will sense the needs of the end user and respond to them through their intelligence. With fast connectivity, IR 5.0 products will be able to increase their efficiency and provide the highest efficiency available throughout the product's lifetime. IR 5.0 is the next phase of industrialization that will return labor to factories, build intelligent supply chains, distributed manufacturing, as well as hyper customization. All designed to deliver a customer experience time and time again, Fig.15.

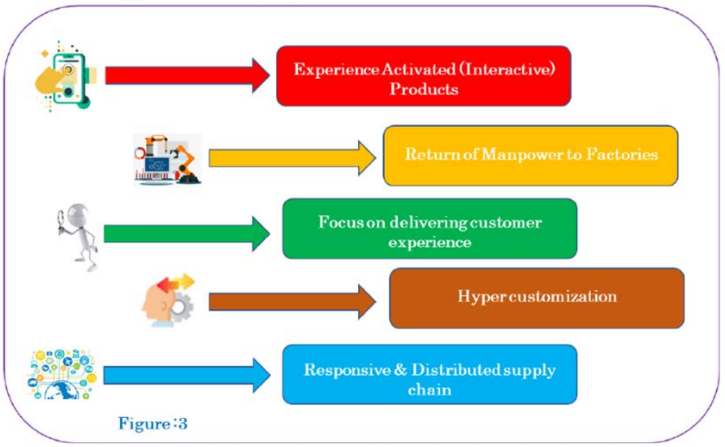

Fig. 15 Highlights of Industry 5

Universities and Industry 5

What changes does IR 5 cause in higher education? This year saw an acceleration in online learning, personalized learning and the use of AI in education and service interactions. There is also a growing debate about the value of full qualifications in relation to costs (ie return on investment in qualifications).

It highlights that several major companies are moving away from hiring people based on degrees as a job requirement. For specific requirements to acquire the required knowledge and skills, the number of short-term courses, interest courses and tutorials available online has increased.

It is emphasized that education is increasingly becoming "learning at the right time the required knowledge" and not "just in case". Learning seems to be more about what you need to know at a particular time, which is most often applied today, than about building knowledge that may never be needed. So the educational models of universities must now reflect the demand for lifelong learning to cope with the technological and social changes already brought about by the 4th industrial revolution and meet the needs of people in the 5th industrial revolution. There is a shift towards a design mindset instead of a production mindset.

Shifting approaches to education for IR5, universities should aim to:

- The need to continuously learn and update students' skills to make them relevant in the long term.
- Re-evaluating the expertise provided (ie re-evaluating how long the given expertise is relevant)
- Reassessing the methods of teaching and training so that students become competent

- Changes in approach, what the student should remember and what to "know"
- To teach students to navigate in a large amount of information and evaluate the quality and accuracy of this information
- Prepare for anxiety when networks or resources go down because it means you can't access your online library or resources
- To teach students to work with information in real time and online processing
- Innovate education and qualifications so that they are reflected in a specific career and income.

This new era will allow people to take advantage of the technological achievements of Industry 4.0, which was focused on automation, artificial intelligence, big data and the Internet of Things, and transform them into human-centered solutions in a wide range. Industry 5.0 is about moving forward to a more sustainable hybrid model that synthesizes the strengths between machine intelligence and human intelligence. Critical analysis will become even more important as our workplace merges with the incredible power of AI, cobots and big data.

The shift from current education methods to methods that are ready to adapt students to the upcoming changes brought about by the 5th industrial revolution is becoming more and more important as time goes on. Although we cannot deny that the need for the evolution of education is global, we cannot face it as a single system that evolves equally everywhere. Given this, we still have a long way to go to achieve this goal on a global scale. The rapid digital advent has required improved skills for workers in all sectors – from those working remotely or on the front lines to teachers and school administrators. Digital skills remain a key priority for the future to ensure that no groups are left behind in the transition to IR5 with a digital economy.

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1.4 EUROPEAN UNION DIGITAL TRANSFORMATION OVERVIEW

The state of digitization in the European Union is compiled on the basis of Eurostat information sources and the Digital Economy and Society Index. The Digital Economy and Society Index (DESI) is a composite index that **measures the progress made by EU Member States towards the digital economy and society**, summarizes relevant indicators of Europe's digital performance and monitors the evolution of EU Member States' digital competitiveness.
DESI consists of five main policy areas, Fig. 16:

1 Connectivity	Fixed broadband take-up, fixed broadband coverage, mobile broadband and broadband prices
2 Human capital	Internet user skills and advanced skills
3 Use of internet	Citizens' use of internet services and online transactions
4 Integration of digital technology	Business digitisation and e-commerce
5 Digital public services	e-Government

Fig. 16 Five indicators of Europe's digital performance

The state according to DESI 2021 in the digital economy and society is mainly based on data from 2020, fig. 17.

Fig. 17 Digital economy and society index

Human Capital

Digital skills enable people to use digital services and engage in online activities, especially when mobility is limited. The Corona crisis has shown that digital skills can give citizens access to important information and services.

Since 2015, the level of digital skills has continued to grow slowly, reaching 56% of individuals with at least basic digital skills, 31% with above basic digital skills and 58% of individuals with at least basic software skills. Skills indicators are strongly influenced by socio-demographic aspects. For example, 80% of young adults (aged 16-24), 84% of individuals with high formal education and 87% of students have at least basic digital skills. In contrast, only 33% of people aged 55-74 and 28% of pensioners and inactive people have at least basic digital skills.

In tomorrow's world, we must rely on digitally equipped and capable citizens, a digitally skilled workforce and digital professionals. The EU has set itself the target of reaching 20 million employed ICT specialists with convergence of women and men by 2030.

In the current circumstances, this is particularly important for staff working in health systems and public administration staff, as well as for teachers and professors and their students.

Basic and advanced digital skills need to be strengthened in school curricula as part of the academic offerings in EU Member States. Digital skills are essential for the effective use of distance learning solutions.

In 2018, around 9.1 million people worked as ICT specialists across the EU, 1.6 million more than 4 years ago. Nevertheless, there is still a shortage of ICT specialists in the labor market. 64% of large companies and 56% of SMEs report that it is difficult to fill vacancies for ICT specialists. **There is also the issue of gender balance, as only one in six ICT specialists is a woman. Fig. 18 show Human capital indicators.**

	EU	
	DESI 2019	DESI 2021
1a1 At least basic digital skills % individuals	**55%** 2017	**56%** 2019
1a2 Above basic digital skills % individuals	**29%** 2017	**31%** 2019
1a3 At least basic software skills % individuals	**58%** 2017	**58%** 2019
1b1 ICT specialists % individuals in employment aged 15-74	**3.8%** 2018	**4.3%** 2020
1b2 Female ICT specialists % ICT specialists	**17%** 2018	**19%** 2020
1b3 Enterprises providing ICT training % enterprises	**22%** 2018	**20%** 2020
1b4 ICT graduates % graduates	**NA** 2016	**3.8%** 2018

Source: DESI 2021, European Commission.

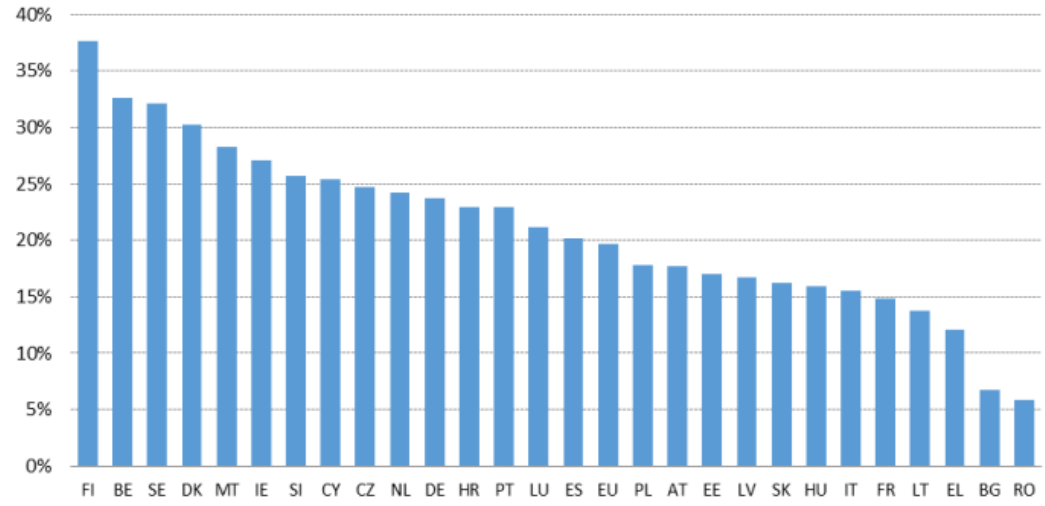
Fig. 18 Human capital indicators

Internet use of citizens

The use of the Internet by individuals during the pandemic has risen sharply. The general restriction has led to teleworking, e-commerce, e-government services and online education.
In 2020, 91% of households had access to the Internet at home. 86% of individuals were regular Internet users (using it at least once a week), with almost 80% using it either every day or almost every day. *Lack of relevant skills is an important factor discouraging households from accessing the Internet at home.* Internet banking and shopping have also become more popular, with 71% of internet users using it.

ICT specialists

In 2020, 8.4 million people across the European Union worked as ICT specialists. The share of ICT specialists is slowly advancing, reaching 4.3% of total employment in 2020. The vast majority of ICT specialists in the EU are men (81.5% of ICT specialists in 2020 were men).
A view of industry is crucial because industry as a whole in the European Union generates 24% of EU-28 GDP and provides employment for around 50 million people, ie around one-fifth of employed individuals in EU Member States (European Commission, 2017). In addition, **the concept of Industry 4.0 is often associated with the concept of digitization and the ICT sector thus plays a very important role in this concept.**
In 2020, 19% of businesses in the EU employed ICT specialists. In 2019, 55% of EU companies that hired or tried to employ ICT specialists reported difficulties in filling vacancies. Businesses are increasingly training their employees to develop or improve their ICT skills. A total of 20% of EU companies have provided ICT training to their employees. If we look at the size of the company, 68% of large companies actively provided training, while only 18% of SMEs. Fig. 19 show Enterprises providing ICT training - % enterprises in 2020.



Source: Eurostat, European Union survey on ICT usage and e-commerce in enterprises.

Fig. 19 Enterprises providing ICT training

Large companies benefit from scale and, as a result, 76% of them employ in-house ICT specialists. *The share of small businesses in the EU employing ICT specialists has remained roughly at the same level over the last 6 years* (14%), and similarly for medium-sized enterprises at 42%. Not

surprisingly, the share is over 80% in the computer programming and consulting sectors, but it is also high in telecommunications (68%) and publishing (48%). On the other hand, it is below 7% in accommodation and food services and below 9% in construction. Fig. 20 shows companies employing ICT specialists - % of companies in the period 2014-2020.

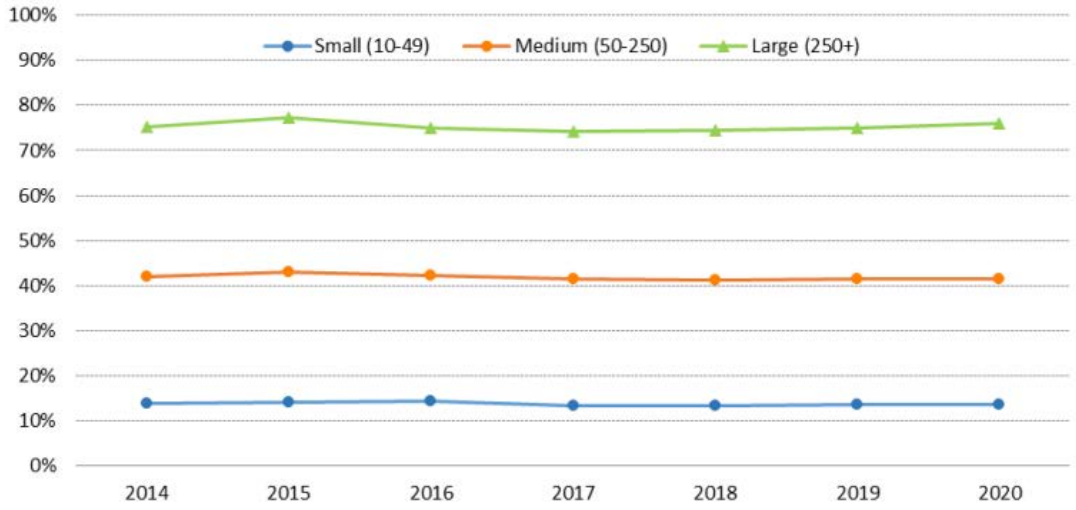
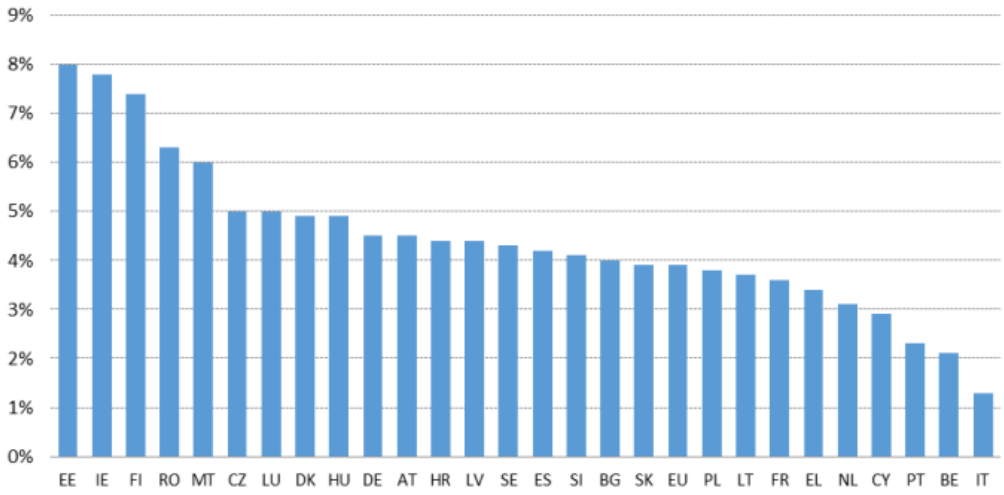


Fig. 20 Companies employing ICT specialists, 2014-2020

ICT Graduates

Employers in the EU are looking for employees with the necessary digital skills and workers able to use digital technologies properly. In 2019, 3.9% of Europeans graduated with an ICT degree. Fig.21 show ICT graduates - % of graduates in 2019.



Source: Eurostat, Education and training statistics (table educ_uoegrad03, using selection ISCED11=ED5-8 and ISCEDF_13).

Fig. 21 ICT graduates - % of graduates in 2019

Connectivity

The connectivity dimension of the Digital Economy and Society Index (DESI) focuses on both the demand and supply side of fixed and mobile broadband. Mobile broadband includes 4G coverage, mobile broadband usage (3G and 4G) and a 5G readiness indicator. Digital connectivity is considered a social right in the EU. The connectivity index is on Fig. 22.

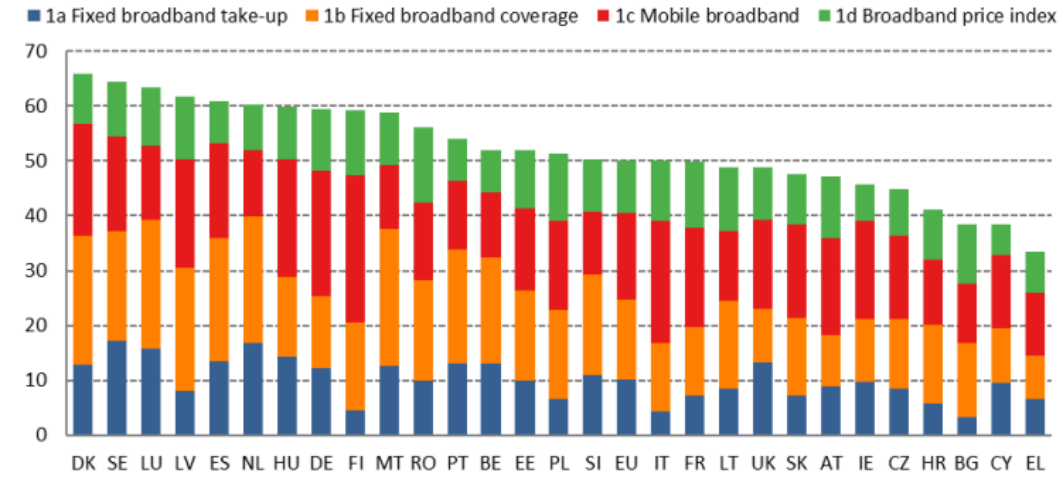
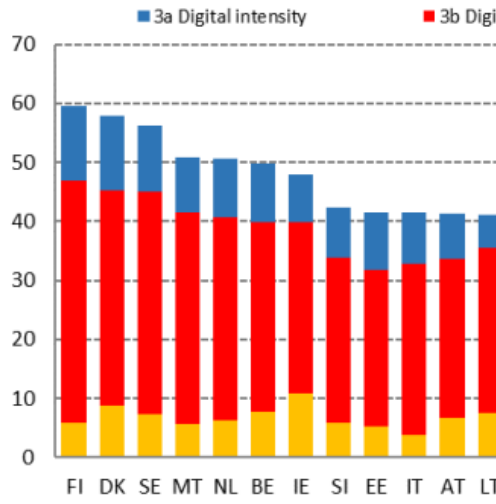


Fig. 22 Connectivity index

Digital intensity index

The Digital Intensity Index (DII) measures the use of various digital technologies at the enterprise level. The company's DII score is based on calculating how many of the 12 selected technologies are used. Figure 2 shows the composition of DII in 2020. It also shows the degree of penetration and the rate of adoption of the various technologies monitored by DII. Large companies are more digitized than SMEs. Digital intensity index is on Fig. 23 and digital intensity index indicators tracking digitisation process,% enterprises, is on Fig. 24, (2020).



Source: DESI 2021, European Commission.

Fig. 23 Digital intensity index

	Large	SMEs
Have a website	94%	76%
The maximum contracted download speed of the fastest fixed line internet connection is at least 30 Mb/s	92%	76%
Website has at least one of : description of goods or services, price lists; possibility for visitors to customise or design online goods or services; tracking or status of orders placed; personalised content in the website for regular/ recurrent visitors	78%	62%
Enterprises where more than 50% of the persons employed used computers with access to the internet for business purposes	56%	46%
Provide more than 20% of the employed persons with a portable device that allows internet connection via mobile telephone networks, for business purposes	47%	39%
eInvoices sent, suitable for automated processing	53%	32%
Buy medium-high CC services	48%	25%
Employ ICT specialists	76%	18%
Enterprises with e-commerce sales of at least 1% turnover	39%	17%
Analyse big data internally from any data source or externally	34%	14%
Use industrial or service robots	28%	6%
Use 3D printing	17%	5%

Source: Eurostat, European Union survey on ICT usage and e-commerce in enterprises.

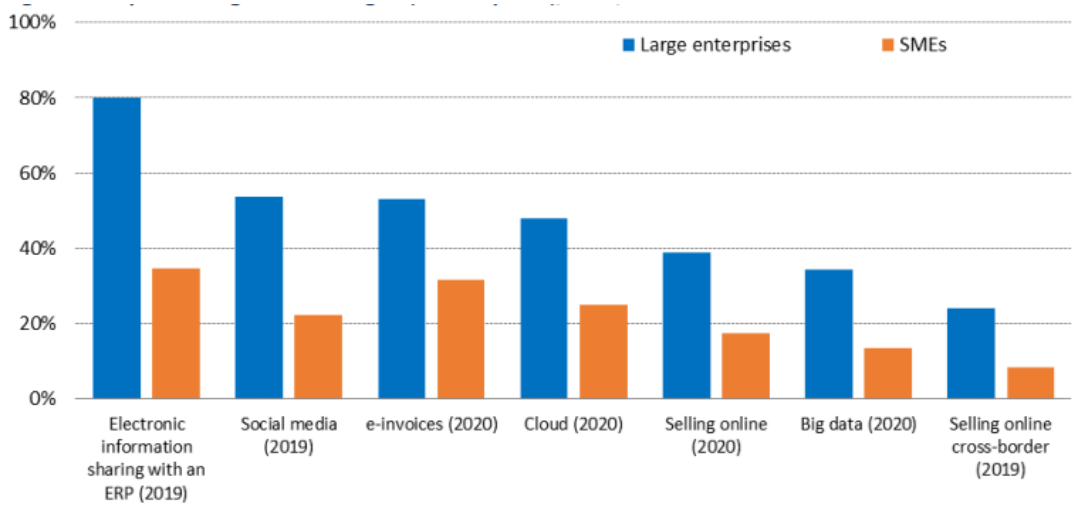
Fig. 24 Digital intensity index indicators tracking digitisation process,% enterprises

Adoption of digital technologies by enterprises

Businesses are becoming increasingly digital, with large companies playing a leading role. 38.5% of large companies already rely on advanced cloud services and 32.7% said they use big data analysis. However, the vast majority of SMEs do not yet use these digital technologies, as only 17% of them use cloud services and only 12% use big data analysis. In terms of e-commerce, only 17.5% of SMEs sold products or services online in 2019, after a very slight increase of 1.4 percentage points compared to 2016. In contrast, 39% of large companies used online sales in 2019.

It is clear that large companies are adopting new technologies more often. For example, electronic information sharing through enterprise resource planning (ERP) software is much more common in large enterprises (80%) than in SMEs (35%). SMEs make limited use of e-commerce opportunities, as only 17% sell online (compared to 39% of large companies) and only 8% sell cross-border online

(24% for large companies). Adoption of digital technologies, % enterprises, in years 2019 and 2020 is on Fig. 25.

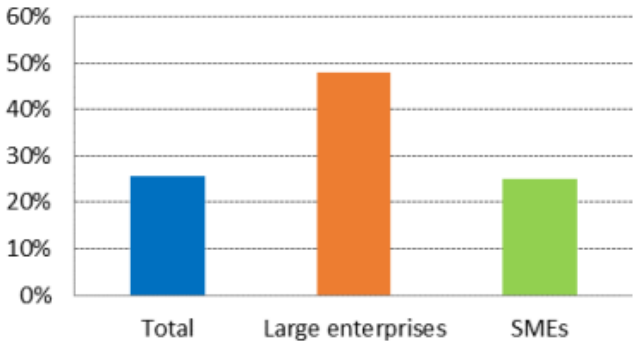


Source: Eurostat, European Union survey on ICT usage and e-commerce in enterprises.

Fig. 25 Adoption of digital technologies, % enterprises, in years 2019 and 2020

Cloud computing

The Digital Compass target requires more than 75% of EU companies to adopt cloud computing by 2030. By 2020, 26% of EU businesses had purchased cloud computing services with a medium level of sophistication (enterprise database hosting, accounting software applications, CRM software and computing power) and integrated cloud technologies to improve their operations while reducing costs. The use of the cloud by large companies (48%) was higher in 2020 than in the case of small and medium-sized enterprises (25%), Fig. 26. Cloud adoption is highest in the computer programming and consulting sectors (65%), in construction, retail, transport and warehousing, as well as in accommodation and food services, at around 20%.

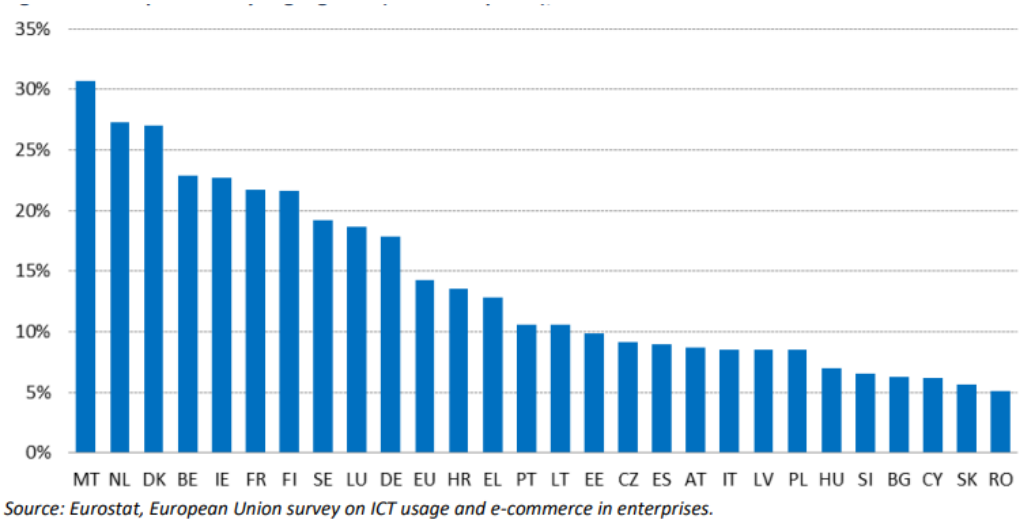


Source: Eurostat, European Union survey on ICT usage and e-commerce in enterprises.

Fig. 26 Cloud computing services of medium-high sophistication - % of enterprises in 2020

Big data

The Digital Compass goal requires more than 75% of EU companies to adopt big data by 2030. Businesses across the EU are constantly adapting to new technologies for collecting, storing and analysing data. In 2020, 14% of companies performed big data analysis. This has helped them produce results in the near or real time from data that comes in different types of formats. Large companies have a dominant share in big data processing (34% of them use big data), while SMEs still have room for improvement to take full advantage of big data (14% use big data).The percentage of EU companies analysing big data in 2020 is shown in Fig. 27.

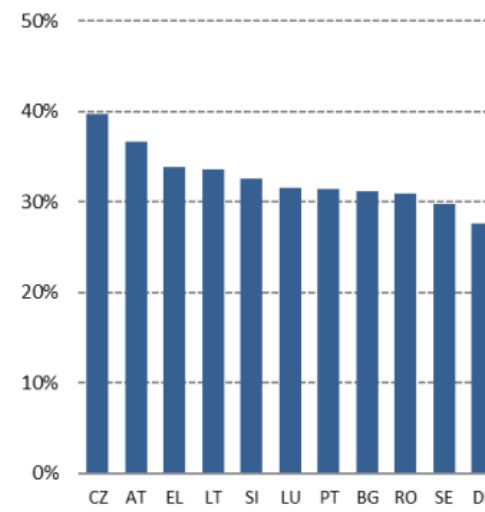


Source: Eurostat, European Union survey on ICT usage and e-commerce in enterprises.

Fig. 27 percentage of EU companies analysing big data in 2020

Artificial intelligence (AI)

Regarding the deployment of artificial intelligence technologies in the European Union, companies can be divided into two groups: "recipients" (42%) who currently use at least one artificial intelligence technology and "non-recipients" (40%) who do not. They currently use AI and do not plan to use any AI technologies (at least in the next two years) and those companies that plan to adopt AI in the next two years do not currently use AI solutions (18%). When we look at the intensity of adoption, a quarter (25%) of companies use at least two AI technologies. On Fig. 28 is the ranking of EU countries based on the use of at least two AI technologies.



Data for Cyprus and Malta are not available.

Source: Ipsos, European enterprise survey on the use of

Fig. 28 Ranking of EU countries based on the use of at least two AI technologies

In terms of sector overview, the uptake of at least one AI technology is highest in the ICT sector (63%), followed by education (49%), health, social work and manufacturing (all 47%), Fig. 29.

Sector (Part I)	At least one AI technology	At least two AI technologies	Plans to use
Agriculture, forestry and/or fishing	39%	24%	18%
Manufacturing	47%	27%	16%
Construction	36%	23%	16%
Oil and gas	38%	19%	6%
Waste management	31%	21%	27%
Water and electricity supply	45%	28%	17%
Trade, retail	38%	22%	20%
Transport	36%	22%	20%
Food	36%	26%	20%

Sector (Part II)	At least one AI technology	At least two AI technologies	Plans to use
Accommodation	42%	22%	15%
Recreation activities	37%	24%	11%
IT	63%	43%	12%
Finance, insurance	40%	20%	27%
Real estate	42%	23%	18%
Other technical and/or scientific sectors	43%	22%	18%
Education	49%	21%	21%
Human health	47%	29%	19%
Social work	47%	26%	10%

Base question Q1: What is the current state of adoption in your firm for [AI technologies]?; Base: EU27, N=8661. (Base size represents only EU27 Member States, excluding the UK, Iceland and Norway).

Source: Ipsos, European enterprise survey on the use of technologies based on artificial intelligence, 2020.

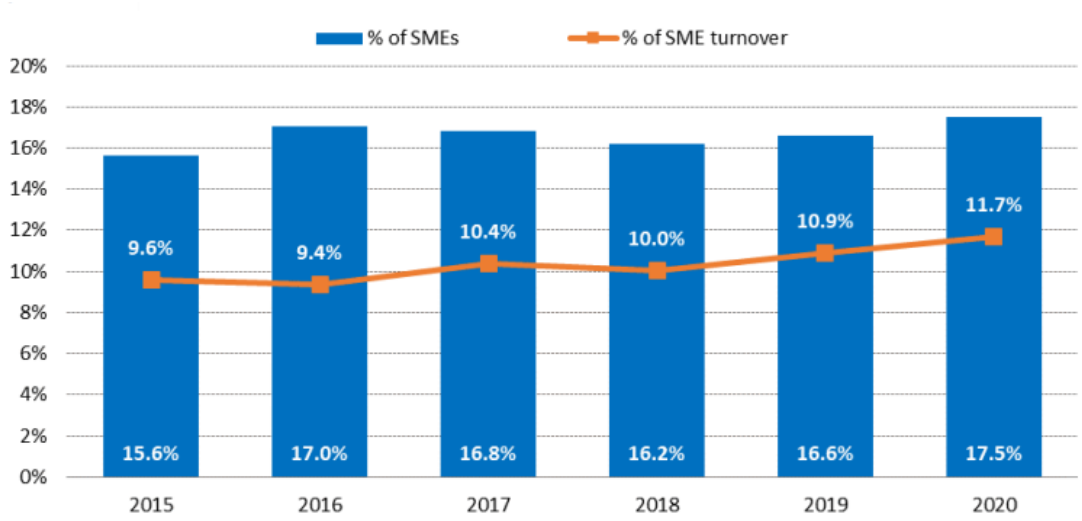
Fig. 29 Levels of adoption of AI by sector

The sectors with the lowest AI uptake are waste management (31%), construction, transport and food (all 36%).

e-Commerce

One in five businesses in the EU made online sales in 2020, representing 18% of the total turnover of companies employing 10 or more people. Between 2015 and 2020, the percentage of companies

selling online increased by 1.9 percentage points and the turnover of these companies realized from online sales increased by 2.1 percentage points. Trend in e-commerce show Fig. 30.



Source: Eurostat, European Union survey on ICT usage and e-commerce in enterprises.

Fig. 30 Trend in e-commerce in years 2015-2020

Digital Public Services

Digital technologies are increasingly placing new demands and expectations on the public sector. Unlocking the full potential of these technologies is a key challenge for government organizations. Effective eGovernment can provide a wide range of benefits, including greater efficiency and savings for governments and businesses. It can also increase transparency and openness. The Digital Decade aims that all key public services for businesses and citizens should be fully online by 2030. Indicators 4a3 and 4a4 monitor progress towards these goals.
Digital public services indicators in DESI: Fig. 31.

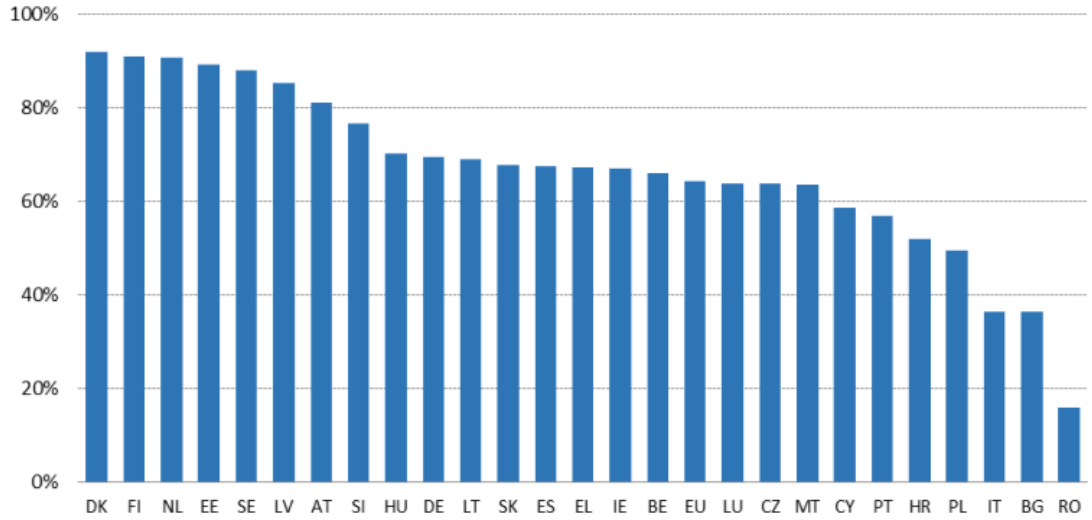
	EU	
	DESI 2019	DESI 2021
4a1 e-Government users % internet users	**60%** 2018	**64%** 2020
4a2 Pre-filled forms Score (0 to 100)	**NA** 0	**64** 2020
4a3 Digital public services for citizens Score (0 to 100)	**NA** 0	**75** 2020
4a4 Digital public services for businesses Score (0 to 100)	**NA** 0	**84** 2020
4a5 Open data % maximum score	**NA** 0	**78%** 2020

Source: DESI 2021, European Commission.

Fig. 31 Digital public services indicators in DESI

e-Government users

Of all Internet users, this indicator takes into account the percentage of individuals who have used the Internet to interact with public authorities in the last 12 months, Fig.32.



Source: Eurostat, Community survey on ICT usage in Households and by Individuals.
**Data for France was not collected for 2020*

Fig. 32 e-Government users interacting online with public authorities over the Internet in the last 12 month

Digital public services for citizens

The corona crisis has shown the importance of the digitization of public services, with social distance measures in place, and further large-scale digitization in health and public services. While in 2014 *57% of Internet users used online forms with public administration, in 2019 it was already 67%.*

This is a new indicator that measures the extent to which a service or information related to a service for citizens is provided online and through a portal, Fig. 33. Services that are offered entirely, partially or not at all online. The indicator represents the proportion of steps that can be taken online at major life events (eg birth of a child, new residence, etc.) for citizens. It is calculated as the average of the national and cross-border online availability of information and transaction services.

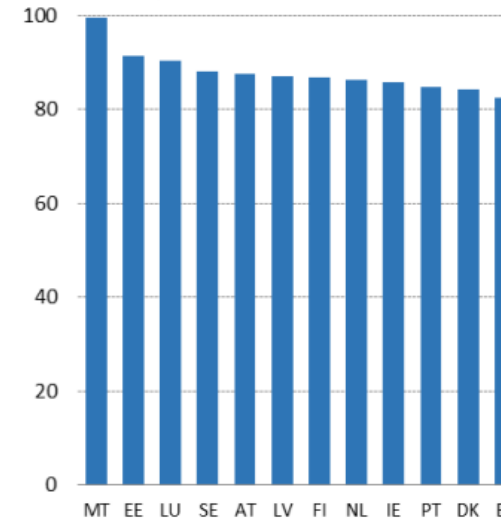
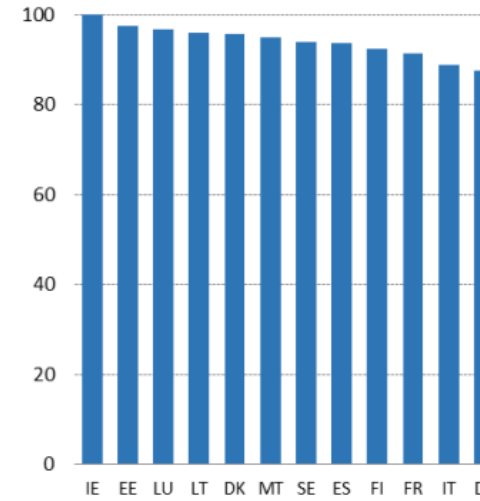


Fig. 33 Digital public services for citizens, 2020

Last but not least, *there is a growing trend towards the use of digital public services in the areas of eGovernment and eHealth, which allows for greater efficiency and savings for governments and businesses, better transparency and greater citizen participation in political life.* 67% of internet users who submitted forms to their public administration in 2019 now use online channels, an increase from 57% in 2014, proving that using ICT-enabled services is advantageous over paper ones.

Digital public services for businesses

This indicator measures the extent to which public services for businesses are interoperable and operate across borders, Fig. 34. The indicator assesses the extent to which information and transaction services, public utilities for start-ups and day-to-day business operations are available online and cross-border in other EU Member States.



Source: eGovernment Benchmark, Capgemini.

Fig. 34 e-Government services for businesses

Use of the Internet and online activities in the index of the digital economy and society

The Commission measures the number of people using the internet across the EU and what activities they use it for.

Internet use continued to grow year on year, with 85% of Europeans surfing the Internet at least once a week (compared with 75% in 2014). The use of video calls has increased the most, from 49% of Internet users in 2018 to 60% in 2019. Internet banking and shopping are also more popular, with 66% and 66% respectively. 71% of internet users.

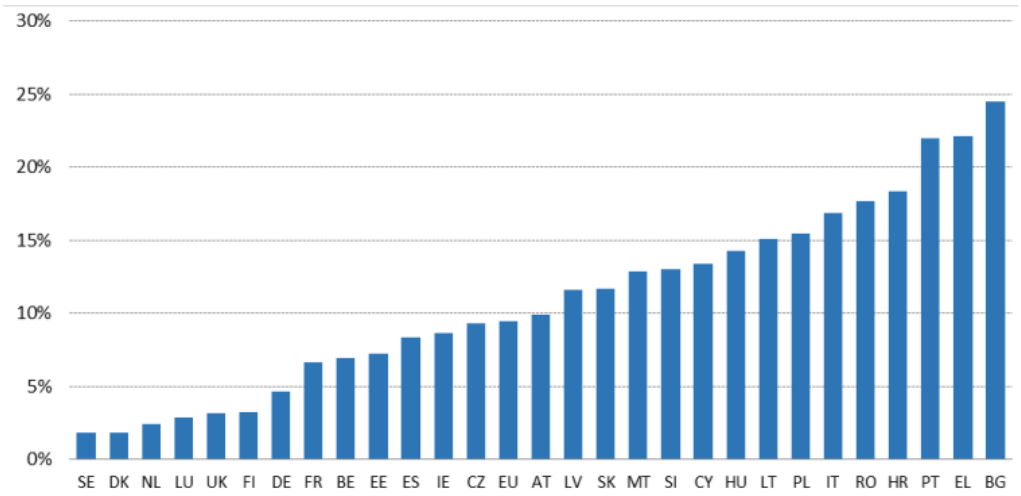
Fig. 35 Use of DESI Internet Services Indicators:

	EU	
	DESI 2018	DESI 2020
3a1 People who have never used the internet % individuals	**13%** 2017	**9%** 2019
3a2 Internet users % individuals	**81%** 2017	**85%** 2019
3b1 News % internet users	**72%** 2017	**72%** 2019
3b2 Music, videos and games % internet users	**78%** 2016	**81%** 2018
3b3 Video on demand % internet users	**21%** 2016	**31%** 2018
3b4 Video calls % internet users	**46%** 2017	**60%** 2019
3b5 Social networks % internet users	**65%** 2017	**65%** 2019
3b6 Doing an online course % internet users	**9%** 2017	**11%** 2019
3c1 Banking % internet users	**61%** 2017	**66%** 2019
3c2 Shopping % internet users	**68%** 2017	**71%** 2019
3c3 Selling online % internet users	**22%** 2017	**23%** 2019

Source: DESI 2020, European Commission.

Fig. 35 Use of Internet services indicators in Desi

The proportion of people in the EU who have never connected to the internet fell again in 2019, Fig. 36, although the current 9,5 % requires further action. *The high number of non-users is among people with or without a low level of education (24%), among people aged 55 to 74 (23%) and among pensioners and inactive people (26%).*

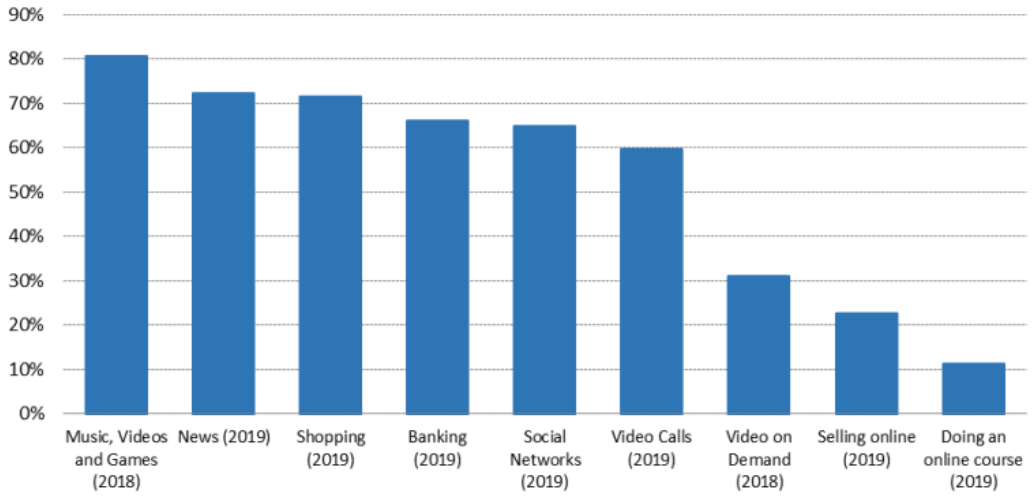


Source: Eurostat, Community survey on ICT usage in Households and by Individuals.

Fig. 36 People who never used the Internet

Online services

Using the internet to listen to music, play games or watch videos is still the most common activity (81% of individuals who have used the internet in the last 3 months). Reading news online is the second most popular activity displayed in DESI (72%), while 2 out of 3 internet users shop (71%) or bank online (66%). On the contrary, the online course is one of the least popular online activities (11%), Fig. 37.

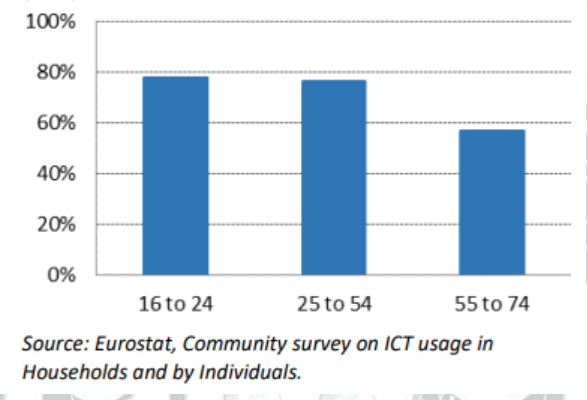


Source: Eurostat, Community survey on ICT usage in Households and by Individuals.

Fig. 37 Online activities - % of Internet users

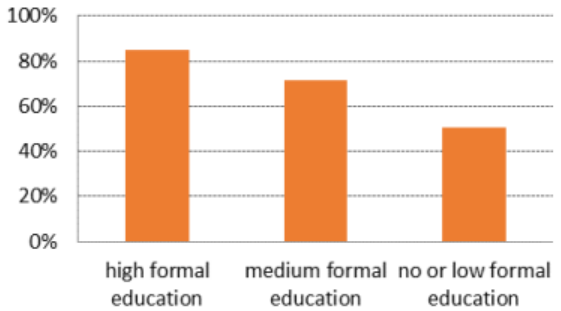
e-commerce

The upward trend in e-commerce continued in 2019,Fig. 38 and Fig. 39, with around 71% of EU internet users ordering goods and services online. E-commerce varies considerably from one EU Member State to another. Young people make up the most active age group of online shoppers (78% of people aged 16-24), with the proportion of internet users with higher levels of online shoppers (85%) being 35 percentage points higher than the proportion of users with lower levels of formal education. *There is no significant difference by gender, as 72% of men and 71% of women shop online.*



Source: Eurostat, Community survey on ICT usage in Households and by Individuals.

Fig. 38 Online shopping by age groups

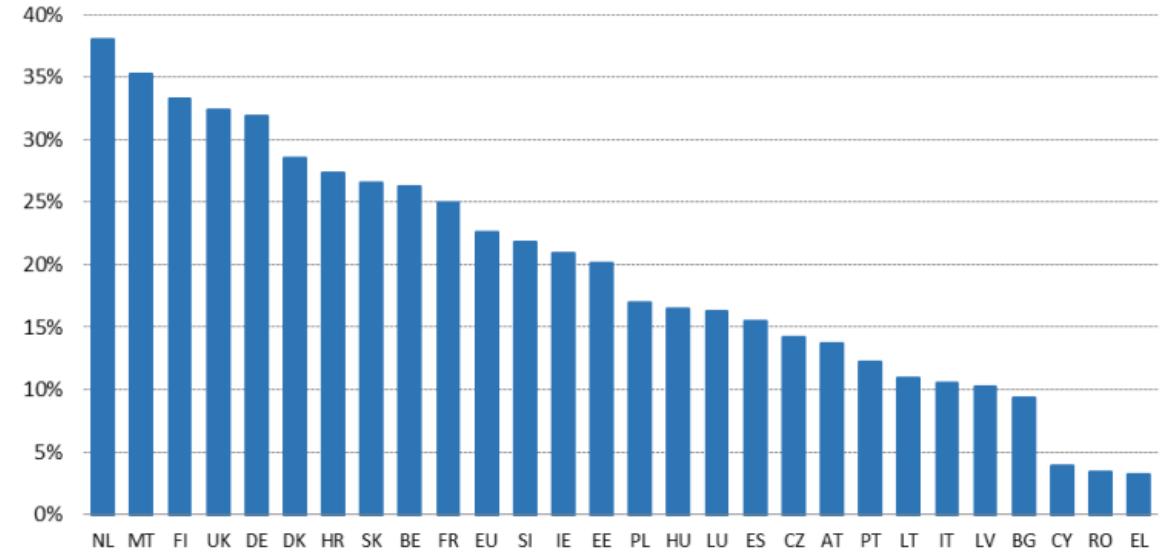


Source: Eurostat, Community survey on ICT usage in Households and by Individuals.

Fig. 39 Online shopping by education level

People selling online

In 2019, 23% of Internet users have sold goods or services over the Internet in the last three months. Fig. 40 shows by individual EU countries.



Source: Eurostat, Community survey on ICT usage in Households and by Individuals.

Fig. 40 People selling online in EU coutries

1.4.1 Position of individual EU countries according to the Industry 4.0 relative performance index

Calculation of the Industry 4.0 relative performance index

In the field of Industry 4.0 measurement, there are a relatively large number of academic studies that focus on composite indicators that try to capture this phenomenon statistically.
This index is calculated according to the methodology of the World Economic Forum. The calculation of the own composite indicator makes it possible to record the development of Industry 4.0's performance over time and thus evaluate the relative positions of the member countries.
A cluster analysis was performed for 2011 and 2019 and data were extracted from Eurostat and World Bank statistics. *The results of this evaluation can be used to compare the state of implementation of Industry 4 in individual partnership countries and with the EU average* as well as in the area of Industry 4.0 support, which may contribute to strengthening the position of the EU economy as a whole in the future.
Industry 4.0 is a complex phenomenon and cannot simply be statistically recorded using a single indicator, so there is a need to calculate these so-called composite indicators.
The relative performance index of Industry 4.0 is calculated according to the formula:

$$component_n^{it} = \frac{v_n^{it} - \min(v^{it})}{\max(v^{it}) - \min(v^{it})}$$

The letter I represents the selected variable, n represents the selected EU member state, and t determines the selected year of analysis. Thus$vn\ it$is the value of the selected statistical indicator I for the given state n in time t. Min (vit) represents the minimum statistical indicator and the value in sample n and, analogically, max (vit) represents the maximum value.

Indicators used for the calculation of the Industry 4.0 relative performance index are presented in Table 1 and an overview of values of input statistical indicators is presented in Table 2.

Tab. 1 Indicators used to calculate Industry 4 Index (% of total enterprises)

CODE	Variable name (i)		Years	
(a)	Share of industry in the economy	% GDP	2011	2017
(b)	Enterprises that have either introduced an innovation or have some kind of innovation (including enterprises with abandoned/suspended or on-going innovation activities)	% of enterprises	2012	2016
(c)	Percentage of the ICT sector in GDP	% GDP	2011	2017
(d)	Enterprises having received orders online (at least 1%)	% of enterprises	2011	2019
(e)	Enterprises that have ERP software packages to share information between different functional areas	% of enterprises	2012	2019
(f)	Enterprises using CRM to analyse information about clients for marketing purposes	% of enterprises	2010	2019
(g)	3D printing and robotics	% of enterprises	-	2018
(h)	Enterprises that employ ICT specialists	% of enterprises	2012	2019
(i)	Internet use: interaction with public authorities (last 12 months)	% of individuals	2011	2019
(j)	Big data analysis	% of enterprises	-	2018

Source: Eurostat and Worldbank database

Tab. 2 Components of Industry 4 relative performance index

STATE	Code country	(a)		(b)	
Austria	AT*	25.4	25.7	54.4	62.0
Belgium	BE*	20.8	19.1	55.9	68.1
Bulgaria	BG	25.6	23.8	27.4	27.2
Cyprus	CY	12.8	12.2	42.1	36.5
Czech Republic	CZ	33.4	32.2	43.9	46.3
Germany	DE*	27.1	27.5	66.9	63.7
Denmark	DK*	20.3	21.2	51.1	51.5
Estonia	EE	25.5	24.1	47.6	47.7
Greece	EL*	13.7	15.3	52.3	57.7
Spain	ES*	22.1	20.0	33.6	36.9
Finland	FI*	25.0	24.5	52.6	64.8
France	FR*	18.0	16.9	53.4	57.7
Croatia	HR	22.3	20.4	37.9	48.0
Hungary	HU	25.2	25.4	32.5	29.0
Ireland	IE*	24.6	36.8	58.7	57.3
Italy	IT*	21.7	21.4	56.1	53.8
Lithuania	LT	28.0	25.5	32.9	50.5
Luxembourg	LU*	11.2	11.8	66.1	63.8
Latvia	LV	21.1	19.5	30.4	30.3
Malta	MT	16.8	12.1	51.1	33.9
Netherlands	NL*	20.1	17.9	51.4	59.7
Poland	PL	29.8	28.6	23.0	22.0
Portugal	PT*	19.3	19.2	54.6	66.9
Romania	RO	38.5	29.0	20.7	10.2
Sweden	SE*	23.6	22.6	55.9	54.2
Slovenia	SI	26.8	28.4	46.5	39.8
Slovak Republic	SK	31.1	30.1	34.0	30.7
United Kingdom	UK*	18.7	17.5	50.3	58.7

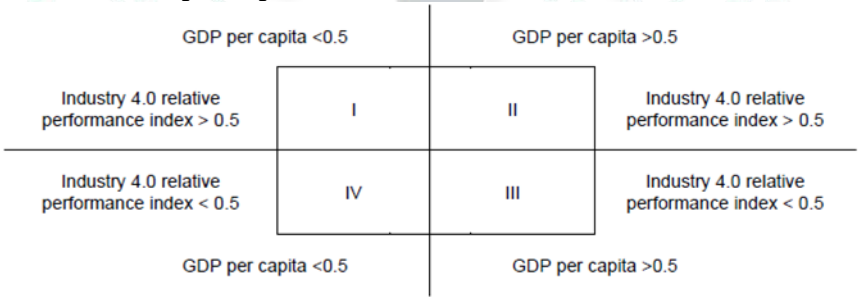
Source: Eurostat and Worldbank database

(*) EU15 – member countries in the European Union prior t
Belgium, Denmark, Finland, France, Germany,

Inclusion of EU member states in clusters according to the Industry 4.0 relative performance index

The calculation of the Industry 4.0 relative performance index allows EU Member States to be included in clusters.

According to this study, Member States have been divided into 4 areas, which form clusters according to the values of the Industry 4.0 relative performance index and GDP per capita (relative performance); these areas are shown in Figure 41. The combination of these two categories determines the relative position of the country. The horizontal axis is a traditional indicator of economic performance - GDP per capita.



Source: own research

Fig. 41 Overview of the division of EU countries into the Industry 4.0 relative performance index and GDP per capita

Area I includes Member States that have Industry 4.0 relative performance index values greater than or equal to 0.5, but per capita GDP is <0.5. Area II includes countries that have Industry 4.0 relative performance index values higher than 0.5 and a GDP per capita value ≥0.5. Area III

includes Member States which have Industry 4.0 relative performance index values below 0.5 and a GDP per capita value ≥0.5. Area IV includes countries that have Industry 4.0 relative performance index values below 0.5 and a GDP per capita value <0.5.

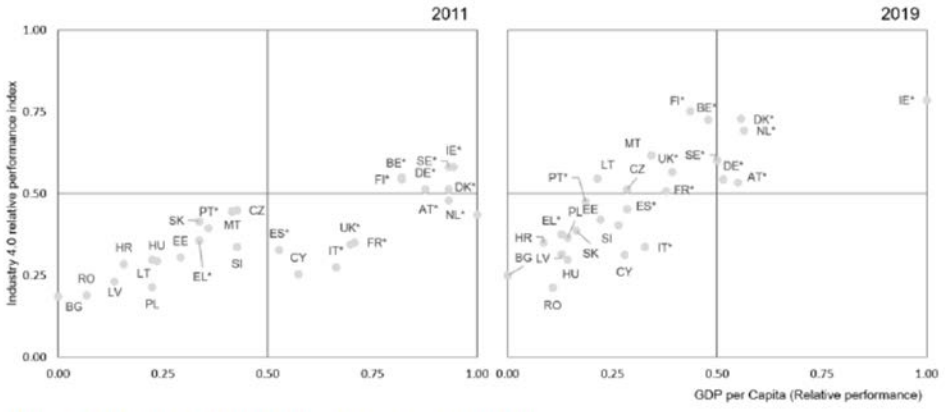
The results

Table 3 shows the calculated values of the Industry 4.0 relative performance index (score) for the years 2011 and 2019. The table also shows the order of countries in individual years and the change in order between 2011 and 2019.

Tab. 3 Industry 4 relative performance index

STATE	Code country	Score 2011	Rank 2011	Score 2019	Rank 2019	Change Rank 2019 vs. 2011
Austria	AT*	0.48	7	0.53	11	-4
Belgium	BE*	0.55	3	0.73	4	-1
Bulgaria	BG	0.18	28	0.25	27	1
Cyprus	CY	0.25	24	0.31	25	-1
Czech Republic	CZ	0.45	9	0.51	12	-3
Germany	DE*	0.51	6	0.54	10	-4
Denmark	DK*	0.51	5	0.73	3	2
Estonia	EE	0.30	19	0.42	17	2
Greece	EL*	0.36	14	0.38	20	-6
Spain	ES*	0.33	18	0.45	16	2
Finland	FI*	0.54	4	0.75	2	2
France	FR*	0.35	15	0.51	13	2
Croatia	HR	0.28	22	0.35	22	0
Hungary	HU	0.29	21	0.30	26	-5
Ireland	IE*	0.58	2	0.79	1	1
Italy	IT*	0.27	23	0.34	23	0
Lithuania	LT	0.30	20	0.55	9	11
Luxembourg	LU*	0.47	8	0.50	14	-6
Latvia	LV	0.23	25	0.31	24	1
Malta	MT	0.44	10	0.62	6	4
Netherlands	NL*	0.44	11	0.69	5	6
Poland	PL	0.21	26	0.37	21	5

For a better depiction of the relative position of member states, graphs have been created and are shown in Figure 42.



Source: Eurostat and Worldbank database, own calculation

Note: In regard to the extreme GDP per capita value, the observation of Luxemburg was left out of the cluster analysis.

Fig. 42 Cluster Division

It is clear that in 2011 Member States were located in areas II-IV and, as expected, a large number of EU-15 Member States were located in area II. In 2019, the situation changed. For Member States in Area IV, they can be described as hesitant, Industry 4.0 has a strong but probably still untapped potential to increase their economic performance. This untapped potential could be a signal for targeted support for Industry 4.0, thus strengthening the EU economy as a whole in the future.

1.4.2 The COVID-19 pandemic's effect on digital transformation

The COVID-19 global pandemic has brought digital technologies to the forefront and accelerated the development and deployment of digital services at an unprecedented pace. The Covid pandemic has led to a large part of the workforce across Europe switching to teleworking, e-commerce, a sharp increase in the use of delivery applications and the continuation of millions of pupils and students through online education. The EU and national governments have rapidly begun to adopt programs to develop new digital services to be able to serve citizens at a time of social distancing. *The need for digital transformation today is greater than ever. Programs that support the digital transformation can therefore be a driver of growth and increased global competitiveness.*

1.4.3 Programs for shaping Europe's digital future

All Europeans need digital skills to study, work, communicate, access online public services and find credible information. However, *many Europeans do not have sufficient digital skills. The Digital Economy and Society Index (DESI) shows that 4 out of 10 adults and one in three who work in Europe do not have basic digital skills. There is also a low representation of women in technology-related fields and studies, with only 1 in 6 ICT specialists and 1 in 3 science, technology, engineering and mathematics (STEM) graduates being women.*
The European Commission has set targets in the European Skills Agenda and Digital Learning Action Plan to ensure that by 2025, 70% of adults have basic digital skills.
More than 70% of businesses said that a lack of staff with adequate digital skills is a barrier to investment. Europe also faces a shortage of digital professionals who can develop cutting-edge technologies for the benefit of all citizens.
A strong digital skills economy is vital for innovation, growth, employment and European competitiveness. The spread of digital technologies has a huge impact on the labor market. Member States, businesses, training providers, the European Commission and other organizations need to work together to address the digital skills gap.
Greater progress is needed in digital skills, especially as the corona crisis has shown that adequate digital skills are key for citizens to have access to information and services. A large part of the EU population, 42%, still do not have at least basic digital skills. In 2018, around 9.1 million people worked as ICT specialists across the EU, 1.6 million more than 4 years ago. 64% of large enterprises and 56% of small and medium-sized enterprises that recruited ICT specialists in 2018 said that it was difficult to fill vacancies for ICT specialists.

The Digital Europe Program (DIGITAL)

About program

The Digital Europe Program (DIGITAL) is a new EU funding program focused on bringing digital technology to businesses, citizens and public administrations.

The Digital Europe program provides funding for projects in five key areas:

- supercomputers
- artificial intelligence
- cyber security
- advanced digital skills
- ensuring the widespread use of digital technologies throughout the economy and society

What will the Digital Europe Program fund?

€ 2.2 BILLION for supercomputing to:

Build up and strengthen the EU supercomputing and data processing capacities by buying world-class exascale supercomputers by 2022/2023 (capable of at least a billion billion or 1018 calculations per second) and post exascale facilities by 2026/2027.

Increase accessibility and broaden the use of supercomputing in areas of public interest such as health, environment and security, and in industry, including small and medium-sized enterprises.

€ 2.1 BILLION for artificial intelligence to:

Invest in and open up the use of artificial intelligence by businesses and public administrations.

Set up a true European data space and facilitate safe access to and storage of large datasets and trustworthy and energy efficient cloud infrastructure.

Strengthen and support existing artificial intelligence testing and experimentation facilities in areas such as health and mobility in Member States and encourage their cooperation.

€ 1.6 BILLION for cybersecurity to:

Strengthening cybersecurity coordination between Member States tools and data infrastructures.

Support the wide deployment of the cybersecurity capacities across the economy.

€ 580 MILLION for advanced digital skills to:

Support the design and delivery of specialized programs and traineeships for the future experts in key capacity areas like data and AI, cybersecurity, quantum and HPC.

Support the upskilling of the existing workforce through short trainings reflecting the latest developments in key capacity areas.

€ 1.1 BILLION for ensuring the wide use of digital technologies across the economy and society to:

Support high impact deployments in areas of public interest, such as health (complemented by EU4Health program), Green Deal, smart communities and the cultural sector.

Build up and strengthen the network of European Digital Innovation Hubs, aiming to have a Hub in every region, to help companies benefit from digital opportunities.

Support the uptake of advanced digital and related technologies by the industry, notably small and medium-sized enterprises.

Support European public administrations and industry to deploy and access state of-the-art digital technologies (such as blockchain) and build trust in the digital transformation.

The program is designed to bridge the gap between digital technology research and technology take-up. It will benefit European citizens and businesses, especially SMEs. Investment in the Digital Europe program supports the European Union's dual objective: to achieve a green and digital transformation and to strengthen the Union's resilience and technological sovereignty.

Program duration: 2021 - 2027

Advanced Digital Skills

The actions under Strategic Objective 4 aim at supporting the excellence of EU education and training institutions in digital areas, including by encouraging their cooperation with research and businesses.

In the same way as the EU joins forces to invest in digital infrastructure, through the EuroHPC, or the European Alliance for Industrial Data and Cloud, it needs to build on the strength of its best education and training institutions to improve the related specialized education offer needed to become world-leader. *The goal is to improve the capacity to nurture and attract digital talents, whilst fostering an ecosystem that will help drive innovation and digital breakthroughs.* Strategic Objective 4 will focus on the following main work strands in the first two years of implementation:

- *it will provide education and training opportunities for the future experts in key capacity areas like data and ethical AI, cybersecurity, quantum and HPC. The support will be provided for networks of education and training institutions, research centers and businesses for the design and delivery of specialized education programs (such as Master degrees) as well as traineeships to acquire advanced digital skills needed for specific technologies.* A detailed analysis will be conducted in order to ensure relevance and detect emerging trends.
- *the investments will also target the reskilling and upskilling of the existing workforce through shortterm trainings reflecting the latest developments in key capacity areas,* through the sustainability of the EU digital platform for skills and jobs, as well as a coordination action for the digital transformation of the education sector at European level, ensuring that all EU citizens can benefit from these upskilling opportunities. The topics will contribute to implement actions such as the Digital Crash Courses for SMEs announced in the 2020 Skills Agenda and SME strategy. They will be complementary with actions for digital skills development implemented by Erasmus + and European Institute on Technology (EIT) 109. The Coordinated plan on artificial intelligence also has a specific section on skills and education, including a dedicated list of actions. Notwithstanding the main focus on the Advanced Digital Skills Strategic Objective, the program will also address the digital transformation of the education sector in line with the strategic priorities of the Digital Education Action Plan 2021-2027, namely the development of high-performing digital education ecosystem and enhancing digital skills and competences for the digital transformation. The participation is open to all eligible entities as established by Article 18 of the Digital Europe program, in particular public sector as well as private sector organizations including SMEs, higher education establishments and NGOs. the program will also address the digital transformation of the education sector in line with the strategic priorities of the Digital Education Action Plan 2021-2027, namely the development of high-performing digital education ecosystem and enhancing digital skills and competences for the digital transformation. The participation is open to all eligible entities as established by Article 18 of the Digital Europe program, in particular public sector as well as private sector organizations including SMEs, higher education establishments and NGOs.

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Specialized education programs in key capacity areas

Objective

The action aims at increasing and improving the offer of education programs and the number of students specialized in key capacity areas. The offer will be expanded in terms of geographical distribution (including outermost regions and other disadvantaged regions), number of opportunities and relevance to latest technological developments. The actions also aim at supporting more inter-disciplinary courses that can equip professionals with relevant advanced digital skills and increase diversity among students and future digital experts111. The action will support cooperation between higher education institutions and the private sector, together with research and excellence centers in digital technologies, including those funded in the other actions of the program. The goal is to encourage organizations to work together and develop ecosystems of excellence able to train, attract and retain the best digital talents, including by contributing to closing the gender gap in these fields112,. This action will contribute to the implementation of the Digital Education Action Plan 2021-2027.

Scope

The chosen projects shall design and deliver a tertiary degree education program of 60, 90 or 120 academic credits (The European Credit Transfer and Accumulation System - ECTS). The calls in the first two years will address the following topics: Data, Internet of Things (IoT), AI, Blockchain, cybersecurity, HPC, quantum, among others and interdisciplinary courses, including the teaching of the above areas in a non-ICT education field (eg AI applications for agriculture or cybersecurity and law etc ..). Proposals can address only one technological areas, or more, or only one inter-disciplinary program, with a specific focus on one sector. Tertiary education institutions in consortia with relevant competence and excellence centers and industry will receive funding to set up and strengthen excellent courses in the above areas. Partners in these consortia will be encouraged to share expertise, facilities, staff and learning material Inter-sectorial mobility between Higher Education Institutions and the private sector is also encouraged. These courses need to reflect the latest state of the art of the technologies, provide opportunities to students to have access to laboratories and testing and experimentation facilities and making use-where appropriate- of the EU data spaces. They will also make use of digital technologies to provide learning experiences that are flexible in time, scope end place, as appropriate. Activities to exchange on good practices to involve and interact with external stakeholders will also be encouraged. Particular attention will be given to aspects such as green application and environmental impact of these technologies. At present, all Member States face a shortage of digital specialists

Promoting European innovation in education

Objective
This action will support the digital transformation of the education sector at European level by boosting innovation in education in Europe by supporting EdTech start-ups and SMEs to accelerate their disruptive EdTech solutions. The project will support the strategic priority of the Digital Education Action Plan 2021-2027 and in full synergy with, and complementarity to, the objective of setting up a European Digital Education Hub and in line with the European Education Area framework.
The DIGITAL Europe program will fund the design and delivery of specialized programs and traineeships for future experts in key capacity areas like data and AI, cybersecurity, quantum and HPC.
It also aims to support the upskilling of the existing workforce through training in key capacity areas.

Europe's Digital Decade: digital targets for 2030

On 9 March 2021, the European Commission presented a vision and avenues for Europe's digital transformation by 2030. The Commission proposes a Digital Compass for the EU digital decade that evolves around four cardinal points, Fig. 43:

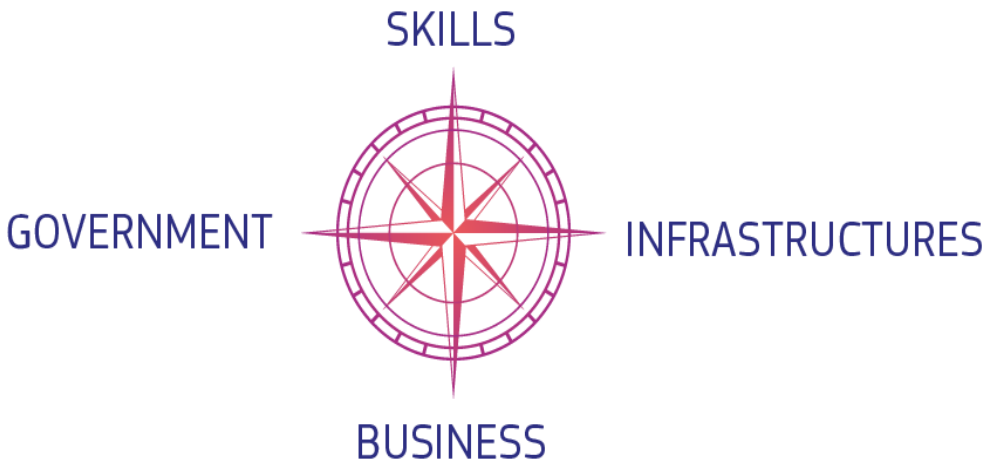

Fig. 43 The four cardinal points of a digital compass

Skills

ICT Specialists: 20 million+ Gender convergence
Basic Digital Skills: min 80% of population


Secure and sustainable digital infrastructures

Connectivity: Gigabit for everyone, 5G everywhere
Cutting edge Semiconductors: double EU share in global production
Data - Edge & Cloud:10,000 climate-neutral highly secure edge nodes
Computing: first computer with quantum acceleration


Digital transformation of businesses
Tech up-take: 75% of EU companies using Cloud / AI / Big Data
Innovators: grow scale-ups & finance to double EU Unicorns
Late adopters: more than 90% of SMEs reach at least a basic level of digital intensity


Digitization of public services
Key Public Services: 100% online
e-Health: 100% of citizens having access to medical records
Digital Identity: 80% of citizens using digital ID

Digital citizenship: rights and principles for Europeans
On 26 January 2022, the Commission proposed an inter-institutional solemn declaration on digital rights and principles for the digital decade.
People at the center
Digital technologies should protect people's rights, support democracy, and ensure that all digital players act responsibly and safely.
Freedom of choice
People should benefit from a fair online environment, be safe from illegal and harmful content, and be empowered when they interact with new and evolving technologies like artificial intelligence.
Safety and security
The digital environment should be safe and secure. All users, from childhood to old age, should be empowered and protected.
Solidarity and inclusion
Technology should unite, not divide, people. Everyone should have access to the internet, to digital skills, to digital public services and to fair working conditions.
Sustainability
Digital devices should support sustainability and the green transition. People need to know about the environmental impact and energy consumption of their devices.

Conclusion

Customers expect the highest quality products, but at the same time they want the solution to be individual and as much as possible adapted to their requirements, they expect fast project development and comprehensive services even after its completion. Previous processes can no longer take this changed state into account.

In the long run, companies risk losing competitiveness due to inefficiency. The solution is to embark on the path of digitization at all process levels, including production. Many processes, such as bid preparation, are still performed manually and on a paper basis by many companies. In practice, this means a slow response to change, there is not always an up-to-date overview of processes and capacities. With digitization, these problems disappear and the released reserves can be invested in innovation and further growth.

At a time of growing skills shortages for digitization and Industry 4, it has become crucial for companies to make the most of their employees' creative workforce and added value. But they need not only good training staff but also quality training materials.

Companies are gradually digitizing. Surveys of digitization projects have been indicating this for several years. More and more small and medium-sized companies are realizing the benefits of automated and digital processes.

Businesses consider the lack of experts with specific knowledge in the field of IT to be obstacles to the implementation of new technologies.

Companies have already understood the massive impact of Industry 4.0 and the role of digitization and technology in the fundamental transformation of business and production models and processes. **The challenge** is to find the steps they need to take to reap and realize the benefits of the future of Industry 4.0. It **is not just a matter of creating a technology plan, but mainly of having people with the necessary knowledge and skills to work with these technologies.**

The report concludes that there is a need to educate a new type of engineers and especially developers who will not only master digital technologies but will be able to develop new products and industrial components for Industry 4.0. Another important knowledge is the urgent societal need for more technically educated professionals.

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1.5 EUROPEAN COUNTRIES OVERVIEW

1.5.1 CASE OF BULGARIA

Statistics and economic indicators on digitalisation and digital skills

Bulgaria score in composite indexes and indicators relevant to digitalization and Industry 4.0 readiness

Digital Economy and Society Index

Since 2014, the European Commission's Digital Economy and Society Index (DESI) summarises indicators on Europe's digital performance. Four dimensions are being assessed: human capital, connectivity, integration of digital technology, and digital public services. According to the DESI 2021 reports (based on data from 2020), Bulgaria's overall ranking in the EU context is very low, equal to that of Greece and higher only than that of Romania. Regarding the digital skills of the population, Bulgaria's level is the lowest in the EU. Only 29% of the population aged 16 to 74 is digitally literate - a poor result against an EU average of 56%. Only 11% of the population have above basic digital skills, also a poor result that is just a third of the EU average. The only positive result is that 28% of all ICT specialists are women, a score that is very high compared to other EU countries. In the area of Connectivity, Bulgaria scores lower than the EU average in terms of both fixed and mobile broadband take-up. 5G readiness is also lower than the EU average. The examination of enterprises' ability to integrate digital technology shows mixed results. According to this index, the use of Artificial Intelligence is higher than the EU average; this assessment, however, contradicts Eurostat data where Artificial Intelligence use in Bulgarian enterprises is lower than the EU average. Bulgaria scores low on enterprise engagement in e-commerce (the result is around half the EU average). In the area of digital public services, the score is below the EU average for citizens but above the EU average for enterprises due to an active national strategy in that regard (European Commission, 2021).

Digital Transformation Scoreboard

In 2018, Bulgaria scored low in the European Commission's Digital Transformation Scoreboard. The scoreboard provides a comparative assessment of the factors supporting digital transformation

in the EU countries. The Digital Transformation Enablers' Index assesses five categories of enablers (digital infrastructure, investment and access to finance, supply and demand of digital skills, e-leadership and entrepreneurial culture). The Digital Technology Integration Index assesses the effects of digital transformation, namely to what extent companies are using digital technologies (enterprises that have an ERP, enterprises using RFID technologies as part of production and service delivery process, enterprises using two or more social media, enterprises sending invoices in an agreed standard format which allows their automatic processing, enterprises that buy at least one cloud computing services, SMEs selling online, SMEs' total turnover from e-commerce, SMEs that carried out electronics sales to other EU countries). The scoreboard focuses on 9 technologies – big data and data analytics, cybersecurity solutions, social media, robotics and automation, 3D printing, mobile services, cloud technologies, Internet of Things, Artificial Intelligence.

Bulgaria's score on the Digital Technology Integration Index is 22.5, compared to an EU average of 37.3. Similarly, Bulgaria scores 33.8 on the Digital Transformation Enablers' Index compared to an EU average of 49.2 (European Commission 2018). It is found to be among the EU's least digitally aware countries, with little ongoing discussion of key technologies such as cybersecurity, blockchain, Artificial Intelligence, Robotics or 5G. On the positive side, Bulgaria is assessed to have a positive entrepreneurial culture and boasts a good score on ICT start-ups, higher than the EU average (a score of 67, compared to an EU average of 43). All in all, the Scoreboard concludes that while Bulgaria performs well in the field of entrepreneurial culture and ICT start-ups, it performs poorly in the field of investments, digital infrastructure, e-leadership, supply and demand of digital skills, and digital transformation.

Roland Berger Industry 4.0 Readiness Index

The Industry 4.0 Readiness Index developed by Roland Berger (2014) is based on two sets of indicators:

1. *Industrial excellence,* which bundles together indicators related to the sophistication of the production process, the degree of automation, the workforce readiness and innovation intensity
2. *Value network,* which bundles together indicators related to high value added, industry openness, innovation network and Internet sophistication.

Bulgaria has the lowest score compared to all other EU countries included in the study. Based also on the share of manufacturing in GDP, it is included in the cluster of „hesitators", together with Poland, Slovakia, Italy, Spain, Portugal, Estonia and Croatia. While the index was calculated back in 2014, it stands to reason that Bulgaria's position has not improved relatively to the position of the other countries.

Readiness for the Future of Production Index

Bulgaria scores relatively low in the European context according to the Readiness for the Future of Production Index, which measures the factors that enable the successful adoption of emerging technologies in production (WEF, 2018). The index is based on comparing the countries' structure of production (complexity and scale), and 6 drivers of production – 1) innovation and technology, 2) human capital and skills, 3) regulation and governance (institutional framework), 4) natural resources and sustainability, 5) global economy, trade and investment, and 6) demand environment.

Out of 100 countries in the world, Bulgaria scores 36th on Technology and Innovation and 30th place on Sustainable Resources, but occupies only 52nd place on Human Capital and Skills, 55th place on Institutional Framework, 51st place on Global Trade & Investment and 60th place on Demand Environment. The country's score is fairly reasonable with respect to share of manufacturing in employment, share of venture capital relative to the economy and to some extent economic complexity. However, very low scores stand out in the areas related to human capital and skills, and in particular with respect to Availability of scientists and engineers (80th place in the world), Digital skills of the population (72nd place), Capacity to attract and retain talent (88th place), On-the-job training (90th place).

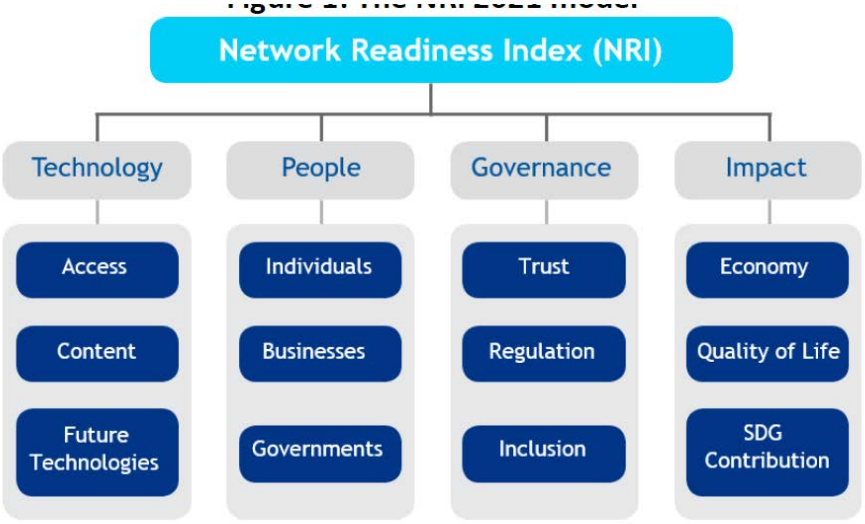
The scores on Technology and Innovation are less than satisfactory, too, especially in the European context. The country's performance on indicators such as firm-level technology absorption, impact of ICTs on new services and products, company investment in emerging technology and companies embracing disruptive ideas are less than would be expected for a EU member state.

Driver: Technology & Innovation 0-10 (best)	36	4.8
Technology Platform 0-10 (best)	44	6.4
2.01 Mobile-cellular telephone subscriptions /100 pop.	41	127.2
2.02 LTE mobile network coverage % population	50	86.8
2.03 Internet users % pop.	58	59.8
2.04 FDI and technology transfer 1-7 (best)	43	4.7
2.05 Firm-level technology absorption 1-7 (best)	57	4.5
2.06 Impact of ICTs on new services and products 1-7 (best)	51	4.7
2.07 Cybersecurity commitment 0–1 (best)	45	0.6
Ability to Innovate 0-10 (best)	35	3.1
2.08 State of cluster development 1-7 (best)	60	3.7
2.09 Company investment in emerging technology 1–7 (best)	45	3.7
2.10 Gov't procurement of advanced technology products 1-7 (best)	50	3.3
2.11 Companies embracing disruptive ideas 1-7 (best)	65	3.4
2.12 Multi-stakeholder collaboration 1-7 (best)	65	3.5
2.13 R&D expenditures % GDP	39	1.0
2.14 Scientific and technical publications Number per Billion PPP$ GDP	43	15.3
2.15 Patent applications applications/million pop.	40	3.86
2.16 Venture capital deal volume US$ millions	47	3,171.9
2.17 Venture capital deal volume per size of economy US$/GDP	18	59.7

Source: WEF, 2018, pp. 80-81.

Portulans Institute Network Readiness Index

The Network Readiness Index (NRI) developed by the Portulans Institute is a global index on the application and impact of ICTs in economies around the world. The 2021 Portulans Institute report maps the network-based readiness of 130 economies based on their performances in four different pillars: Technology, People, Governance, and Impact. The index is composed of 60 variables.



Of the 4 pillars, the Technology pillar is the most important one for the purpose of our study. Unfortunately, this is where Bulgaria scores rather low, ranking 56 out of all 130 countries. In the sub-pillar Future Technologies (adoption of emerging technologies, investment in emerging technologies, robot density and computer software spending), it performs even worse and ranks 78. Bulgaria lags behind the Europe region in all Pillars (Portulans Institute, 2021).

Other studies

According to a 2017-2018 survey of 367 Bulgarian enterprises, covering all geographical regions and most of the traditional sectors (Nikolova-Alexieva and Mihova, 2019), 5% of the Bulgarian small and medium-sized companies lack any digitalization. The majority of the companies (68%) are at the early stage of digitalization and only provide digital information but have no active interaction with customers online. Only around 20% of the companies are involved in e-engagement, including e-commerce, two-way communication with customers online, and e-business processes. 6% of the companies are in the integral stage of digitalization, with fully digitalized internal processes, customer relations and value-chain relations. Only 1% of all companies can be characterizes as having the highest degree of digitalization (Nikolova-Alexieva and Mihova, 2019, p. 262). Even though we believe some major improvements have been observed in the period after 2019, these 2018 results clearly show that Bulgarian industry does not utilize the potential of digitalization to a satisfactory extent.

Bulgaria's score in composite indexes and indicators relevant to innovation and talent development

European Innovation Scoreboard

The European Innovation Scoreboard 2021 classifies Bulgaria in the group of "emerging innovators" with an overall index amounting to just 44.5% of the EU average for the same year. There has been some gradual improvement over the last few years (around 7% compared to the 2014 baseline), but even this upward trend does not live up to the potential shown by the EU as a whole, where the average improvement has been 12.5% over the same period. The best performance is recorded in:

- Digitalization, but the result is only due to better performance on the broadband penetration indicator
- Intellectual assets, due to good performance in the trademark applications and industrial design applications indicators
- Environmental sustainability, due to the environment-related technologies indicator, where Bulgaria scores over 80% of the EU average for the same year.

Yet Bulgaria's performance on the other digitalization-related indicator – People with above basic overall digital skills – is overall dismal, assessed at just 9% of the EU average (https://ec.europa.eu/docsroom/documents/45907/attachments/1/translations/en/renditions/native).

Global Innovation Index

According to the results in the 2021 Global Innovation Index of the World Intellectual Property Organization (Global Innovation Index, 2021), Bulgaria showcases a positive trend and reaches 35th position out of 132 countries (up from 37th compared to 2020). More specifically, it reaches 27st position on knowledge and technology outputs and 36th position on infrastructure.

In 2020, enterprises have provided 36% of the Research and Development (R&D) funds in Bulgaria, but over 90% of them have been spent within the enterprise sector itself, mostly on in-house research and development. Technology transfer is much less common. Only 6% of business (R&D) spending is targeted at scientific organizations and universities. In the same year, the public sector has provided 25% of all R&D funds. Around 85% of these funds have been spent within the public sector and 12% have been spent in higher education institutions. Much of the public-sector research is not sufficiently applicable to the economy and society or does not receive market realization. Public institutions and universities are not active in start-up and spin-off activities or technology transfer (despite the formal existence of Transfer of Technology Offices). There has been no clear connection between funding for universities/research organizations and the quality and applicability of the research they produce. This latter problem is being addressed by the government with recent policy measures.

According to both the Global Innovation Index 2021 and the IMD World Talent Ranking 2020 (https://www.imd.org/centers/world-competitiveness-center/rankings/world-talent-competitiveness/), Bulgaria struggles with deficiencies concerning human capital for research activities. It ranks very low in Europe in areas such as factors enabling talent, and ability to attract, grow and retain talent.

Digital skills

In Bulgaria the level of digital skills of the population and the workforce is very low by European standards. Based on 2021 Eurostat data, only 31% of individuals have at least basic digital skills; in the EU-27 the average share is 54%. The individuals with above basic digital skills in Bulgaria are

only 8%, compared to an EU-27 average of 26%. This stalls the economy, hinders industrial transformation, reduces Bulgarian companies' competitiveness in the digital world and hinders the development of e-government. In Bulgaria, only around 17% of the population interacts electronically with the government, one of the lowest score in the EU (Hallward-Driemeier et al., 2020, p. 133). There is a clear relationship between digital skills and age in Bulgaria, which is directly related also to productivity. More than 80% of the younger people consciously use the internet and digital devices, while this is not true of the older population. The digital inequalities between age groups are likely to also influence jobs and employment (Kostov et al., 2021, p.7). The share of graduates in tertiary education in science, mathematics, computing, engineering, manufacturing and construction per 1000 of population aged 20 – 29 stands at 14.3%, making Bulgaria one the countries with the lowest such share in the EU. According to the OECD's PISA survey from 2018, Bulgarian students were the worst performer in science and the second to worst in mathematics in the EU-27. The survey found out that 47% and 44% of the 15-year olds in Bulgaria underperformed in science and mathematics respectively. The corresponding OECD-average percentages are 22% and 24% respectively (OECD, 2018).

Shortages of skilled ICT staff are a continuous issue for the business sector in Bulgaria and impede competitiveness. Around 40% of the Bulgarian companies report shortage of ICT personnel (Stefanov et al., 2021, p.54). On the positive side, the number of ICT experts in Bulgaria is growing, as is the share of ICT experts in employment.

Bulgaria ranks 46th in the Global Talent Competitiveness Index, which compares 125 economies in terms of human capital and its contribution to national competitiveness. This score is very low in the European context. As regards the enabling factors for talent, the country scores low on technology utilization and professional management, and not very high on investment in emerging technologies. The score is generally low in terms of attracting and developing talent, and higher on the indicators concerning mid-level skills and high-level skills and innovation output. Bulgaria scores 95th in the global pool in terms of availability of scientists and engineers. On the positive side, the country has been improving its position since 2019 (Lanvin and Monteiro, 2021).

Statistical data

Statistical data, as presented in the tables below and additionally in Annex I, indicates that despite good basic economic indicators, such as the share of industry and the ICT sector in GDP, Bulgaria lags behind other EU countries in almost all enterprise-level indicators pertinent to digitalization and Industry 4.0. Overall, Bulgarian enterprises are not taking up new digital technologies and innovative business models as fast as enterprises in most other EU countries. For some indicators, the performance of Bulgarian enterprises is far below the EU average. This includes basic indicators such as digital intensity of enterprises and innovation potential. Performance is also rather poor in the area of e-commerce, use of cloud computing, and cybersecurity. The raw data thus confirms the information derived from composite indexes presented above.

Note on source: The statistical data below is derived from the Eurostat database.

Basic economic indicators pertinent to Industry 4.0 readiness

Indicator	Year when data is provided	Bulgaria	EU-27

Percentage of industry in GDP	2020	17.7%	17.5%
R&D spending (as % of GDP)	2020	0.85%	2.32%
Percentage of the ICT sector in GDP	2019	6.62%	4.89%
Percentage of innovative industrial enterprises in the overall number of enterprises	2018	35.3%	53.1%
SMEs with at least a basic level of digital intensity (% of enterprises)	2020	33%	60%

Notes:

The industrial sector in Bulgaria is dominated by the manufacturing sub-sectors (metallurgical, chemical, and machine building). However, the most dynamic sectors are textile, pharmaceutical products, cosmetic products, mobile communications and the software industry (Kostov et al, 2021, p.10).

In 2020, R&D expenditure as a share of Bulgarian GDP was only 0.85% (as compared to an EU-27 average level of 2.32%). 40% of all R&D expenditure was financed from foreign sources. Within the public sector and the higher education sector, 90% of the R&D spending is used to cover regular costs such as salaries, renovations and consumables, while only 10% is invested into specific research projects. Risk financing is just 0.018% of GDP, and most financing opportunities are concentrated in Sofia and the ICT sector. Business expenditure on R&D is growing faster than public expenditure but, at a level of 0.56% of GDP, it is still below the EU-average of 1.46% of GDP (Draft Programme "Research, Innovation and Digitalization for Smart Transformation" 2021-2027, 2022, p. 5).

Basic enterprise indicators pertinent to electronic information sharing

Indicator	Year when data is provided	Bulgaria	EU-27
Electronic information sharing (% of enterprises)	2019	23%	36%
Enterprises that use ERP software package to share information between different functional areas (% of enterprises)	2021	22%	38%
Enterprises using software solutions like Customer Relationship Management (CRM) (% of enterprises)	2021	17%	35%

Basic enterprise indicators pertinent to e-commerce

Indicator	Year when data is provided	Bulgaria	EU-27
SMEs selling online (% of enterprises)	2020	8%	17%
e-Commerce turnover (% of SME turnover)	2020	3%	12%
Enterprises sending e-invoices in a standard structure suitable for automatic processing (% of enterprises)	2020	10%	32%

Basic enterprise indicators pertinent to Industry 4.0 technologies – Internet of Things

Indicator	Year when data is provided	Bulgaria	EU-27
Enterprises using interconnected devices or systems that can be monitored or remotely controlled via the internet (% of enterprises)	2021	15%	29%
Enterprises using two or more Internet of Things devices or systems (% of enterprises)	2020	5%	7%
Enterprises using Internet of Things devices for premises' security (% of enterprises)	2021	11%	21%
Enterprises using Internet of Things devices for production processes (% of enterprises)	2021	3%	5%
Enterprises using Internet of Things devices for logistics management (% of enterprises)	2021	4%	6%

Basic enterprise indicators pertinent to Industry 4.0 technologies – Artificial Intelligence (AI)

Indicator	Year when data is provided	Bulgaria	EU-27
Enterprises using AI (% of enterprises)	2020	5%	7%

Enterprises using AI technologies for machine learning (e.g. deep learning) (% of enterprises)	2021	1%	3%
Enterprises using AI technologies for automating different workflows or assisting in decision making (% of enterprises)	2021	2%	3%
Enterprises using AI technologies for marketing or sales (% of enterprises)	2021	1%	2%
Enterprises using AI technologies for production processes (% of enterprises)	2021	1%	2%
Enterprises using AI technologies for organisation of business administration processes (% of enterprises)	2021	1%	2%
Enterprises using AI technologies for management of enterprises (% of enterprises)	2021	0%	1%
Enterprises using AI technologies for logistics (% of enterprises)	2021	0%	1%
Enterprises using at least one of the AI technologies: AI_TTM, AI_TSR, AI_TNLG, AI_TIR, AI_TML, AI_TPA, AI_TAR (% of enterprises)	2021	3%	8%

Basic enterprise indicators pertinent to Industry 4.0 technologies – Cloud Computing

Indicator	Year when data is provided	Bulgaria	EU-27
Enterprises buying cloud computing services used over the Internet (% of enterprises)	2021	13%	41%

Basic enterprise indicators pertinent to Industry 4.0 technologies – Big Data

Indicator	Year when data is provided	Bulgaria	EU-27
Enterprises analysing big data internally from any data source (% of enterprises)	2020	6%	13%

Enterprises analysing big data internally from any data source or externally (% of enterprises)	2020	6%	14%
Enterprises having another enterprise or organisation perform big data analysis for them (% of enterprises)	2020	1%	3%
Enterprises purchasing (access to) any big data (% of enterprises)	2020	0%	1%
Enterprises analysing big data from smart devices or sensors (% of enterprises)	2020	2%	3%
Enterprises analysing big data from geolocation of portable devices (% of enterprises)	2020	4%	7%
Enterprises analysing big data generated from social media (% of enterprises)	2020	2%	7%
Enterprises analysing big data internally using machine learning (% of enterprises)	2020	1%	2%

Basic enterprise indicators pertinent to Industry 4.0 technologies – 3D Printing

Indicator	Year when data is provided	Bulgaria	EU-27
Enterprises using 3D printing (% of enterprises)	2020	3%	5%
Enterprises using own 3D printers (% of enterprises)	2020	1%	3%
Enterprises using 3D printing services provided by other enterprises (% of enterprises)	2020	2%	3%

Basic enterprise indicators pertinent to Industry 4.0 technologies – Automation

Indicator	Year when data is provided	Bulgaria	EU-27
Enterprises using service robots (% of enterprises)	2020	2%	2%

Enterprises using industrial robots (% of enterprises)	2020	4%	5%
Enterprises using industrial or service robots (% of enterprises)	2020	6%	7%

Basic enterprise indicators pertinent to Industry 4.0 technologies – Cybersecurity

Indicator	Year when data is provided	Bulgaria	EU-27
Enterprises that experienced at least once problems due to an ICT related security incident (unavailability of ICT services, destruction or corruption of data, disclosure of confidential data) (% of enterprises)	2019	16%	13%
Enterprises having insurance against ICT security incidents (% of enterprises)	2019	3%	20%

Variations across enterprise size and region

In Bulgaria, digitalization and the innovations related to Industry 4.0 are much more widespread in big companies than in small ones. According to experts, companies owned by international corporations are also more likely to be digitalized.

Indicator	10-49 employees	50 - 249 employees	Over 250 employees
Enterprises with internet access	95.4%	99.3%	100%
Enterprises using paid cloud computing services	10%	22.6%	44.6%
Enterprises performing big data analysis	5%	10.7%	21.4%
Enterprises using ERP software	17.1%	40.1%	65.2%
Enterprises using CRM software	14.3%	27.9%	34.8%
Enterprises sending e-invoices suitable for	8.9%	13.8%	24.2%

automated processing			
Percentage of innovative enterprises in the overall number of enterprises 2018	24.2%	46.8%	76.1%

Source: Bulgarian National Statistical Institute, data for 2021 (https://nsi.bg/en/content/2841/ict-usage-enterprises; https://www.nsi.bg/en/content/2712/innovation-active-enterprises-share-all-enterprises)

There is also great divergence between the Industry 4.0 readiness of different regions in Bulgaria. Yugozapaden region (the region in and around Sofia) has great potential in augmented reality (top 10 of all European regions), cybersecurity, additive manufacturing and autonomous vehicles (Hallward-Driemeier et al., 2020, p. 193). In the Sofia region there is a large concentration of companies in the mechatronics and ICT sectors. The demand side – the users of mechatronics and ICT products, as well as various intermediaries, are also located in Sofia. In the subsector of computer programming, 87% of the revenue of the entire sector is concentrated in Sofia, as well as 80% of the jobs, and 91% of the added value. A similar disproportion is observed in other subsectors, such as: Information Service Activities (81% of the sector revenues are in Sofia), Manufacture of Computer, Electronic and Optical Products (67% of the sector revenues are in Sofia), Scientific R&D (92% of the sector revenues are in Sofia) (Stefanov et al., 2021, p.57).

Main barriers to digitalization in Bulgarian SMEs

According to experts and current studies, some of the main barriers to digitalization in Bulgarian SMEs are:

- Low level of investment in the development of industry, both in terms of financial and human resources. Resource mobilisation is dependent on financial assistance from the EU
- Suboptimal coordination and use of the different EU level instruments
- Low levels of R&D spending overall, and especially in the public sector.
- Low levels of patenting and publication activity, indicating that Bulgaria is relying on imported technology
- Insufficient awareness and knowledge about high-tech solutions
- Insufficient financial resources for the purchase of technology and digital solutions
- Insufficient capacity to invest in research and innovation activities for the creation of the necessary technology
- Shortages of highly qualified ICT staff and difficulties in training existing staff to use high-tech solutions, especially in smaller towns (Kostov et al., 2021, p. 8)
- Low levels of digital skills across the population
- Adoption of some elements of Industry 4.0 but overlooking other steps in automation and digitalization, which makes the process suboptimal and does not allow the companies to capitalize on all potential gains in productivity and competitiveness.
- Suboptimal interaction and coordination between the national and regional authorities

- Suboptimal collaboration between the public authorities, the business sector and other stakeholders affected by industrial transformation
- Small domestic market for ICT and mechatronics services and products, especially for the more advanced ones. The public sector is also not acting as a driver for innovative services and products in the ICT and mechatronics sectors. Export markets are not fully used due to the lack of integrated public-private market intelligence services and instruments (Kostov et al., 2021, p. 95)
- Weak connection with international networks and value chains; insufficient Foreign Direct Investment flows to the mechatronics and ICT business, which prevents upward movement on the value-added chain
- While the export orientation of the ICT and mechatronics companies is an advantage, there is no specific market niche where Bulgarian enterprises emerge as competitive.

National strategic planning and regulatory documents

Policy context and strategic documents

In the 2014-2020 period, the Bulgarian government developed several strategic plans relevant to the digitalization of Bulgaria's economy and industry. These documents were relatively effective in kick-starting important reforms and support measures and shaping a pro-digitalization policy context:

- National Broadband Development Strategy 2012 – 2015
  https://www.mtitc.government.bg/upload/docs/AktualiziranaStrategia.pdf
- Connect Bulgaria: National Broadband Infrastructure Plan for Next Generation Access 2014
  https://www.mtitc.government.bg/upload/docs/2014-07/BG_NGA_PLAN_ENG.pdf
- Digital Bulgaria 2015 Programme and Action Plan
  https://www.mtc.government.bg/en/category/85/national-programme-digital-bulgaria-2015
- Updated policy in the field of electronic communications 2015 – 2018
- Innovation strategy for smart specialization 2014 – 2020
  https://www.mi.government.bg/files/useruploads/files/innovations/ris3_26.10.2015_en.pdf
- E-Governance Development Strategy 2014 – 2020
  https://www.mtc.government.bg/sites/default/files/uploads/pdf/e_governance_strategy.pdf
- Concept for promoting the education of software specialists 2015
  https://www.strategy.bg/FileHandler.ashx?fileId=6315
- National Cybersecurity Strategy: Cyber Resilient Bulgaria 2020
  https://www.strategy.bg/StrategicDocuments/View.aspx?lang=bg-BG&Id=1120
- National Strategy for Small and Medium-sized Enterprises 2014 – 2020
  https://www.mi.government.bg/files/useruploads/files/national_strategy_sba_2014-2020-veren.doc

- Concept for Digital Transformation of the Bulgarian Industry (Industry 4.0) 2017 – 2030
  https://www.mi.government.bg/bg/themes/koncepciya-za-cifrova-transformaciya-na-balgarskata-industriya-industriya-4-0-1862-468.html
- Draft Industry 4.0 Strategy 2018
  https://www.bia-bg.com/uploads/files/events/Industry_4.0/Strategy_Industry%204.0_draft_30%20March%202018.pdf

More recently, many of these documents have been updated and some new ones have been adopted with the objective to further shape the state of digitalisation in the course of industrial transition. The documents are in general harmony with, and faithfully reflect, current EU priorities and policies:

- National Program "Digital Bulgaria 2025"
  https://www.mtc.government.bg/sites/default/files/uploads/it/09-12-2019_programa_-cifrova_bulgariya_2025.pdf
- Connected Bulgaria: Updated National Broadband Infrastructure Pan for Next Generation Access 2020
  https://www.mtc.government.bg/sites/default/files/updatedngaplanconnectedbulgaria.pdf
- National Development Programme Bulgaria 2030
  https://www.minfin.bg/upload/46720/National%2BDevelopment%2BProgramme%2BBULGARIA%2B2030.pdf
- Draft Partnership Agreement for Bulgaria 2021 – 2027
  https://ec.europa.eu/info/publications/partnership-agreement-bulgaria-2021-2027_en;
  https://www.eufunds.bg/bg/node/4825
- Updated Innovation Strategy for Smart Specialisation 2021 – 2027
  Under elaboration, draft available from
  https://www.strategy.bg/FileHandler.ashx?fileId=29718
- National Strategy for the Development of Scientific Research 2017 – 2030
  https://www.strategy.bg/FileHandler.ashx?fileId=9594
- National Strategy for SMEs 2021 – 2027
  https://www.mi.government.bg/files/useruploads/files/MSP/SME_strategy.doc
- Digital Transformation of Bulgaria for the period 2020 – 2030
  https://www.mtc.government.bg/sites/default/files/digitaltransformationofbulgariafortheperiod2020-2030f.pdf
- Concept for the Development of Artificial Intelligence in Bulgaria until 2030
  https://www.mtc.government.bg/en/category/157/concept-development-artificial-intelligence-bulgaria-until-2030
- Updated National Cybersecurity Strategy: Cyber Resilient Bulgaria 2023
  https://www.strategy.bg/FileHandler.ashx?fileId=24215
- The Digital Bulgaria 2025 Programme and its Roadmap

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The policy context created by these different but interconnected strategies is presented in detail below.

Policy in support of Industry 4.0

The 2018 Industry 4.0 Strategy outlines the following priority areas of intervention:

(1) Strengthening the links between science and industry and facilitating the participation of Bulgaria in European and international programs, initiatives and networks related to Industry 4.0

(2) Achieving higher technological sophistication of the Bulgarian economy by introducing standards, ensuring the security of smart production systems, taking up innovative business models, building a broadband infrastructure for industry, improving the business environment and the regulatory framework, and improving resource and energy efficiency

(3) Building human, scientific, organizational and institutional capacity through changing outdated organization and structures of work and promoting digital skills at all levels of education and training, including on-the-job training, retraining and lifelong learning

Among some of the measures proposed for supporting Industry 4.0 in Bulgaria are:

- Attracting relevant Foreign Direct Investment through government initiatives. Current investment promotion policies focus on industrial sectors such as mechanical engineering, electronics and electrical engineering, automotive sector, production of medical equipment and medicines, production of optical products, ICT, scientific and research activity, technological and industrial parks
- Tax relief
- Financial guarantees thought the Bulgarian Development Bank
- Risk capital funds
- Innovation vouchers through the National Innovation Fund
- Funding for relevant projects through the National Innovation Fund
- Infrastructure such as test laboratories, clusters, research and innovation infrastructure, establishment of Digital Innovation Centres. Digital Innovation Centres are planned as key elements of a support ecosystem for the digitalization of industry, with specific focus on supporting small and medium-sized enterprises (SMEs).

In general, the government's policy for promoting Industry 4.0 focuses on:

- Institutional support for the development of Industry 4.0 and creating synergies between existing policies, programs, strategies and support measures
- Educational and scientific initiatives to build institutional and organizational capacity for Industry 4.0
- Supporting the creation of pilot projects and demonstration models.

In addition to this overarching strategy, the Bulgarian government has developed strategic documents focusing on specific areas of technology pertinent to Industry 4.0, such as cybersecurity and Artificial Intelligence.

The national strategy for cybersecurity was updated in 2021. While it is mostly focused on national security, some of the priorities and identified interventions concern also industry, both in terms of maximizing the contribution of industry to the development of cybersecurity solutions, and in terms of industrial cybersecurity. The strategy includes a multitude of priorities and broadly defined aspirations, many of which are, as of now, not translated into concrete realistic plans of action. All in all, however, it manages to outline the key areas and actions that will likely become a focus of government interventions in the future. Among those that are relevant to industry are:

- Improving the legal and regulatory frameworks
- Improving the security of internet environments
- Strengthening European cooperation in the cybersecurity area and introducing a EU framework (and a national system) for cybersecurity certification of IT products, services and processes
- Improving network and information systems security - accelerating the transfer and adoption of good practices and technologies; implementation of modern tools and platforms for identifying and responding to incidents and security breaches; carrying out analysis, tests and simulations, and pilot and test projects at the initiative and with the resources of industry; increasing investments in network and information systems security; improving the knowledge and skills of specialists in network and information systems security
- Addressing emerging cybersecurity issues in digital processes and spheres such as e-commerce, internet payment gateways, financial services, e-payments and digital currencies, e-healthcare and insurance, social networks, search engines, cloud services and applications, online media, etc.
- Implementation of enterprise-level standards for information security and cybersecurity suitable for SMEs
- Improving awareness of cybersecurity and building a cyber culture in enterprises, with a focus on SMEs
- Including SMEs in information sharing and prevention networks
- Introducing measures to ensure the reliability, accessibility and security of open data
- Building skills, competences, capacity and momentum for research and innovation in the field of cybersecurity, including through new initiatives and through technology parks, centers of excellence and centers of competence
- Implementing programs for the technological development of industry that incorporate systems and solutions designed to ensure cybersecurity and protection
- Supporting industry through testing for cyber security breaches, and through simulation environments for checking and increasing resistance to attacks and breaches
- Establishing of a mechanism for sharing resources, capacity and skills between the private, public and academic sectors

- Engaging the major ICT companies and multinational technology companies in the process of developing a National Cybersecurity System, in increasing the security of the Internet space, and in supporting SMEs and national and international centers of competence.

The Concept for the development of Artificial Intelligence (AI) in Bulgaria until 2030 charts the vision and the policy priorities for the development and use of AI in Bulgaria. It prioritizes the development of modern and reliable communications and scientific infrastructure, availability and access to open data, data sharing architectures, interoperability of available public data, and introduction of AI-based innovation in key sectors. The concept recognizes the need to improve knowledge, skills and research, innovation and technology transfer capacity. Finally, setting up the necessary regulatory framework for the development and implementation of reliable and ethical AI technologies is recognized as a precondition for further innovation in the AI sector, along with raising awareness and building trust in society. Interestingly, with the exception of the information technology industry (software industry), the industry sector is not mentioned as a priority sector for the development of AI.

Some of the specific proposed measures are:

- Organizing and integrating available infrastructure
- Organizing experts for the accumulation of large data sets in priority areas to help define formats, structures, standardization approaches and interoperability of data sets
- Creating incentives for organizations to share data
- Providing freely accessible data for AI applications and high-tech AI platforms
- Constructing digital information hubs in the field of AI and robotics, co-financed by the European programme "Digital Europe"
- Creating a Bulgarian Research Programme for AI and robotics
- Involving Bulgarian teams in pan-European networks in artificial intelligence, robotics and digitalization, and otherwise enhancing the cooperation between Bulgarian and EU researchers
- Cooperation between education, research and AI professionals in developing joint AI training
- Focusing on the development of education (at all levels) that can provide digital skills specific to the creation and application of AI
- Supporting the transfer of knowledge from science to business via incubators and the creation of start-ups in universities and research organizations
- Enabling the development of research capacity in industry by funding innovative in-house laboratories in companies.

Innovation support policy

Innovation support policy includes support for Industry 4.0. The current framework focuses on:

- Human capital and scientific research, which is focused on improving the digital skills of the population, as well as on enhancing education and training in Information Technology and

Informatics. In order to improve the quality of the workforce, Bulgaria carried out a number of educational reforms and increased the intake of students in professional areas related to Mathematics, Informatics and Computer Sciences, and Communication and Computer Technology. At the end of 2015, the Government developed a Concept for Supporting the Education of Software Specialists. A Strategy for the Effective Application of ICTs in Education and Science until 2020 was also adopted

- Bulgaria's innovation strategy for smart specialization prioritizes Mechatronics, Informatics and ICTs. *Informatics and ICT* and *Mechatronics and Clean Technologies* were priority thematic areas in the Innovation Strategy for Smart Specialization 2014 – 2020. The thematic area *Informatics and ICT* will be a priority in the new Innovation Strategy for Smart Specialization 2021 – 2027. New measures to foster the digitalisation of enterprises through Industry 4.0 will be introduced. It is envisaged that there will be integrated projects for financing innovation in enterprises, which will combine both priority thematic areas - *Informatics and ICT* and *Mechatronics and Clean Technologies*.

  In the 2021 – 2027 Innovation Strategy for Smart Specialisation, the following new approaches are expected:

  - Implementation of Industry 4.0 technologies, business models and processes, and an overall digital transformation of Bulgarian SMEs
  - A much stronger regional dimension, including more focused regional strategies for smart specialization that will pick up just two of the four national thematic priorities.
  - Establishment of an Agency for Research and Innovation at the Council of Ministers, tasked with integrating national Research & Innovation policies and exploiting synergies between initiatives and projects funded by the EU. In the future, the agency is also expected to run a new Operational Programme on Smart Transformation. The said program should support: (i) increasing the quality and capacity of the science and innovation system; and (ii) digitalisation of public services.
  - Progress with technological upgrade support outside Sofia and outside the IT sector

Development policies

Objectives and measures related to Industry 4.0 and digitalization are included in the broader developmental policies of the country. The *National Development Program Bulgaria 2030* outlines the current vision and the overall goals of development policies in Bulgaria. It provides the overarching perspective for the development of the country in the next decade and will likely guide the utilization of the resources from the next Multiannual Financial Framework 2021 – 2027 and the Recovery Package. The program generally aims to accelerate Bulgaria's economic development through specialisation in products and industries with high technological and research intensity. The basic indicators of success are reaching the EU-average in the Digital Economy and Society Index (DESI) and a 15% share of high-tech exports in total exports.

The *Innovative and Intelligent Bulgaria* development axis aims at an economy based on knowledge, smart growth and a high-tech industrial base. This is the basis of the current policy in support of Industry 4.0. The key priority is to stimulate the process of digitalisation of the real economy.

Specifically, efforts will be targeted at strengthening the link between science and industry and developing Industry 4.0.

This axis also foresees interventions at all levels of the education system and the system for qualification and retraining. The interventions are geared towards overcoming the low level of digital competences of the population (with a specific focus on young people, the unemployed, and the economically inactive and disadvantaged groups). A key tool is the partnership with the private sector.

In the field of science and scientific infrastructure, it is planned to (further) develop Centres of Excellence, Competence Centres and Regional Innovation Centres, to raise the standards of research institutions, to modernise R&D equipment, to encourage stronger cooperation between higher education institutions, research institutes and businesses, and to build capacity and develop human resources in the R&D system. This priority includes the objective to improve Bulgaria's performance in the European Innovation Scoreboard by achieving the label "Moderate innovator".

The three priorities – (1) education and skills, (2) science and scientific infrastructure, and (3) smart industry – are rightly addressed together in pursuit of a broader objective and it may be expected that the approach will initiate a coherent policy in support of Industry 4.0 in Bulgaria. It is positive that the Ministry of Economy has developed a draft detailed strategy on the Smart Industry with fairly adequate objectives and planned measures.

Objective	Measures
Digitalization of the economy	Support the development, implementation and use of e-commerce tools, management information systems, and information security systems
	Training for enterprises in the field of digital technologies, information security, e-commerce
	Support for the introduction and implementation of Industry 4.0 technologies, products, processes and standards and business models. The technologies that will be supported include physical computing, Internet of Things, 3D printing and prototyping, Big Data, cloud computing, augmented reality, Artificial Intelligence, cybersecurity systems, machine learning, robotics.
	Creation of a fund to finance Bulgarian Artificial Intelligence and Industry 4.0 projects and provision of national financing for project proposals under the "Horizon 2020" and "Horizon Europe" programs that have received a Stamp of Excellence but have not received EU funding
	Establishment and financing of a centre for testing Industry 4.0 technologies
	Information campaigns to raise awareness about Industry 4.0
	Further development of Sofia Tech Park as a platform for providing

	specialized services in support of the automation and digital transformation of the industry
Technological intensity and innovation ecosystem	Support for the development of innovation-friendly institutional ecosystems and innovation capacity in enterprises, including in SMEs.
	Support for the development of innovations in enterprises, including in SMEs
	Development of a high-tech industrial base
	Promoting specialization in products and services characterised by high technological intensity and innovativeness
	Strengthening the links between business and science and promoting R&D
	Development of regional innovation ecosystems through regional innovation strategies for smart specialization
	Widening the network of innovation centers and creating new ones, including innovation clusters, Centers for Competence, Centers for Excellence, Digital Innovation Hubs, Regional Innovation Centers, Centers for approbation of new technologies, etc. There will be state support for the establishment of Digital Innovation Centers (Hubs) (partly funded by the "Digital Europe" program) to provide businesses with access to technological expertise and experimental facilities. Recently, 17 candidates for European Digital Innovation Hubs under the Digital Europe program were selected. They are geographically located in the six regions of Bulgaria. The selection is in line with the regional specialisation plans set out in Bulgaria's innovation strategy for smart specialisation
	Support for technological modernization and implementation of innovations – priority beneficiaries are the start-ups in the high- and medium-tech industries or the sector of knowledge intensive services
	Support for entrepreneurship and start-ups through financial instruments, guarantees, risk finance, microfinancing and access to infrastructure – priority beneficiaries are the start-ups in the high- and medium-tech industries or the sector of knowledge intensive services
	Support for the development of a strong entrepreneurship ecosystem

	including technological parks, business incubators, venture funds, business angels, crowdfunding platforms, shared spaces, etc.
	Support for the internationalization of the innovation process in enterprises, in particular by promoting the participation of enterprises in international projects and supporting exports and foreign market access for enterprises

In the *Connected and Integrated Bulgaria* development axis, it is foreseen to improve the country's digital connectivity through the establishment of modern and secure digital infrastructure as a basis for offering more services through digital management and collaboration. Cybersecurity is also acknowledged as a prerequisite for the effective functioning of digital infrastructure. The priority focuses on improving access to high-speed internet and the introduction of 5G mobile networks.
The other development axes in the *National Development Program Bulgaria 2030* are unrelated to Industry 4.0 and less related to digitalization.

Policy in support of SMEs
The National Strategy for SMEs 2014 – 2020 is aimed at providing adequate government support for SMEs (specifically innovative SMEs) and at encouraging entrepreneurship. Digitalization and Industry 4.0 are directly addressed in several priority areas that were outlined in this strategy, including those related to more efficient public administration, skills and innovation, and environmental protection. An adequate strategy towards SMEs can encourage Industry 4.0 by supporting: (i) technological transfer and links between business, education, technological parks and the public sector; (ii) R&D in SMEs; (iii) e-commerce; (iv) e-education; (v) SMEs' access to ICTs.

One of the key strategic goals set in the updated National Strategy for SMEs 2021 – 2027 is to promote SME specialization in high-tech and medium-tech industries and in knowledge intensive services, while also reducing existing regional disparities. The proposed areas of interventions are focused on digitalization and skills. Efforts will be targeted at:

- Promoting the digital transformation of SMEs, including by supporting e-commerce, cybersecurity and data storage applications, CRM systems, ERP systems, automation and robots, digital technologies in industrial production
- Reducing the energy intensity of industrial SMEs through technologies and software for the management of production processes
- Encouraging SMEs to provide digital skills training for their employees, and to get actively engaged with vocational education and training, in particular dual education and on-the-job training in STEM-related professions
- Development of web-based platforms and tools for education and training for SME professionals

Policy in support of digital transformation

Bulgaria's strategy for digital transformation for the period 2020 – 2030 (published 2020) identifies the following operational priorities:

- Deployment of secure digital infrastructure, with a focus on improving access to high-speed connectivity via broadband internet access and mobile connectivity, including 5G. The strategy focuses on investment in infrastructure, as well as ensuring cybersecurity, simplifying regulation and reducing the costs for business. The ambition is to ensure by 2030 gigabit connectivity of schools, transport centers, major public service providers and digitally intensive enterprises. Further efforts will be aimed at building an efficient cloud infrastructure, as well as infrastructure for data sharing and artificial intelligence
- Cybersecurity, with a focus on improving cybersecurity training and raising awareness about cybersecurity
- Unlocking the potential of the digital economy, with a focus on encouraging enterprises to take advantage of digital technologies such as Internet of Things, big data, robotics, Artificial Intelligence, blockchain, 3D printing, etc.; financially supporting high-risk innovative start-ups, in both their initial stages and in the scaling stages; digitalization in specific economic sectors such as agriculture, transport, energy, healthcare, finances, culture; digitalization in the area of environmental protection, the circular economy and low-carbon, resource-efficient solutions; promoting and enabling digital governance and the use of open data, digital solutions and interoperable models for data sharing in public administration and the public services
- Access to adequate technological knowledge and digital skills, with the following focus areas:
    - Promoting research and innovation, based on close university-business cooperation, continuing support for, and the development of new, research centers of excellence and centers of competence, participation in collaborative research funded by the EU (e.g. the Horizon program), funding market-oriented applied research in the field of digital technologies, and supporting innovative enterprises in the ICT and other innovative industrial sectors
    - Education and training - provision and maintenance of high-speed and secure basic internet connectivity and cloud-based services, infrastructure and platforms, to enable the digital provision of education, digital governance and network interaction. The strategy mentions also use of big data, augmented and virtual reality, and Artificial Intelligence in education but is not very specific as to the concrete applications. The same is true about the issue of cybersecurity of educational systems and networks. The development of the digitals skills of the participants in the education process, and especially pedagogical staff, is another priority in this part of the strategy.
    - Adaptation of the labor market – measures to provide an effective lifelong education and training system in order to help the workforce adapt, retrain and acquire new skills and knowledge in the digital field. The strategy also recognizes the need for special measures to improve the training of highly qualified ICT specialists, especially within the system of higher and secondary vocational education, through modernization of programs, training of teachers, and appropriate material base. The

role of employers and labour market intermediaries in providing non-formal training is also acknowledged

The Digital Bulgaria 2025 Programme and its Roadmap mirror the above priorities. They plan modernization and widespread introduction of smart IT solutions in all spheres of the economy. The priority areas include development and accessibility of digital networks and services, enhancement of digital competence and skills, a secure cyber ecosystem, Internet governance, a new regulatory framework for electronic communications and digitalization of Bulgarian industrial sectors.

Policy in support of education, training and learning

The Strategic framework for the development of education, training and learning 2021 – 2030 outlines a number of measures in support of digital education:

It is foreseen to purchase computer hardware, with priority given to schools that have not recently received equipment and schools with ICT profiles. The 2016 Pre-School and School Education Act introduced computer programming in the curricula of primary school, starting for 3rd and 4th grades. Additional measures are taken with regard to developing the digital skills of employees. Since 2021, an initiative financed by the European Social Fund and the national budget has focused on developing and testing digital skills profiles for key professions in different economic sectors, and on developing sectoral qualifications frameworks for digital skills development. Young unemployed people are targeted in an initiative of the Ministry of Labour and Social Policy which organises free training courses in digital competences. A 2021-2027 digital competences training program is also launched for all age groups including the elderly and disadvantaged people. The initiative receives EU funding under Operational Programme Human Resources Development (2021-2027).

Digital literacy is a priority in EU funding for the 2021 – 2027 programming period and the available support is expected to benefit more than 670,000 people. Government initiatives are complemented by the efforts of the Digital National Alliance in Bulgaria, whose Memorandum has been signed by key stakeholders such as the Bulgarian Academy of Science, leading Bulgarian universities, the Bulgarian Association of Information Technologies, the Bulgarian Association of Software Companies, the ICT Cluster, and various companies, start-ups and NGOs. The Alliance supports the building of a smart digitized Bulgarian economy.

In 2016, the profession Software Developer was included in the list of professions in Vocational Education and Training in Bulgaria. The government also signed collaboration agreements with relevant business associations to deliver software development training for students, including through a National Program "Training for IT Career".

ICT and Mechatronics are identified as priority areas for R&D in Bulgaria. In 2017, a National Strategy for the Development of Scientific Research in Bulgaria 2017 – 2030 was approved and a National Roadmap for Scientific Infrastructure has been developed and updated (https://www.mon.bg/upload/4012/Roadmap_2017_BG.pdf). The strategy aims at modernizing research and supporting the development of new technologies. Ensuring stronger links between education and business is also recognized as a priority.

A major drawback in the implementation of an effective research and innovation strategy is the unbalanced regional distribution of scientific organizations, universities and successful industrial centers. To address this drawback, policy plans foresee the gradual development of scientific research in the regions, namely through the establishment of regional scientific research centers in the priority areas for smart specialization.

Key support programs

EU-funded operational programmes provide most of the funding for R&D in Bulgaria, including that earmarked for supporting digitalization and Industry 4.0.

Past support programs

Operational Programme *Competitiveness* 2007 – 2014 primarily funded the technological upgrading of Bulgarian companies. A science component existed within the Operational Programme *Human Resources* in the same time period.

In the 2014 – 2020 period, digitalization and Industry 4.0 were mostly supported by Operational Programme *Innovation and Competitiveness* (OPIC) and Operational Programme *Science and Education for Smart Growth* (OPSESG), managed by the Ministry of Economy and the Ministry of Education and Science respectively. The total funding was EUR 1.05 million and 2,131 companies benefited from it.

OPIC and OPSESG funded new technologies in four thematic areas of Bulgaria's first Research and Innovation Smart Specialization Strategy (RIS3):

- Mechatronics and Clean Technologies (around 38% of the funding)
- Informatics and Information and Communication Technologies (26% of the funding)
- Healthy Living and Biotechnology Industries (22% of the funding)
- New Technologies in Creative and Recreational Industries (14% of the funding).

Two RIS3 horizontal priorities - mainstreaming of digital technologies (further digitalisation of industry) and development of resource effective technologies – could also be used to obtain funding for Industry 4.0.

Examples from the 2014 – 2020 programming period include:

OPIC provided funding amounting to EUR 320.8 million for 469 beneficiary companies in the Mechatronics sector (894 projects). These beneficiaries were in the sectors of manufacturing of machinery and equipment (163 beneficiaries), electrical equipment (63 beneficiaries) and computers (52 beneficiaries), ICT (108 beneficiaries), scientific research (33 beneficiaries) (Kostov et al., 2021, p.45).

OPIC and OPSESG funding also focused on intermediary bodies and collaboration between business and research. Among the major projects was the completion of the Sofia Tech Park (funded by OPIC), the creation of 10 Centres of Competence and 4 Centres of Excellence, funded under OPSESG (for a total of 348 million BGN), and two Centres of Excellence, funded by Horizon 2020 and co-funded by OPSESG.

With the exception of one Centre of Competence, all others are in the Mechatronics, clean tech and ICT sectors. The centres merge the expertise of 59 institutes, universities, research organizations

and business organisations. They were expected to raise the market relevance of scientific research, build capacity for research and innovation, build scientific infrastructure and contribute toward the establishment of new enterprises. The Strategic Evaluation of the Centres of Competence and Centres of Excellence (2021) concludes that the Centres have not managed to develop research and innovation programs that are sufficiently industry or market specific, and that technology transfer activity is still limited. A specific challenge is the lack of technology transfer knowledge and skills, as well as adequate strategies for IP exploitation. The Evaluation recommends that government policy should not just provide funding for the Centres but intervene to support a strong Research & Innovation ecosystem through capacity building targeted at academia-industry collaboration and technology transfer.

Some 650 Bulgarian organizations have received around EUR 156 million funding from Horizon 2020, which is only 0.26% of the EU's total (Draft Programme "Research, Innovation and Digitalization for Smart Transformation" 2021-2027, 2022, p. 12). Among the most substantial projects is Sofia's new Big Data Center of Excellence. Some projects focused on big data, robots and advanced computing are led by Bulgarian universities and research institutes.

In addition to EU funding, Bulgaria provides funding for R&D from the national budget. Most of it is in the form of direct subsidies to public research institutions such as the Bulgarian Academy of Sciences. Competitive national funding for R&D is not substantial and is allocated through two instruments: the National Science Fund, which funds only research organisations, and the National Innovation Fund, which funds businesses. The National Innovation Fund follows the RIS3 priorities. Since 2005, the Fund has financed over 500 projects for around BGN 100 million.

Current support programs

National Recovery and Resilience Plan

The Plan (2020), which falls under the NextGenerationEU temporary recovery instrument of the EU, has 4 pillars, two of which are relevant to digital transformation and Industry 4.0. The table below provides more details based on the preliminary plans:

Pillar	Components	Key interventions	Projects
Innovative Bulgaria	Education and skills	Reforms at all levels in education Creating a national STEM environment for skills of tomorrow (building a comprehensive educational STEM environment in Bulgarian schools) Trainings for digital skills and building a national online platform for adult learning	***STEM Centres and Innovations in Education (2021-2025)*** - Building a comprehensive educational STEM environment in Bulgarian schools - Creating a National STEM Center and regional STEM Centres - Creating STEM Centres in 2,240 schools, featuring STEM laboratories and learning spaces *Total budget: BGN 480 million EU funding, BGN 96 million national co-funding* ***Trainings for digital skills and building a national online platform for adult learning***

			(2021-2026) - Free and accessible training for unemployed and employed persons – basic and medium level of skills - Building national online platform for adult learning *Total budget: BGN 322 million EU funding, BGN 57.5 million national co-funding*
	Research and innovation	Implementing a common policy for development of research, innovation and technologies in view of improving economic and social development of the country Programme for accelerating economic recovery and transformation through science and innovation	***Programme to accelerate economic recovery and transformation through science and innovation (2021-2026)*** - implementation of project proposals from innovative SMEs that have received „Seal of Excellence" in European Innovation Council competitions, and project proposals under the "Widening Participation" element of the "Horizon Europe" program for strengthening the research and innovation capacity of the Bulgarian higher education institutions and research organizations - creating and piloting a national model for development of research universities and a network of such universities in Bulgaria *Total budget: BGN 366.5 million EU funding, BGN 34.5 million national co-funding* ***Enhancing the innovation capacity of the Bulgarian Academy of Sciences in the field of green and digital technologies (2021-2026)*** - Infrastructure improvements - Development of innovation products and technologies - Acquisition and development of new technologies - Development of human capital - Improving the pool of experts *Total budget: BGN 46.5 million EU funding, BGN 5.5 million national co-funding*
	Smart industry (Industry 4.0)	- Updating the strategic framework for the industrial	***Programme for public support for development of industrial parks and improvement of their infrastructural***

		sector (reform) - Building a mechanism to attract industrial investments and develop industrial ecosystems (reform) - Programme for public support for the development of industrial parks and improvement of their infrastructural connectivity (investment) - Economic transformation programme (investment)	***connectivity (2021-2026)*** - Development of infrastructure of industrial parks - Measures to attract and retain strategic investors *Total budget: BGN 216.5 million EU funding, BGN 420 million private funding* ***Economic transformation programme*** The program provides targeted support to SMEs in areas slowing down the transformation to a digital, low-carbon and resource-efficient economy. The following funds are relevant to Industry 4.0 - Fund 1 - "Growth and Innovation" (BGN 731 million EU financing and BGN 826 million private funds): a) providing support for technological modernization through the purchase of technological equipment, with a special emphasis on digitalization; b) grants for ICT and cybersecurity solutions – support for solutions for the initial stages of digitalisation (Computerisation and Connectivity) and cybersecurity solutions; c) support for innovations, with special emphasis on the areas of ICT, industrial automation, Artificial Intelligence, robotics, blockchain, fintech, cybersecurity, quantum technologies, biotechnologies, etc. - Fund 3 - "Climate Neutrality and Digital Transformation" (BGN 59 million EU financing and BGN 59 million private funds): supports infrastructure projects, including digital infrastructure (ICTs, optical infrastructure, data centers, 5G, etc.)
Connected Bulgaria	Digital connectivity	- Development and implementation of an effective policy and regulatory framework - Efficient use of the radio frequency spectrum - Creating a favourable investment environment - Large-scale deployment of	***Large-scale deployment of digital infrastructure (2021-2025)*** - building of symmetric gigabit access networks throughout the country *Total budget: BGN 527 million EU financing, 105.5 million national co-financing*

		digital infrastructure	

Research, Innovation and Digitalization for Smart Transformation Program 2021-2027

The total funding planned to be made available is EUR 1,095,010,854, of which EUR 864,290,000 European funding and EUR 209,500,853 national co-financing.

The Research, Innovation and Digitalization for Smart Transformation Program (2022) seeks to boost research and innovation, with the ultimate aims of helping Bulgaria achieve the status of moderate innovator and supporting a more intensive use of digital technologies in the economy and society. The program complements the National Recovery and Resilience Plan and national instruments – National Innovation Fund and Bulgaria National Science Fund. Specific measures and objectives are implementing various synergies with other key support programs.

The program addresses the following challenges:

- Low levels of public and private investment in research and development resulting in a relatively low innovation capacity of the economy
- Outdated and inadequate regulatory framework which fails to cover all innovation processes, develop an efficient national policy on funding R&D, create better conditions for the participation of business in scientific research, and properly regulate transfer of technology and intellectual property
- Insufficient efforts to build and maintain capacity for cutting-edge research. This is largely due to deficiencies in the area of human capital for research and innovation
- Limited and inefficient cooperation between scientific organizations, higher education institutions and business, resulting in low levels of transfer of technology and knowledge
- Insufficient level of internationalization of the research ecosystem
- Weak innovation activity of enterprises
- Continuing regional disparities in scientific output and innovation
- Low level of investment into e-government which results in low level of digitalization of the economy
- Universities in Bulgaria are lagging behind in the implementation of modern systems of management and control

In relation to these identified weaknesses, the program plans the following priority areas and measures:

Priority area	Measures / interventions
Sustainable development of the capacity for research and innovation	Developing Centers of Competence and Centers of Excellence created during the last programing period Supporting key other research and innovation infrastructures and infrastructure projects

	Supporting partnerships between Centers of Competence and Centers of Excellence and other research organizations and SMEs – the main purpose is to motivate business to use the innovation capacity of research organisations. The support targets SMEs in the thematic areas for smart specialization, including Mechatronics and ICTs Developing innovation capacity at regional level through the creation of Regional Innovation Centers, innovation infrastructure within industrial parks and pilot collaboration initiatives involving business, research organizations and academia. These Centres will be tasked with supporting the links between business and science at regional level in the priority areas for smart specialization, including Mechatronics, clean tech and digitalisation. The plan is to create at least one centre for each thematic priority in each of the six planning regions in Bulgaria. The Centres are expected to counterbalance the concentration of innovative companies and research in the region in and around the capital and to thus nurture regional innovation systems Developing a unified information platform for scientific research and innovation Developing conditions for sharing and managing research data according to FAIR principles and introducing open science as a standard practice in research Improving the visibility of scientific research results
Transfer of technologies and knowledge	Developing a national model of knowledge and technology transfer Programs for collaboration and transfer of technology Mobility programs between industry, research organizations and universities Developing innovation clusters Supporting technology- intensive and knowledge-intensive spin-offs Developing industrial start-up systems aimed at large-scale research and innovation Creating European Digital Innovation Hubs Building capacity for property rights protection and use
European integration and internationalization of research and innovation	Financing of projects that have received a Seal of Excellence from the European Innovation Council, the European Research Council, or Maria Curie Actions Increasing the participation of Bulgarian scientific organizations, universities and SMEs in the EU Horizon Program through scientific, innovation and administrative capacity building (participation in European partnerships, cooperation with the European Institute of Innovation and Technology, additional financing for projects under certain actions in the

	Horizon Program) Exploiting synergies with other programs and instruments Developing skills and a platform for smart specialization, industrial transition and entrepreneurship, bringing together highly qualified training organizations and experts
Using data as key social capital	Creating a data management framework and building interoperable data spaces Building a smart data-driven management platform Development of data processing and technological tools for depersonalization of sensitive data Capacity building for competent authorities and promotion of data sharing - streamlining the process of requesting and providing data Development of cross-border services for the use and sharing of data and integration in cloud infrastructures at the European level Organization of large-scale campaigns, events and initiatives to develop specific digital skills to create and use digital services and products, share data and reuse public data to create innovation and added value for the economy and society
Cybersecurity	Building a collaborative environment to promote and enhance trust and cooperation between cybersecurity partners at the national level. Building the capacity of the National Competent Authorities (NCAs) and their sectoral teams to respond to computer security incidents Building a cyber-secure environment for vulnerable public and business organizations through centralized monitoring and protection Building a system for cyber protection of shared information resources

Competitiveness and Innovation in Enterprises Program 2021-2027

The Competitiveness and Innovation in Enterprises Program (2022) aims at promoting smart and sustainable growth of the Bulgarian economy, as well as industrial and digital transformation. It responds to EU-level policies aimed at innovative and smart economic transition and a greener, low-carbon Europe. The program addresses the insufficient development of high-tech and high to medium-tech industries and knowledge-intensive services in Bulgaria. It provides targeted support for these sectors and also tackles the issue of regional disparities.

In relation to these identified weaknesses, the program plans the following objectives and interventions that relate to Industry 4.0:

Objective	Interventions

Exploiting the benefits of digitization for citizens, companies and governments	Supporting the introduction of Industry 4.0 technologies in enterprises according to RAMI 4 standards Supporting investments aimed at introducing digital technologies, software, digital applications and implementing appropriate cybersecurity and data privacy processes in SMEs Creation of a module/tool for measuring the level of digitization of enterprises Support for digitization of SMEs and restructuring of work processes and flows
Building capacity for research, innovation and the introduction of advanced technologies	Support for the development of innovations in enterprises Support for the implementation of innovations in enterprises Internationalization of the innovation process in enterprises by attracting foreign researchers, with a focus on enterprises in the growth stage Support for the creation of innovative start-up enterprises, preferably with main activity in the medium to high-tech industries and knowledge-intensive services Support for claiming and protecting industrial property in enterprises
Strengthening the growth and competitiveness of SMEs, including through productive investments	Support for production investments in enterprises with growth potential or according to the regional development potential Encouraging entrepreneurial activity – support for the establishment and growth of start-up enterprises Support for the development of the entrepreneurial ecosystem, internationalization and attracting foreign investments Support for growth and competitiveness of SMEs within new/existing industrial parks

Educational events related to Industry 4.0

Educational events related to Industry 4.0 in Bulgaria are mostly academic conferences and events organized by business, for business. While there are undoubtedly some events organized in the frame of EU-funded projects, too, most of them do not have a pronounced educational value. Rather, they mostly raise awareness about Industry 4.0, mobilize stakeholders or provide information about project results. One notable example of an EU-funded event is the 2017 conference *Industry 4.0 – Digitization and prospects for the growth of the Bulgarian economy* which was organized in Sofia Tech Park by the Bulgarian Small and Medium Enterprises Promotion Agency and was targeted at representatives of SMEs. Another such example is the 2022 High-Tech Summit for the Black Sea, which is financed under the Horizon 2020 program.

Examples of mostly academic events focused on Industry 4.0 topics are:

- The annual DIGILIENCE conference focused on cyber information sharing and situational awareness, Artificial Intelligence for cybersecurity, policies and solutions for security and resilience of Industry 4.0 and critical infrastructures. The conference was first held in 2019 and was organized by the Institute of Information and Communication Technologies at the Bulgarian Academy of Sciences. In 2020 it was hosted by Nikola Vaptsarov Naval Academy in Varna and in 2021 by the National Military University "Vasil Levski" in Veliko Tarnovo. The 2022 DIGILIENCE conference will be held in Plovdiv
- The annual international scientific conferences *Industry 4.0 and High Technologies, Business, Society*, organized by the Scientific Technical Union of Mechanical Engineering in collaboration with a number of leading Bulgarian research institutions and universities. As of 2022, the conference is in its 7th edition
- The 2022 international applied science conference "The Circular Economy in the Context of the Relationship Industry 4.0 – Society 5.0"
- The 2017 international scientific conference *Industry 4.0* organized by two of the leading universities in Bulgaria – Sofia University "St. Kliment Ohridski" and the University of National and World Economy
- Industry 4.0 has been discussed in conferences focused on education in Bulgaria. An example is the 2018 *The Future of Education Conference*, which was jointly organized by the America for Bulgaria Foundation and the European Commission in Bulgaria, in partnership with the Ministry of Education and Science. The conference included a special panel *Unlocking the Potential of Vocational Education in the Age of Technology, Preparing Students for Industry 4.0*
- GATE *Big Data and Artificial Intelligence* forum, organized by GATE Institute Bulgaria and the Chalmers University of Technology, Sweden
- The 7th IEEE International Conference "Big Data, Knowledge and Control Systems Engineering" (BdKCSE'2021) organized by John Atanasoff Union of Automatics and Informatics

Examples of events organized by business are:

- The annual International Technical Fair, organized in the frame of the prestigious International Fair in Plovdiv – the event provides special attention to Industry 4.0 in recent years. It allows companies to present their products and establish business contacts
- Annual business forum *Industry 4.0*, which has been held in Plovdiv since 2017
- Annual Global Tech Summit which brings together high-tech firms
- Global Conference Women in Tech Sofia 2022
- 2017 Sofia AI Summit, organized by hacker.works
- 2022 Webit Impact Forum, focused on innovations and technologies and organized in Sofia Tech Park

- A number of other relevant events organized in Sofia Tech Park

Bulgaria has also hosted some major regional events that bring together policy makers, scientists and business, e.g. the Fourth Regional Cybersecurity Forum for Europe and the Commonwealth of Independent States in 2020, the Fourth Regional Cybersecurity and Cyber Crime Forum for South East Europe in 2017, the Regional Cybersecurity forum InfoSec SEE (for the Balkans) 2022.

International and local projects on Industry 4.0

Bulgaria has been involved in a relatively high number of international EU-funded projects focused on Industry 4.0.

Bulgarian organizations are not particularly active in the EU's Horizon Program and other high-level research programs as compared to organizations from other EU countries. However, a few of them have been involved in EU-funded research projects relevant to Industry 4.0. These projects are briefly presented below:

- ACTPHAST4.0 (Accelerating Photonics Innovation for SMEs: A One Stop-Shop-Incubator) --- creates a photonics innovation incubator to cater to the needs of SMEs in in the context of Industry 4.0 in which photonics technologies are a key enabler
- BEYOND4.0 (Inclusive Futures for Europe BEYOND the impacts of Industrie 4.0 and Digital Disruption) --- examines the impact of the new technologies and Industry 4.0 developments on the future of jobs, business models and welfare
- DiManD (Digital Manufacturing and Design Training Network) --- designs and implements an integrated programme in the area of intelligent informatics-driven manufacturing that should provide the benchmark for training future Industry 4.0 practitioners
- MIND4MACHINES: Manufacturing Industry's Novel Digitalisation Value Chains for Connecting Machines with People, Process and Technology --- focuses on solutions for new cross-sector interconnections and digitalisation value chains combining manufacturing and novel, disruptive solutions in ICT (hardware, software, services and connectivity, Big Data, Cloud Computing, Artificial Intelligence, Blockchain, IoT and Cybersecurity)
- ECHO: European network of Cybersecurity centres and competence Hub for innovation and Operations --- seeks to improve the proactive cyber defence of the EU, through effective and efficient multi-sector collaboration
- 5G-INDUCE: Open cooperative 5G experimentation platforms for the industrial sector NetApps --- develops an open, ETSI network functions virtualisation-compatible, 5G orchestration platform for the deployment of advanced 5G network applications in the Industry 4.0 service deployment environment
- RAINBOW: An Open, Trusted Fog Computing Platform Facilitating the Deployment, Orchestration and Management of Scalable, Heterogeneous and Secure IoT Services and Cross-Cloud Apps --- develops an open and secured fog computing platform that will advance the management of extensible, diverse and safe IoT services and cross-cloud applications.

All the projects mentioned above can be explored at https://cordis.europa.eu/.

Some notable projects funded under Interreg focus on improving regional-level policy and enhancing the capacity of regions to support digital transformation and industrial innovation. Under the DIGITAL REGIONS project (Regional policies adopting Industry 4.0 for their Digital Transformation) eight regions engage in policy cooperation with the objective to adapt innovation policies in order to support the transformation of their manufacturing sectors and their transition to Industry 4.0. The CARPE DIGEM project (Catalysing Regions in Peripheral and Emerging Europe towards Digital Innovation Ecosystems) is focused on collaborative development of policy instruments promoting inclusive digital innovation ecosystems and services. The DEVISE project (Digital tech SMEs at the service of Regional Smart Specialisation Strategies) involves 9 regions in efforts to unlock and exploit the potential of digital tech SMEs to boost the competitiveness of other SMEs in sectors included in Regional Smart Specialisation Strategies. The SKILLS+ project (Supporting knowledge capacity in ICT among SME to engage in growth and innovation) is focused on improving SME competitiveness policies through public policies promoting ICTs. In the INNOBRIDGE project (Bridging the innovation gap through converting R&D results into commercial success in a more effective and efficient way) the consortium engages in sharing good practices to empower regional economies to exploit their own Research and Development results by effective commercialization (More about the above 5 projects can be found at https://projects2014-2020.interregeurope.eu/). The DIGITRANS project (Digital Transformation in the Danube Region) addresses the need for new business models in view of the increasing digitisation of business processes. The SMART FACTORY HUB project (Improving RD and business policy conditions for transnational cooperation in the manufacturing industry) engages partners in efforts to improve the cooperation between research and business in the smart factory field (More about the above 2 projects can be found at http://www.interreg-danube.eu/).

Bulgarian organizations participate in many Erasmus+ projects. Such initiatives are primarily contributing to innovations in the field of education or are enabling learning mobility across borders. A great number of projects are focused on digitalization, especially the development of digital skills in the education sector. A few projects are specifically looking into Industry 4.0. Examples of projects led by Bulgarian organizations:

- Upskilling Lab 4.0: focused on developing a model, framework and tools for skills improvement of companies' staff, with a focus on modern technologies and open innovation in the area of Industry 4.0
- Apprenticeship Cluster for Industry-Ready Engineers of Tomorrow: focused on elaborating a new partnership structure between technical universities, enterprises, local authorities and social partners, specifically in the area of Mechanical Engineering and Mechatronics and in view of providing work-based learning and apprenticeship that responds to Industry 4.0 job demands.
- Maker schools: Enhancing Student Creativity and STEM Engagement by Integrating 3D Design and Programming into Secondary School Learning: the project develops learning materials for secondary school students in the area of 3D printing and design, including through the use of programming languages.

- Industrial Internet of Things VET Network: raises awareness about the potential and possible applications of the Internet of Things technologies, and contributes to upskilling and reskilling of company employees, professionals and VET providers.

Examples of projects with Bulgarian organizations involved as partners:

- The ICT Engineer of the 21st Century: Mastering Technical Competencies, Management Skills, and Societal Responsibilities --- develops a transnational multidisciplinary intensive study program in the field of ICT-based entrepreneurship
- Digital Transformation in Advanced Manufacturing --- designs, tests, refines and exploits an integrated curriculum in digital transformation competence for mid to high-level technicians
- INGENIOUS-Strengthening Digital Pedagogy Skills and Competencies of Educators --- focuses on developing the digital skills of VET educators
- Developing STEM Competences with Robotics --- focused on learning approaches in Robotics for younger learners
- Joint Cyber Workforce Development Initiative to Enable the European Industry to Overcome the Shortage of Cybersecurity Professionals --- a training package for manufacturing SMEs to ensure data security in the context of Industry 4.0 context and reduce the shortage of staff with cybersecurity competences
- Active Learning Community for Upskilling Technicians and Engineers --- develops a learning platform and a mobile application for the sector of Machine Building and Mechatronics, with course content and industry-relevant problems as source materials for practical assignments
- Work-based training approach in the field of Industry 4.0 for competitive European Industry: provides a training course and promotes work-based learning on the topic of Industry 4.0, with special attention to apprenticeship training, by involving social partners, companies and VET providers.

All the projects presented above can be explored further at https://erasmus-plus.ec.europa.eu/projects.

Industry 4.0 and higher education

Industry 4.0 is not usually directly referred to in the programs offered in higher education institutions. There are occasional papers published by Bulgarian academics, but they are mostly introductory in nature and do not suggest a strong research activity in this field in the relevant university faculties. Teaching and research capacity is obviously more developed strictly within individual technical areas making up Industry 4.0. No university offers a comprehensive program covering all aspects of Industry 4.0. In all fairness, this is not surprising and would perhaps not be the most adequate approach at the moment, at this level of development of Industry 4.0 in Bulgaria and considering the available teaching and research capacity. We believe at this stage it is important for universities to focus on providing skills and knowledge in the various study areas that are the building blocks of Industry 4.0 – Artificial Intelligence, Big Data, Internet of Things, Cybersecurity,

etc. A more comprehensive approach can be taken at a later stage, when there is sufficient academic capacity.

Annex 2 of this report provides a comprehensive analysis of the Industry 4.0-relevance of all the Bachelor, Masters and Doctoral programs offered in Bulgarian Universities. The data is based on the accreditation results published by the National Evaluation and Accreditation Agency. Looking at the data, we believe several conclusions are in order:

- Almost all Universities offer programs in Computer Science, Information Systems, Informatics and ICTs. This is largely a response to the high demand for ICT specialists on the labor market and also reflects a desire of some of the less popular universities to secure candidates. This is an excellent result at first glance. There is really not much more that could be expected in terms of increasing the availability of such programs. The real issue, however, is the quality of the education offered in some of the non-technical universities. It is beyond doubt that the availability of ICT education will raise awareness of digitalization and will improve the digital skills of the new generation. However, we believe there is a great divide between the level and quality of Computer Science and Informatics education across the different universities, with the Technical Universities and the Kliment Ohridski University in Sofia offering the highest quality IT education. The extent, to which students graduating from other universities are prepared to take up challenges related to programming and the complex technologies making up the backbone of Industry 4.0, is dubious. Another issue is the relevance and applicability of the knowledge received in universities to the actual business needs and the processes and practices in the high-tech industry. Unfortunately, many students still leave the universities not prepared to work with the latest technologies or according to industry standards. While this is a common challenge for all Bulgarian universities (including the leading ones), there is again a quality divide between the main technical universities and the established universities in Sofia and the rest of the higher education sector. All in all, in the future Bulgaria needs to focus more on ensuring the quality of IT education than on increasing the quantity of available programs.
- Some of the 52 accredited Higher Education Institutions in Bulgaria offer programs specialized in various areas of Industry 4.0. Out of the range of Industry 4.0 study areas, automation appears to be most widely covered in accredited programs and is available for students in almost all geographical regions. However, it is beyond doubt that great variations in quality are observed in this area, too. At the very least, the Technical Universities and the Kliment Ohridski University in Sofia are the only ones that boast relatively strong cooperation with business and well-equipped laboratories featuring industry-grade technologies and robots, which allows them to offer quality practical training and generally relevant courses. In the area of Artificial Intelligence, Big Data, Mechatronics and Robotics there are just a few programs that are unlikely to be able to meet the future demands for skills in these areas. Internet of Things is not taught as a comprehensive program as of now but is taught as a course in some universities. At first glance, there are quite a few programs on cybersecurity, but the fact is that the available academic offer is mostly focused on the national security aspects; cybersecurity is usually taught in the Military Academies or as part of the National Security professional stream. It is thus unclear if Bulgaria has the necessary educational offer to ensure specific cybersecurity and information security skills for industry, seeing as the offer in the area of information security is also not great. There are some

programs on innovation management and tech entrepreneurship, which is encouraging. However, this offer needs to diversify and grow, too.

All in all, ICT has become by far the most popular discipline in secondary schools and universities but issues remain. Firstly, quality of the programs can be significantly improved. Secondly, the uptake of digitalisation in non-ICT majors remains limited, which is one of the reasons why we are not seeing fast improvement in the levels of digital literacy in the country. Importantly, the availability of programs and courses in the key technology areas of Industry 4.0 appears insufficient to meet future demands. If Bulgaria is to enact a shift toward Industry 4.0 and further develop its high-tech industries, a concerted effort involving higher education institutions and business needs to be made to ensure that the educational system has the capacity to produce a sufficient number of adequately qualified professionals. There is also room for innovation in higher education to provide training tailored to the needs of SMEs. This could be achieved through modular, blended courses delivered in specific sectors and geographical regions, with flexible timing, and with practical content.

Outside the formal higher education sector, ICT businesses have already started developing alternative education and training institutions or have been teaming up with existing universities to provide specific training. An important facilitating factor for the development of the strong innovation-based ICT sector in Sofia City has been the establishment of several private training and education academies and other talent-developing initiatives of leading ICT companies, e.g., Musala, Telerik Academy, SoftUni, LeanPlum, etc. The new educational offers are primarily geared towards meeting the rapidly rising demand for outsourcing IT services and, considering the short duration of the programs, cannot by themselves develop deeper ICT engineering and innovation skills. However, training in these institutions is led by industry professionals and is sufficiently practical, applicable and relevant to industry standards.

Companies and Industry 4.0

Despite the challenges in the last years, industry in Bulgaria is increasingly adopting automation solutions and investing in hi-tech equipment. Among the companies that recently made substantial investments are Alcomet (manufacturer of rolled and extruded aluminium products), Teklas-Bulgaria (manufacturer of rubber, plastic and metal products), Ewellix (producer of linear motion components and actuation solutions), Ottobock Bulgaria (prosthetics company), Extrapack (manufacturer of paper, plastic, bioplastic, woven and non-woven polypropylene bags), Rollplast (production and installation of aluminium, plastic and wooden joinery), Asarel Medet (copper extracting and processing factory), Astro Clima (manufacturer of heating, air conditioning and ventilation systems), Schneider Electric (energy management and automation), Hills (brewery).

The IT sector in Bulgaria has been expanding at a rate almost twice as high as the growth rate in the rest of the economy. During the last two decades, leading multinational ICT companies have established R&D centres in Bulgaria. Notable examples are VMWare Bulgaria, Software AG, SAP, Devexperts, Paysafe, Integrated Microelectronics, Datecs, Progress, Bosch Software Innovations Sofia, IDT Bulgaria, LeanPlum, Atscale Bulgaria, Nuvolo Technologies Bulgaria, Crayon Bulgaria. Some indigenous Bulgarian companies have also managed to stand out with innovative products and occupy specific market niches - Chaos Software, Ontotext, Interconsult Bulgaria, Mobile Systems, Software Group Bulgaria, etc. Sofia-city has seen an influx of R&D intensive

multinationals in the ICT sector and creation of new start-ups, especially in FinTech, Internet of Things and data analytics (e.g. Payhawk, Connectedbin, Phyre, Sirma Medical Systems, Bizportal, ProDron Sys, Sensika Technologies, etc.).

The export of ICT and mechatronics products and services has been steadily increasing in the last decade. Bulgaria has mostly been regarded as a preferred destination for outsourcing software development, largely due to cost-effectiveness for leading US, UK and European software companies. Outsourcing capacity in the Bulgarian IT sector has been steadily growing, together with the talent pool. The main factors that make Bulgaria an attractive destination for software development outsourcing are the availability of qualified software developers working at the lowest hourly labor cost in the European Union and the geographical proximity to the European market. Additional advantages are the good working ethics, the massive adoption of agile methodology in working processes and a good level of knowledge of the English language. More than 70% of the software companies in Bulgaria use English as a working language.

The Bulgarian domestic market for new technologies is very small. The B2B market within the mechatronics and ICT sectors is limited both within each of the sectors and between the sectors. There are some cluster organisations serving sub-sectors in ICT and mechatronics that work to the benefit of their members. These cluster organisations receive funding through the EU operational programs.

Despite the positive effects of the outsourcing boom on the expansion of the IT sector, it has tended to lead to specialization in services with less added value, and it has not really instigated a remarkable development in Industry 4.0. On the positive side, the trend for the future appears positive. Most companies are increasingly moving away from providing low-cost services with little added value toward developing products and solutions with higher added value. There has been an associated rise in patenting and publication activity in the area of technology, although Bulgaria's performance in this area remains low by European standards.

Demand for skills and knowledge in the context of Industry 4.0

In Bulgaria, the demand for skills and knowledge in the context of Industry 4.0 is not significantly different from the demand worldwide, especially if we adopt a future-proof approach and factor in the expected further growth in the main sectors relevant to Industry 4.0. We can thus expect an increasing demand for specialists in robotics, cybersecurity, big data management, big data analytics, data security, network engineering and cloud computing, machine learning, Internet of Things, Artificial Intelligence. The demand for software engineers, software developers, programmers and IT architects will remain high. Knowledge and skills in industrial management will need to be adapted to the new realities. Among the basic soft skills that will be needed will be adaptability and knowledge in skills for managing and working in agile environments. Innovation management skills will become increasingly applicable for a growing number of industries. Finally, tech entrepreneurship needs to be developed in terms of both skills and attitudes.

In the education sector, there will be a growing demand for specialists in transfer of technology, as well as for boundary spanners able to effectively link business, research and education within the innovation ecosystems at national, regional and local levels.

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1.5.2 CASE OF LATVIA

Disclaimer

This document has been developed in the framework of the Project "Digital Transformation, Industry 4.0 and Human Resources Management: Innovative skills to enhance HE students employability, flexibility and transversal capabilities "/DigiWork/, Ref. No. 2021-1-PL01-KA220-HED-000032182.

Introduction

This report describes the current situation of awareness and development of Industry 4.0 in Latvia. It covers aspects related to statistic and economic indicators of digitalisation level, national strategic planning documents, policies and law, educational events and projects relevant in the context of Industry 4.0, an overview of companies and best practices of digital transformation and implementation of Industry 4.0 concept. Moreover, the report summarises knowledge and skills that should be purposefully developed to support the successful introduction of Industry 4.0 into the economics and industrial competitiveness of the country.

The report is based on a systematic analysis of information sources published between 2017 and 2022. The following information sources were identified as being of interest for the current report:

- websites of companies, higher education institutions, government institutions, and projects;

- articles in the media;
- books;
- project reports;
- Latvian legal framework, decisions and policies adopted by the government;
- Scientific publications.

The search for information sources was performed on Google and in scientific databases such as IEEE Xplore, Science Direct, SCOPUS, and Web of Science. The report's authors used the combination of the terms "Industry 4.0" and "Latvia" as the main keyword for searching information sources. However, terms combinations that cover the main pillars of Industry 4.0 (Internet of things and Latvia, cloud computing and Latvia, robotics and Latvia, big data analytics and Latvia, augmented reality and Latvia, cyber security and Latvia, additive/advanced manufacturing and Latvia) were also used to extend search results.

The main text of the report is presented in the following eight sections. It represents conclusions made based on information collected from the information sources and represented in a structured way in the appendices of this report.

Statistics and economic indicators on digitalisation and digital skills

In general, Latvia has highly advanced coverage of fast broadband and, as a result, almost all enterprises and most householders have access to the Internet. At the same time, Latvia ranked 20th among the 27 EU countries (below the EU average) in terms of digital skills at all levels, from basic to advanced levels, in 2021 [1]. Although an increasing number of Latvians engage in online activities, Latvia's level of digital skills is one of the lowest in the EU [2]. Only 43% of the population aged 16 to 74 have at least basic digital skills, versus the EU average of 56% [1]. According to [2], the lack of digital skills is identified as a factor hindering the introduction of innovations. Improving the population's digital skills is a precondition for creating and ensuring an environment conducive to digitalisation, improving business productivity and promoting Latvia's progress and investment in new digital technologies [3]. Also, the regions still have the unused potential for broadband optical internet access, providing a reliable and fast digital infrastructure for businesses and remote working possibilities for employees [4].

Regarding the integration of digital technologies in enterprises, Latvia ranks 23rd among EU countries, which is still well below the EU average level. The share of SMEs with at least a basic level of digital technologies is 42%, while the EU average is 60% [1]. The proportion of companies that acquire cloud services is 18%, only 9% of enterprises use big data, and only 19% have activities on social media [1]. Latvian enterprises have to adapt to the reality of "Industry 4.0" and should be able to integrate these new technologies. In order to succeed, it is necessary to overcome the limitations and have a clear strategy and vision of what is Latvian future high-tech manufacturing [5]. Currently, more significant efforts are needed to promote the use of digital technologies in small businesses. At present, Latvia is focusing on improving digital skills; however, there is a lack of a policy to expand the use of digital technologies in small businesses, as well as a strategy for the digitalisation of the private sector [6]. Significant factors limiting the international competitiveness of Latvian companies are administrative burdens (e.g., labour taxes)

and general business costs (e.g., electricity costs, real estate taxes, and others). Also, the laws and regulations that govern the employment relationship are inappropriate today since they do not include information on remote work opportunities, temporary dismissal, downtime, and other modern trends [7]. Therefore, developing a comprehensive national digital strategy with adequate resources can help Latvia further increase the use of digital technologies by individuals, companies, government, and educational institutions [6].

Appendix 1 provides detailed information on statistics and economic indicators related to the digitalisation level and digital skills development in Latvia.

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National strategic planning and regulatory documents

During the analysis of information sources, it was identified that national strategic planning and regulatory documents relevant to digitalisation and Industry 4.0 could be divided into two categories:

- Policy documents for the planning period 2021-2027 that set national strategic aims, priorities and actions for economic growth and transformation in the next seven years (National Development Plan of Latvia for 2021-2027, National Industrial Policy Guidelines 2021-2027, Digital Transformation Guidelines for 2021-2027, Guidelines for Science, Technology Development and Innovation 2021-2027, Research and Innovation strategy for Smart specialisation of Latvia, Implementation strategy of Platform "Industry 4.0", Cyber Security Strategy, Guidelines for the Development of Education for 2021-2027. Future Skills for the Future Society);
- Support programmes and initiatives that allow companies, government and local municipalities, business start-ups, public research organisations, merchants and others to get funding for digitalisation and innovation introduction initiatives (Latvia's Recovery and Resilience Plan, Norwegian Financial Mechanism, Innovation Motivation Programme, Business Incubators, Start-up support programmes, Innovation vouchers and support for

attraction of highly-qualified specialists, Support for science result commercialisation, International competitiveness development, Support for staff training, Acceleration funds).

One of the priorities of the Ministry of Economics of the Republic of Latvia is to improve the business environment. The vision of the Ministry of Economics is to create an excellent business environment and move towards an innovative economic model. Therefore, five priority directions of action have been defined for further work on improving the business environment, and the digitalisation of public services and industry (Industry 4.0) is one of them [1]. Overall, several policy documents related to the Industry 4.0 have been approved mainly for the planning period 2021-2027. Digital transformation as a fundamental principle of Latvia's economic development is included in several state government planning documents for the next policy development period 2021-2027, for example, National Development Plan of Latvia 2021-2027, National Industrial Policy Guidelines 2021-2027, Digital Transformation Guidelines for 2021-2027 and other binding strategies and guidelines [2].

In general, innovation does not play a significant role in Latvian companies; however, Latvia is taking steps to increase the number of companies involved in innovation through regional and ERDF-funded programmes [2, 3]. Latvia uses different measures to support its growing start-up ecosystem. The law on aid for the activities of start-ups established a support programme to recruit highly skilled workers and provide personal income tax relief for start-up employees. In addition, subsidies and loans are available to business start-ups in rural areas to promote digital innovation or develop new products and services. The loans programme targets agricultural, rural and fisheries start-ups [4]. Furthermore, Latvia continues to use the Competence Centre and other complementary programmes, such as the technology transfer programme to promote innovation in SMEs [2]. Other support measures for the digitalisation of enterprises include training programmes organised by the Latvian Information and Communications Technology Association and the EU co-funded development project for SME training in digital technologies and innovation. Furthermore, the Ministry of Environmental Protection and Regional Development and the Ministry of Economics have nominated two Digital Innovation Hubs [4]. The Latvian IT Cluster will focus on the digital transformation of enterprises using available digital solutions; the digital accelerator of Latvia will focus on R&D and innovative digital solutions. Both hubs, which involve public and private stakeholders, plan to be part of the network of European Digital Innovation Hubs and provide the infrastructure for prototyping [4]. The Latvian Investment and Development Agency (LIDA) plays an important role in managing support programmes for entrepreneurs [2]. The LIDA is the primary state agency for innovation and forms part of the Ministry of Economics. It manages innovation programmes funded by EU structural funds such as the Technology Transfer Programme, the Innovation Motivation Programme and the Business Incubators Programme. The LIDA's leading role is to support foreign direct investment (FDI), although FDI flows largely towards sectors that do not tend to invest in R&D [3]. There are also three digital innovation centres in Latvia intended to act as centres of digital excellence and single digital transformation contact points [2].

Appendix 2 lists national policies, plans, laws, initiatives and guidelines related to digitalisation and Industry 4.0 in Latvia.

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Educational events related to Industry 4.0

Even though information on possible Industry 4.0 educational events for 2017-2021 is incomplete and includes only those events, information about which is available on the web, it can be concluded that opportunities for training in new technologies and developing an understanding of digitalisation processes are extensive. They include short, one-time local and international events (seminars, forums, conference sections, and others) and recurring exhibitions of technological achievements and long-term training programs within the framework of ERAF and ESF projects. Furthermore, educational events are offered to academic staff and staff of state institutions and enterprises in specific industries and any working or self-employed person. Some of the events examined in this report are dedicated to Industry 4.0 and digitalisation. In contrast, others focus on individual Industry 4.0 pillars such as cybersecurity, artificial intelligence and data analysis, cloud computing, and others.

In the context of education, it is worth mentioning that, according to [1], the Ministry of Economics developed an investment plan for 2021-2027 to improve the digital skills of company employees:

- Entrepreneurs will receive support in the form of a grant with an intensity of up to 70% of the total training costs.
- The total amount of investment is planned to be 30 million.
- Within the investment framework, it is planned to support at least 3,000 enterprises from the Latvia's recovery and resilience mechanism funding by 2027 and at least 1,273 enterprises by 2029 from the ERDF funding.
- It is planned to divide the investments into three parts:
    - Massive Open Online Courses on topics such as the basics of UX/UI, e-commerce, data analysis and visualisation, database development and maintenance, programming, and business intelligence system development;
    - European Digital Innovation Hubs offering advanced digital skills development through specialised training on topics such as cybersecurity, artificial intelligence and high-performance computing;
    - cooperation with industry associations to support the development of digital skills of employees in areas such as online information storage, use of websites/social portals, software configuration, online sales, image, video and audio processing, presentation preparation, basic programming skills.

Appendix 3 lists many educational events related to Industry 4.0.

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International and local projects on Industry 4.0

Analysing local and international projects linked to Industry 4.0 and its main pillars where partners from Latvia are participating, a wide range of projects were found, and 38 of them are summarised in this report. All projects can be divided into five main categories, and some of them can be categorised in more than one of these categories:

1. Projects that aim at developing some **legal and regulatory framework** for the further progress of Industry 0.4 and related technologies by:
    - gathering best practices (4D4F[1], DIGINNO[2], INNO INNDUSTRY[3]);
    - generating policies (INNO INDUSTRY [3]);
    - formulating action plans (SKILLS+[4], DigiBEST[5], IoTXchange[6], AutoDrive[7]);
    - making guidelines (INTERFRAME[8]);
    - developing standards (ITSVET[9], AutoDrive[7], COMP4DRONES[30]);
    - issuing recommendations (DIGINNO[2], DCDS[10]);
2. Projects whose goal is to **raise awareness** and **level of knowledge** in topics related to Industry 4.0 through:
    - free access online courses (4CHANGE[11], IOT-OPEN.EU[12], BRACKET[13]);
    - study programs (ITSVET[9]);
    - demonstrators (TRINITY[14], VIZTA[23], AI4DI[34]);
    - educational events (DIGINNO[2]);
    - training and consultations (SKILLS+[4], i4.0 Baltics[15], WOMEN4IT[16], INforM[27], DCDS[10]);
    - tools for digitalisation assessment (DIGINNO[2], DINNOCAP[22], DigiBEST[5]);
    - framework of necessary skills for cybersecurity (SPARTA[31]);
3. Projects that aim at developing **specific technological solutions** and architectures that could bring Industry 4.0 to life:
    - various kinds of sensors and sensor networks (VIZTA[23], I-MECH[29], IIWS 1[36], IIWS 2[37]);
    - technologies for augmented reality headset (LEOPC[24], NGEAR 3D[25]);
    - technologies for building (ENACT[33]) and testing IoT (LEOPC[24]);
    - computer vision-based methods for traffic analysis (LEOPC[24], Real-time AI urban video analytics[26]) and manufacturing (LEOPC[24]);
    - optoelectronic system for analysing microbiological pollution (LEOPC[24]);
    - multiple robot cooperation software framework (LEOPC[24]);
    - methods for using computer vision and machine learning for automatisation of industrial processes (LEOPC[24]);
    - eCMR indexing prototype (DIGINNO-Proto[28]);

- technologies for autonomous robots (LEOPC[24], IMOCO4.E[36], RONIN[18]);
- autonomous microrobots (RoVam[35]);
- integrated and modular architecture for drones(COMP4DRONES[30]);
- communication systems for drones (COMP4DRONES[30]) and autonomous vehicles (AI4CSM[32], AutoDrive[7]);
- autonomous vehicles and linked technologies (AI4CSM[32], PRYSTINE[21]);

4. Projects that strive to **implement** Industry 4.0 in a **particular field**:
   - agriculture (AfarCloud[1], RONIN[18], 4D4F[1], AUMENTA[19], LEOPC[24]);
   - food and beverage production (AI4DI[34]);
   - food retail (LEOPC[24]);
   - automotive industry (3Ccar[20], AI4DI[34]);
   - industrial machinery (AI4DI[34]);
   - transportation (AI4DI[34]);
5. Projects that create **communities, clusters and networks** for promoting Industry 4.0 (INNO INDUSTRY [3], i4.0 Baltics[15], SPARTA[31], AUMENTA[19], TRINITY[14]).

Most of the projects described in this report correspond to the categories of raising awareness and knowledge (17 projects) and developing specific technical solutions (16 projects). A few organisations from Latvia operate as partners in most of the projects described in this report: EDI-Institute of Electronics and Computer Science, LMT, and Lightspace technologies.

Out of 38 projects described in the report, 11 belonging to the first, second and fifth categories described before concentrate on Industry 4.0 as a whole. In comparison, other projects focus on one or several of its pillars. For example, there are 13 projects concerning the Internet of Things, 11 - autonomous robots, 9 - big data and analytics, 7 - cybersecurity, 4- augmented reality, 2 - horizontal and vertical system integration, 1 – additive manufacturing and 1- simulation.

Appendix 4 provides detailed information on international and local projects related to Industry 4.0 in which Latvian representatives participated or played a leading role.

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5. DigiBEST https://projects2014-2020.interregeurope.eu/digibest/
6. IoTXchange https://urbact.eu/iotxchange
7. AutoDrive https://autodrive-project.eu/
8. INTERFRAME https://www.lza.lv/aktualitates/projekti/content/82-projekti
9. ITSVET http://database.centralbaltic.eu/project/5
10. DCDS http://www.dcds-project.eu/about/
11. 4CHANGE http://www.change4industry.eu/
12. IOT-OPEN.EU https://erasmus-plus.ec.europa.eu/projects/eplus-project-details#project/2016-1-PL01-KA203-026471

13. BRACKET https://bracket.erasmus.site/
14. TRINITY https://cordis.europa.eu/project/id/825196
15. i4.0 Baltics https://si.se/en/projects-granted-funding/i4-0-baltics-developing-industrial-4-0-competence-centres-and-network-in-estonia-latvia-and-lithuania/
16. WOMEN4IT https://women4it.eu/
17. AfarCloud https://cordis.europa.eu/project/id/783221
18. RONIN https://www.zm.gov.lv/lauku-attistiba/statiskas-lapas/projekts-robotizetas-nezalu-ierobezosanas-iekartas-izveide-?id=19468#jump
19. AUMENTA https://www.itbaltic.com/single-post/aumenta
20. 3Ccar https://cordis.europa.eu/project/id/662192
21. PRYSTINE https://cordis.europa.eu/project/id/783190
22. DINNOCAP https://www.dinnocapbsr.eu/
23. VIZTA https://www.vizta-ecsel.eu/
24. LEOPC (Competence Centre of Electrical and Optical Equipment Production Sector of Latvia) https://www.leopc.lv/projekti/
25. NGEAR 3D https://lightspace3d.com/ngear-3d/
26. Real-time AI urban video analytics https://innovations.lmt.lv/projects/real-time-ai-urban-video-analytics/
27. INforM https://interreg-baltic.eu/project/inform/
28. DIGINNO-Proto https://www.diginnobsr.eu/diginno-proto
29. I-MECH https://cordis.europa.eu/project/id/737453
30. COMP4DRONES https://www.comp4drones.eu/
31. SPARTA https://www.sparta.eu/
32. AI4CSM https://ai4csm.automotive.oth-aw.de/
33. ENACT https://www.enact-project.eu/
34. AI4DI https://ai4di.eu/
35. RoVam https://www.edi.lv/en/projects/development-of-microrobot-based-on-visual-recognition-and-machine-learning-for-manipulation-of-individual-living-cells-rovam/
36. IMOCO4.E https://cordis.europa.eu/project/id/101007311
37. IIWS 1 https://www.edi.lv/en/projects/industrial-inertial-wireless-sensor/
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Industry 4.0 and higher education

Unfortunately, at the moment, the concept of Industry 4.0 is poorly integrated into the discourse of higher education institutions in Latvia. Both the general search on Google and specific searches on the websites of Latvian higher education institutions yield almost no results. An exception is rare references to the professional growth of academic staff through their participation in various events (like conferences and mobility programs) covering some aspects of Industry 4.0, for example, [1, 2, 3]. The only university that addresses the necessity of educational changes in the context of Industry 4.0 is the Latvia University of Life Sciences and Technologies. It emphasises the need to modernise study programs of the Faculty of Information Technologies by including courses on Industry 4.0 and programs of other faculties by incorporating topics on Industry 4.0 in their courses [4]. An important factor that could indicate that higher education institutions are aware of the inevitable

need to change their study programmes under the influence of Industry 4.0 is that, between 2017 and 2021, several higher education institutions developed new study programmes covering one or more pillars of Industry 4.0. A summary of these programs is given in Table 1 based on the register of study programmes of the Higher Education Quality Agency in Latvia [5]. At the same time, the Transport and Telecommunication Institute advertises two study programmes that are not included in the previously mentioned register but can be attributed to Industry 4.0. They both provide a double degree with the University of the West of England:

- Data analytics and artificial intelligence (academic master study programme) that includes courses on intelligent data processing, cybersecurity, machine learning, and data analytics [6];
- Artificial intelligence (academic bachelor study programme) that contains many courses related to developing intelligent systems and understanding the concept of artificial intelligence [7].

Furthermore, there are also two programs in Latvia offered by Riga Technical University that were developed more than ten years ago and seem relevant to the context of Industry 4.0:

- Smart Electronic Systems (professional master study programme, license year: 2009) that includes, among others, courses on signal processing systems, 5G wireless technologies, data transmission in wireless sensor networks [8];
- Intelligent Robotic Systems (academic bachelor's and master's study programme, license year: 2010), which mainly contains courses related to robotics [9].

Separate courses addressing pillars of Industry 4.0 can also be included in other study programmes as mandatory or free electives.

Table 1. New Latvian study programs covering technologies related to Industry 4.0

Title	Higher Education institution	Study level	Licensing and accreditation	Study courses included
Cybersecurity Engineering [10]	Vidzeme University of Applied Sciences	Professional master study programme	License year: 2018	Courses cover different aspects of cybersecurity and corresponding technologies [11]
Cyber Security Engineering [12]	Riga Technical University	Academic master study programme	License year: 2020 Not included in accreditation yet	Courses cover different aspects of cybersecurity and corresponding technologies
Mechatronics [13]	Vidzeme University of Applied Sciences	Professional bachelor study programme	License year: 2017	Courses, among others, include Internet of Things and sensor networks,

				robots and robot control systems, sensors and their use [11]
Robotics [14]	Transport and Telecommunication Institute	Professional bachelor study programme	License year: 2018	Courses cover many topics related to the development of robotics systems
Smart Electronic Systems [15]	Riga Technical University	Professional bachelor study programme	License year: 2020 Not included in accreditation yet	Courses, among others, include Internet of Things technologies, signal processing, smart embedded systems
Smart Technologies and Mechatronics [16]	University of Liepāja joint programme with Ventspils University of Applied Science	Professional bachelor study programme	License year: 2021 Not included in accreditation yet	Courses, among others, include Internet of Things, artificial intelligence, robot control, cybersecurity, cloud computing
Virtual reality and smart technologies [17]	Vidzeme University of Applied Sciences	Professional master study programme	License year: 2018	Courses cover topics of machine learning, 3D graphics, virtual and augmented reality, computer vision [11]

References:

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2. Rēzeknes Tehnoloģiju Akadēmija. (2019). Erasmus+ programma sniedz iespēju pilnveidoties. [in Latvian]. Available at https://2021.rta.lv/aktualitates/1967/
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6. Transport and Telecommunication Institute. (n.d.). Double degree in computer science: Data analytics and artificial intelligence. Available at https://tsi.lv/study_programmes/double-degree-in-computer-sciencedata-analytics-and-artificial-intelligence/
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Companies and Industry 4.0

According to [1], the primary industries engaged in Industry 4.0 are telecommunications, electronics, logistics, smart mobility, and biotechnology, and some of the key networks involved in the Industry 4.0 innovation ecosystem are:

- IT Cluster;
- Latvian Information and Communication Technology Association (LIKTA);
- European Digital Innovation Hubs (EDIH);

• Annual Fifth-Generation Techritory, the leading fifth-generation ecosystem forum in Europe.

Companies from the IT, electronics and telecommunications sectors actively engage in digitalisation, automatisation, robotisation and data-driven analysis of business processes. They offer various services and solutions in data analytics and visualisation, intelligent automation, cybersecurity, the Internet of Things, cloud computing, artificial intelligence, and augmented reality for enterprises of different sizes and industrial fields. The most influential player is LMT, a mobile telecommunications operator and market leader in Latvia [2]. The enterprise participates actively in projects directed towards developing and introducing technologies of Industry 4.0 and collaborates with government, industrial and academic institutions. It is also involved in explanatory activities regarding Industry 4.0, its influence and requirements.

The Association of Mechanical Engineering and Metalworking Industries of Latvia greatly supports enterprises in the metalworking industry. It organises educational and experience exchange events, actively participates in projects related to Industry 4.0 and has also developed training materials in the Latvian language to implement Industry 4.0 in the metalworking industry (see Section 8).

Appendix 5 lists many companies that have introduced or supported Industry 4.0.

References:

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Demand for skills and knowledge in the context of Industry 4.0

The nature of many jobs will change due to digital innovations such as machine learning, big data and artificial intelligence. Concerning economic trends, the demand for labour in low-skilled occupations and occupations where routine activities can be automated is expected to decline [1]. Trends show that, on average, around 14% of existing jobs could disappear due to automation in the next 15-20 years, and the other 32% are exposed to significant changes in their job responsibilities due to the automation of individual tasks [2].

In [1], it was indicated that in the period until 2027, there will be a surplus of the labour force with secondary general education, basic education and a lower level of education, but a shortage of labour force with vocational secondary education, especially in engineering and manufacturing [1]. There is also a forecast of a shortage of highly qualified specialists in natural sciences, ICT and engineering (the shortage in the direction of STEM may increase to ~14 thousand). At the same time, a surplus of workforces with higher qualifications in the social sciences, business and humanities is projected by 2027 may increase to ~17 thousand [1]. Better literacy, numeracy and problem-solving skills are becoming essential for using the Internet effectively and determining the reliability of online information [3].

According to forecasts, the growth of the Latvian economy will be mainly determined by the use of new technological processes, digitalisation (concept "Industry 4.0") and process optimisation [1, 3]. Consequently, the fastest job growth is expected in high- and medium-high-tech sectors, such as ICT, as well as in high-skilled occupations, such as managers and senior professionals [1, 3]. Prospects for future professions are primarily based on the so-called "digital" and "human" factors, namely skills in working with data, artificial intelligence, new technologies, professional skills in technical fields, especially automation, robotics, control and programming of complex technologies [3, 4], as well as skills for successful process management and human interaction [1, 3]. Furthermore, skills such as creativity, problem solving, negotiation, critical thinking, teamwork, empathy and emotion management, intercultural communication and the ability to adapt and lead changes will be relevant [1, 5]. In a world where everything is connected, the ability to communicate successfully is also important; however, it can be considered one of the most difficult skills to develop [5]. Globally, the increased use of ICT has increased the demand for general and specialised ICT skills and additional skills such as online marketing and big data analysis [3]. In addition, the analysis of educational events allows concluding that knowledge and skills in the following fields are vital:

- general understanding of Industry 4.0 (opportunities, challenges, requirements, benefits, importance);
- latest technologies for digitalisation and automation (Internet of Things, artificial intelligence and machine learning, cloud computing, data analytics and cybersecurity).

In Latvia, employers' expenditure on employee training is low compared to other EU countries. The share of training expenditure in total labour costs in enterprises in Latvia is only 0.8%, but in the EU, on average – 1.7% [1]. The main obstacles to employees' growth are their inability to combine training with work schedules and insufficient employer support [1]. Investments in ICT skills in the workplace are low. Only 11% of Latvian companies provide training to their employees in ICT skills compared to the EU average (23%) [1].

It is necessary to strengthen the cooperation between universities and industry to improve the content of study programs and align it with the development needs of the industry, especially by promoting the acquisition of competencies necessary for the development of Industry 4.0 [1, 4]. One of the challenges for higher education is to reduce the shortage of ICT professionals, so there is a need to promote targeted investment in the ICT workforce specifically. Furthermore, with the digitalisation of different sectors and the emergence of new technologies and knowledge, higher education should be more flexible in transferring this knowledge and skills to the population [1]. Also, recently developed HEIs study programs indicate the need to develop skills in cybersecurity, robotics, artificial intelligence, smart technologies and virtual/augmented reality [4].

Skills and knowledge necessary for the current and future workforce largely depend on the employers' demand, willingness, and ability to adopt new ways of working. Three of the projects summarised in this report conducted studies to elicit companies' opinions regarding Industry 4.0 and intentions on digitalising their business. In 2019, the DIGINNO and Women4IT project conducted studies asking respondents about the importance of various digital technologies in their business. The sample is somewhat limited: the DIGINNO survey [6] had 18 respondents from Latvia, while the Women4IT survey [7] gathered responses from 34 companies. Nevertheless, both surveys reveal similar tendencies: Latvian respondents of the first survey indicated automation (3.4 out of 5

points), database (3.3), wireless (3.2), security and encryption (2.8) and cloud computing (2.8) technologies as most useful, while drones (1.1), blockchain (1.2), machine learning (1.4) and augmented reality (1.4) technologies were marked as less important. The Women4IT survey does not represent the data from Latvian respondents separately. However, from all respondents of this survey, 76% marked mobile services, 63% cybersecurity, 62% big data and analytics, 61% cloud technologies, 57% enterprise systems, and 56% IoT as very useful for their businesses. Only 3D printing was considered less useful - marked as very important by 22% of respondents.

Expected tendencies of the use of digital technologies in the nearest future (3-5 years) were studied in surveys conducted within the DIGINNO [6], Woman4IT [7] and the DigiBEST project. The DigiBEST project conducted a survey [8] on 2020 and got responses from 51 Latvian companies. Answers to this question in all three surveys coincide: companies express their intent to invest in wireless technologies, database, automation, security and encryption, cloud computing, big data and analytics, data visualisation technologies and robotics.

In preparing the report, several projects were found that strive to define sets of skills needed for specific areas. One of the deliverables of project ITSVET was a standard for ICT security specialists [9], which describes the knowledge and skills needed for such professionals in great detail. The standard demands professional as well as general skills. Professional skills necessary for such specialists include using the knowledge about future technologies to foresee appropriate security solutions, using the knowledge about secure infrastructure methodology, assessing security risks of ICT solutions and mitigating them, systematically scrutinising the environment for identification of vulnerabilities and threats and avert any breaches of ICT security. 4CHANGE project has created VET programs [10] for CNC machine operators of various qualification levels. These programs aim at developing such skills as ensuring cybersecurity at the workplace, operating, maintaining and troubleshooting additive manufacturing machines, and using wireless, big data and cloud computing technologies at the workshop, among others. The cybersecurity skills framework [11] developed during the SPARTA project describes skills needed for various roles at a company to ensure its cybersecurity. This framework is intended to provide a basis for a discussion between academia, industry, policymakers, specialists and others.

Therefore, specific skills and knowledge that will be demanded in future from employees depend mainly on company size (SME or large company) and targeted market (local or international), the company's digital maturity and the strategic vision of the business. However, the general trends indicate the necessity to develop the following skills and knowledge:

- general digital competence (effective use of software and hardware, searching and evaluating the reliability of information, and others);
- soft skills and transversal competences (creativity, problem solving, critical thinking, teamwork, intercultural communication, emotional intelligence, and others);
- general knowledge of Industry 4.0 (opportunities, challenges, requirements, benefits, importance);
- awareness of and skills in using the latest technologies for digitalisation and automation (Internet of Things, artificial intelligence and machine learning, cloud computing, automation, robotics, big data analytics and cybersecurity, smart technologies, and virtual/augmented reality).

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1.5.3 CASE OF POLAND

DigiWork. Digitalization and Industry 4.0 in Partner Countries Policies

Digitization and Industry 4 in Partner Countries	
1. Country:	**Poland**
2. State aid programs in the field of digital transformation:	

Program no. 1	
Program name:	**Fundusze Europejskie na Rozwój Cyfrowy 2021-2027** **more: https://www.polskacyfrowa.gov.pl/strony/o-programie/fundusze-europejskie-na-rozwoj-cyfrowy-2021-2027/zalozenia-do-nowego-programu/**
Designed for the sector:	**entrepreneurs,** **public administration,** **non-governmental organizations,** **entities of higher education and science system,** **medical entities,** **cultural institutions**
Period: Note: pls add examples from 2018	**2021-2027**
Aid amount:	**2 bln euro**
Other indicators:	
Program No. 2	
Program name	**Akademia Transformacji Cyfrowej MMŚP** **more: https://hrp.com.pl/projekty/akademia-transformacji-cyfrowej-mmsp/**
Designed for the sector:	**MSME**
Period: Note: pls add examples from 2018	**from March 2022**
Amount:	**?**
Other indicators:	
Program No.3	
Program name	**Konwersja cyfrowa domów kultury** **more:** **https://www.nck.pl/dotacje-i-stypendia/dotacje/granty/konwersja-cyfrowa-domow-kultury**
Designed for the sector:	**cultural institutions**
Period: Note: pls add examples from 2018	**from May 2021**
Amount:	**?**
Other indicators:	
3. State aid programs for the implementation of Industry 4	
Program no. 1	
Program name:	**Przemysł 4.0 - dotacja dla firm produkcyjnych na cyfryzację, automatyzację i robotyzację** more: https://bldg.pl/przemysl-4-0/
Designed for the sector:	**SME**

Period: Note: pls add examples from 2018	**15-30 June 2021**
Aid amount:	**800 000 PLN**
Other indicators:	
Program No.2	
Program name:	Przemysł 4.0 more: https://pfr.pl/oferta/przemysl-40-pilotaz.html
Designed for the sector:	**SME**
Period: Note: pls add examples from 2018	**till 30 June 2021**
Amount:	**800 000 PLN**
Other indicators:	
Program No.3	
Program name:	
Designed for the sector:	
Period: Note: pls add examples from 2018	
Amount:	
Other indicators:	
4. State of aid programs aimed at increasing the digital skills of the population:	
Program no. 1	
Program name:	**Digital skills 50+** **http://naviculam.pl/project/rozwoj-kompetencji-cyfrowych-osob-bezrobotnych-po-50-roku-zycia-di-ski-50/**
Designed for the sector:	**Unemployed citizens 50+**
Period: Note: pls add examples from 2018	**01/10/2016 do 31/05/2018**
Aid amount:	**?**
Other indicators:	
Program No.2	
Program name:	**Skills+** **https://www.marr.pl/skills/**
Designed for the sector:	**SME**
Period: Note: pls add examples from 2018	**2016-2021**
Amount:	**?**
5. Programs aimed at supporting the digital transformation of education, supporting the employability of university graduates, other *Note: Please write a minimum 150 words per program.*	

Program no. 1	
Program name:	**Digital Skills Accelerator https://www.digitalskillsaccelerator.eu/**
Designed for the sector:	**Students**
Period: Note: pls add examples from 2018	**2017-2019**
Aid amount:	**199 214,00 EURO**
Other indicators and Impact of the Program	
Program No.2	
Program name:	**AI Tech https://www.gov.pl/web/govtech/akademia-innowacyjnych-zastosowan-technologii-cyfrowych-ai-tech**
Designed for the sector:	**Students**
Period: Note: pls add examples from 2018	**2020-2023**
Amount:	**51,5 mln PLN**
Other indicators and Impact	

6. Digital literacy in the country: (as individual)

Note: 250 words minimum. Please indicate the percentage of the digital literacy level in your country and write a short description of its state, with a link to reference.

Note: 56% of Europeans have basic digital skills and 31% have above average skills. The European Commission has set targets for 70% of adults to have basic digital skills by 2025.

Percentage	**44%**

More: https://digital-strategy.ec.europa.eu/en/policies/desi-poland

Digital literacy in Poland is considered to be among the lowest levels in the whole EU. According to DESI (Digital Economy and Society Index), Poland ranks 24th of 27 EU Member States as of 2021. Poland makes constant progress in all fields rated and tracked by DESI. Still, given the equally positive developments in other countries, this has not translated into a change in its overall position in the past years. Poland ranks 24th of 27 EU countries in the Human capital category, being below average on basic and above basic digital skills. Only 44% of people between 16 and 74 years have at least basic digital skills (EU average is 56%), and only one in five have above-basic digital skills (EU average 36%). The COVID-19 pandemic had a powerful impact on digital skills development due to the modernization and training needed in remote work-related areas, especially education.

Regarding connectivity, Poland ranks 21st, with 32% of Polish citizens not having broadband Internet access. Despite that, Poland ranks higher than average in the percentage of households accessing more than 100mbs internet bandwidth.

Poland ranks 24th among EU countries in integrating digital technology into business activities. 52% of Polish SMEs have at least a basic level of digital intensity, below the EU average of 60%.

Poland ranks 22th in Digital public services. 49% of internet users relied on e-government services, compared to 64% in the EU. Despite below-average usage, the Polish digital solution – the m-Obywatel digital wallet for documents and services – is currently one of the most advanced case studies among European digital identity wallet solutions.

7. What proportion of university graduates were employed within 12 months of graduation?
Note: One of the criteria for EU assessment is: The employability of graduates aged 20-34 three years after graduation is assessed. The reference value is 82% and more.

% of employed graduates within 12 months:	**We do not have current data. Most of the data is from 2014 and indicates a longer-term outlook than 12 months.**

8. What is the awareness and preparedness of individual sectors for the digital transformation:
Note: Use rating: 1-5, where 1- lowest to 5 – highest

Sectors:	State and public administration:	**2**
	Services and trade:	**4**
	Industry:	**3**

9. Which jobs are most in demand: (by individuals)

Sectors:	State and public administration:	**no**
	Services and trade:	**yes**
	Industry:	**yes** **more here:** https://interviewme.pl/blog/zawody-przyszlosci-najbardziej-poszukiwane

10. Which sectors are the leaders in:

1. Digital transformation:	**Finances & insurance** **ICT** **See here:** https://www.mckinsey.com/pl/~/media/McKinsey/Locations/Europe%20and%20Middle%20East/Polska/Raporty/Polska%20jako%20cyfrowy%20challenger/Raport-McKinsey_Polska-jako-Cyfrowy-Challenger.pdf
2. Industry 4:	**Automotive** **Food & Beverages** **Machinery** **Chemistry & Pharmacy** **See here:** https://przemyslprzyszlosci.gov.pl/raport-cyfryzacja-w-polskich-firmach-wymaga-przyspieszenia/

11. To what extent do universities have implemented knowledge for Industry 4 in their curricula: *Note: Please use rating: most schools do not have, most schools have only partially, most schools have, almost all schools have*
Some schools, especially universities of technology, have introduced this knowledge. Business schools, especially private ones, are introducing it faster than public ones. Universities are the slowest.

Add:

1. Statistics and economic indicators related to the level of digitization and the development of digital skills/literacy in your country
2. State policies, plans, laws, initiatives, guidelines, programs related to Industry 4.0
3. Educational Activities intended to raise awareness of society and industry about Industry 4.0
4. Projects (local and international) related to Industry 4.0 in which your country participates
5. University study programs and courses directed towards Industry 4.0 technologies
6. Companies whose website s include information about Industry 4.0

Overview for the Final Report: Poland

Title of the indicator:	**hy and population of Poland**
Value:	The latest population balance sheet reports that Poland has a population of slightly more than 38 million, with almost 23 million living in cities and more than 15 million in villages. The gender statistics are close to equal: women represent more than 51% of the population [1]. According to calculations made in 1775 by cartographer and royal astrologer Szymon Antoni Sobiekrajski, the center of Europe is located in Suchowola, Poland. This is the place where the lines connecting the farthest points of Europe intersect. Although more recent research indicates that the center of Europe runs a bit further east, in Lithuania, Poland's unusual central location is highlighted by an expanding infrastructure of roads and international business [2]. Poland's convenient location makes the country an ideal place to locate investments that have an audience in both Western and Eastern European markets. The main transportation routes leading from north to south and from east to west in Europe intersect in Poland. Four of the 10 continuously expanding trans-European corridors run through Poland: from Helsinki via Warsaw, with a branch to Gdansk; from Berlin via Warsaw, Minsk and Moscow to Nizhny Novgorod; from Brussels via Krakow to Kiev; and from Gdansk to Brno [3].
Reference:	1. https://demografia.stat.gov.pl/BazaDemografia/Tables.aspx 2. https://pl.wikipedia.org/wiki/Środek_Europy 3. https://www.paih.gov.pl/dlaczego_polska/strategiczne_polozenie

Title of the indicator:	**Digitalisation and digital literacy in Poland**
Value:	In the case of Poland, it is worth noting that the level of digitization has increased significantly by the COVID-19 pandemic, however, it is still low. The COVID-19 crisis has accelerated the digital

	transformation trends around the globe, as evidenced in the development and expansion of digital infrastructure; the shift to digital delivery of services by companies and within organizations, for instance, in education, healthcare and retail; and increased implementation of digital technologies in manufacturing. Although the pandemic has had a negative impact on many businesses, it has also uncovered new opportunities for entrepreneurship. It has boosted digital entrepreneurship, for instance, reflecting changing consumer behaviour during and in the aftermath of the pandemic. Digital literacy in Poland is considered to be among the lowest levels in the whole EU. According to DESI (Digital Economy and Society Index), Poland ranks 24th of 27 EU Member States as of 2021. Poland makes constant progress in all fields rated and tracked by DESI. Still, given the equally positive developments in other countries, this has not translated into a change in its overall position in the past years. Poland ranks 24th of 27 EU countries in the Human capital category, being below average on basic and above basic digital skills. Only 44% of people between 16 and 74 years have at least basic digital skills (EU average is 56%), and only one in five have above-basic digital skills (EU average 36%). The COVID-19 pandemic had a powerful impact on digital skills development due to the modernization and training needed in remote work-related areas, especially education. Regarding connectivity, Poland ranks 21st, with 32% of Polish citizens not having broadband Internet access. Despite that, Poland ranks higher than average in the percentage of households accessing more than 100mbs internet bandwidth. Poland ranks 24th among EU countries in integrating digital technology into business activities. 52% of Polish SMEs have at least a basic level of digital intensity, below the EU average of 60%. Poland ranks 22th in Digital public services. 49% of Internet users relied on e-government services, compared to 64% in the EU. Despite below-average usage, the Polish digital solution – the m-Obywatel digital wallet for documents and services – is currently one of the most advanced case studies among European digital identity wallet solutions [1]. The ICT industry is one of the fastest growing in the country. In 2020, the number of ICT companies increased by 3.1% over the previous year (from 2393 to 2468). ICT service providers represented 90.8% of ICT sector businesses, and most of them (77.4%) specialized in IT services. The number of employees in the ICT sector increased by 3.2% year-on-year (from 260 654 to 269 030). Those working in ICT services accounted for 86.1% of the sector's workforce, including 64.7% in IT services. Compared to 2019, the largest increase in the number of employees among service companies was observed among wholesale entities (6.3%). Telecommunications service providers, as well as device makers, saw a decrease of 3.1% and 0.5%, respectively [2].
References:	1. https://digital-strategy.ec.europa.eu/en/policies/desi-poland 2. https://stat.gov.pl/obszary-tematyczne/nauka-i-technika-spoleczenstwo-informacyjne/spoleczenstwo-informacyjne/spoleczenstwo-informacyjne-w-polsce-w-2021-roku,1,15.html

Title of the indicator:	**Most demanded digital skills in Poland**
Value:	Based on the national research conducted for the DigiWork project, we believe that the most in-demand skills in the area of digital transformation are: a. core skills: o analytical thinking o critical thinking

	o creative problem solving o lean management b. hard skills: o product and service design: 1. web design 2. e-learning design 3. designing digital ecosystems for companies (using AI, OCR, etc.) 4. designing digital payment management systems 5. creation of digital attendant-free customer service points o human-centered design: 1. user experience (UX) design 2. user interface (UI) design 3. WCAG implementation o managing a modern company and/or production: 1. ERP implementation & management 2. implementation and management of automation and robotics 3. data management 4. QA tests
Reference:	

1.5.5 CASE OF SLOVAKIA

Digitalization and Industry 4.0 in Slovakia

Initial state in Slovakia - Position of Slovakia in international indexes

The progress and level of development of Europe's digital competitiveness in individual member countries is monitored annually by the European Commission using the Digital Economy and Society Index (DESI), which uses a combination of 37 indicators in five main measurement dimensions:

1. availability of internet connection,
2. human capital,
3. use of internet services,
4. integration of digital technologies in enterprises a
5. digital public services.

The development of individual dimensions of the DESI index in individual dimensions for Slovakia for the period 2015-2021 is shown in fig. 44:

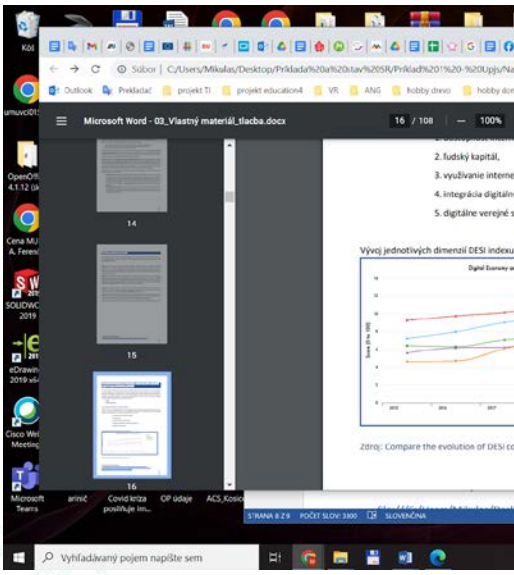


Fig. 44 Development of individual dimensions of the DESI index for Slovakia

In 2021, Slovakia ranked 22nd among the 27 EU member states in the Digital Economy and Society Index (DESI), fig. 45:

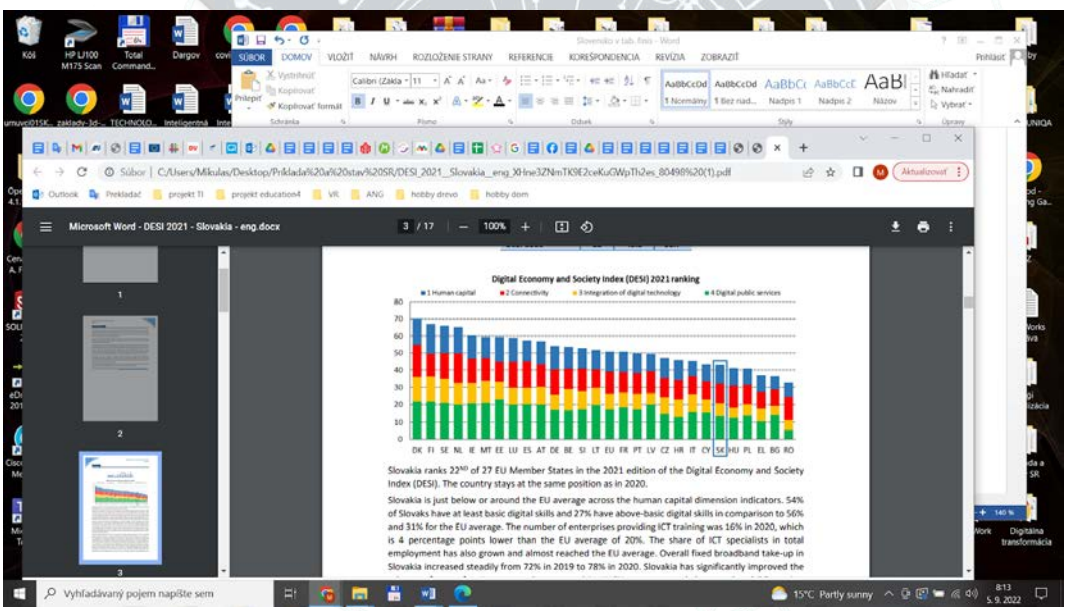


Fig. 45 Position of Slovakia in the EU according to the DESI index in 2021

Human capital

In the area of human capital, Slovakia ranks 19th among the 27 EU countries, and is thus below the EU average. According to DESI, 54% of Slovaks have at least basic digital skills and 27% have above-average digital skills, compared to the EU average of 56% and 31%, Fig.46. The number of businesses providing ICT training in 2020 was 16%, which is 4 percentage points below the EU average of 20%. The share of ICT specialists in total employment also increased and almost reached the EU average. Overall, the best digital literacy in the survey was achieved by people aged 25-34,

who are, however, university students and young employees. Young people aged 14-17 express a slightly worse opinion.

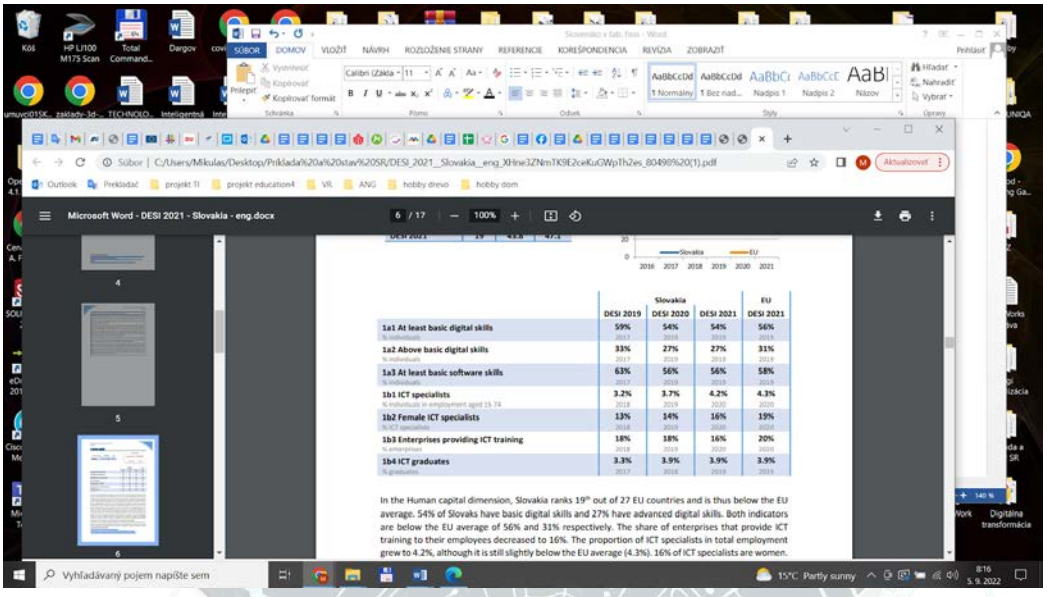


Fig. 46 Human capital of Slovakia in 2021, (DESI)

Integration of digital technologies

Within the EU, Slovakia ranked 21st in the field of integration of digital technologies by businesses, fig. 47. Only 52% of Slovak SMEs achieve at least a basic level of digital intensity (EU average: 60%). Slovakia lags behind the EU average when it comes to the use of artificial intelligence in businesses (15% versus 25%) and the use of cloud services (18% versus 26%). The share of enterprises that use big data analysis fell from 9% to 6%. The country's e-commerce score has improved somewhat: 17% of SMEs sell online, which is on par with the EU average. However, the share of SME turnover from e-commerce stagnates at 11% (EU average: 12%). In 2020, 16% of Slovak businesses used electronic invoices, compared to 32% in the EU. 76% of Slovak enterprises in 2021 used information and communication technologies for measures, which are more environmentally friendly, at a medium-high to high level, which is 10 percentage points more than the EU average of 66%. . 15% of businesses used at least two artificial intelligence (AI) technologies in 2020, compared to 25% in the EU. The overall use of fixed broadband in Slovakia steadily increased from 72% in 2019 to 78% in 2020. Slovakia has significantly improved the rollout of superfast internet and progressed with very high capacity network coverage.

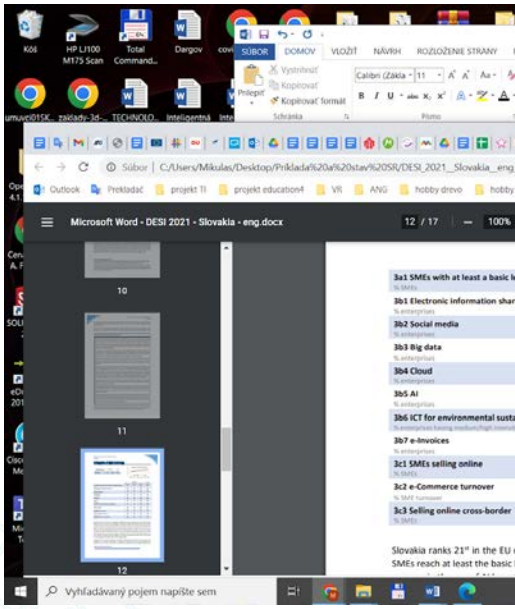


Fig. 47 Integration of digital technologies by enterprises

Digital public services

Public administration in Slovakia achieves insufficient results, while the comparatively low level of digitization of public administration and public services is a key obstacle to the business environment and economic growth.

With a score of 53.7 in 2021, Slovakia ranks 23rd in the EU in the field of digital public services. The share of e-government users among Internet users decreased slightly to 68%, but is still above the EU average (64%). In all other monitored indicators, Slovakia achieves lower results than the EU average. Regarding the category "amount of pre-filled data in public online forms", the country scored 36 points in 2020, which is well below the EU average of 63. Digital public services for citizens are also below the EU average, representing 64 compared to 75 points in EU. This difference is less pronounced in the case of digital public services for businesses, where Slovakia scores 79 points compared to the EU average of 84 points.

Application of Industry 4.0 elements

Despite the fact that Slovakia is progressing in the application of the elements of Industry 4.0, compared to other countries of the European Union, Slovakia has been lagging behind for the last 3 years, and this lagging behind is getting worse. The Slovak education system is still adapted to memorization rather than to the effective development of skills (soft skills as well as necessary knowledge).

Industry 4.0 and digital transformation are accompanied by changes that take place with varying intensity and extent in Slovak companies as well. The share of companies that started with the Industry 4.0 application is decreasing for the second year in a row, fig. 48. From the point of view of trends, implementation in terms of parameters - we have a ready strategy, we are starting with the application and we are fully implementing our strategy - still maintains a slightly upward trend.

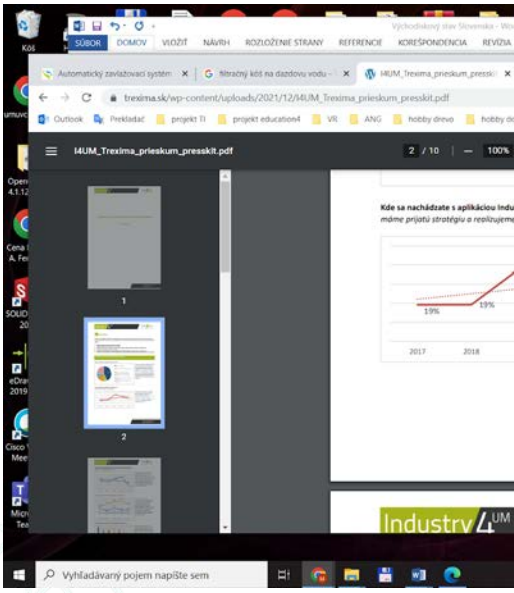


Fig. 48 Share of companies that started with the Industry 4.0 application

Figure 6 shows the lack of qualified workforce for Industry 4.0 technologies. The lack of qualified workers is mainly for digitalization system solutions (opportunity search, concept design, solution architecture and business development), artificial intelligence, analytics and data evaluation and Big Data application and robotics.

Digitization and Industry 4 in Partner Countries	
1. Country:	**Slovakia**
2. State aid programs in the field of digital transformation: State aid programs in the field of digital transformation:	
Program no. 1	
Program name:	**Slovakia's recovery and resilience plan - QUALITY EDUCATION** **Component:**Education for the 21st century
Designed for the sector:	Pupils of elementary schools and students of secondary and higher schools, teachers, professionals, trainers
Period:	**2022-2030**
Aid amount:	**EUR 892 million**

Other indicators:	**Preparation and development of teachers for new content and form of teaching** **Innovative education in the context of Industry 4.0**
Comment	In Slovakia, as in other advanced economies, the importance of highly qualified skills, which are needed to operate them, is growing with the ever wider implementation of new technologies. These changes require a critically thinking population with the ability to quickly adapt to dynamic changes in the labor market and society. Curricula, content and methods of education must therefore be adapted to the new requirements of global digital economies and the social changes associated with them. Prerequisites for making changes in teaching are well-prepared teachers and sufficient school and digital infrastructure. The main tool will be changing the content of education and its effective implementation in schools. Pupils will acquire the necessary digital skills and the share of pupils with insufficient basic skills will be reduced to the level of 15% in accordance with the objectives of the European Commission within the framework of the European initiative ("Reskill and Upskill"). Gradual digital transformation and a better connection between education and the labor market will help reduce mismatches and skills shortages, increase labor market participation and contribute to long-term and sustainable growth. The goal is to develop students' critical thinking and soft skills such as the ability to solve problems, process information, work in a team, argue and ask questions, take initiative and responsibility, create and implement personal projects. Pupils and students will be able to understand and analyze different perspectives and critically evaluate contemporary global and intercultural issues. To achieve a basic level of digital skills, they will be able to work with the Internet in four basic areas: searching for information, communicating, solving problems and creating digital content. As part of the reform, there will be support for the digitalization of textbooks in order to strengthen interactive elements in teaching and, if necessary, facilitate distance learning and enable their use by students with disabilities. **Preparation and development of teachers for new content and form of teaching** The main goal of the reform is to improve the quality of the skills of teaching and professional staff and to motivate them for lifelong professional development. The reform will support the ability of teachers to respond adequately to three challenges: a. implementation of the curriculum reform into everyday practice, b. increasing the rate of use of digital technologies in teaching, c. taking into account the individual needs of each student in the teaching process, especially in a multilingual environment or in an environment with students from socially disadvantaged backgrounds. The goal of investments in digitization in schools will be to achieve full digital equipment at the entry level of all primary and secondary schools in Slovakia (according to defined ICT standards built on the basis of the "highly equipped and connected classroom" (HECC) model). This goal is in line with the recommendation of the European Commission for the main initiative in the field of retraining and improving skills and with the Digital Education Action Plan 2021-2027.

The main tool is support for the purchase and installation of digital equipment and software. Primary and secondary schools will be able to upgrade their digital equipment to HECC entry level.

Innovative education in the context of Industry 4.0

Due to the automation of the industry, approximately 40% of traditional professions in Slovakia are expected to disappear. In accordance with the application of the elements of Industry 4.0 across the branches of the national economy, the requirements for qualifications, knowledge and skills of employees are also gradually changing. In particular, the necessity of education in the field of IT, data analysis, the ability to work with modern technologies is assumed, but the demands on employees and entrepreneurs are also increasing in the field of so-called soft skills, such as analytical thinking, active learning, the ability to solve complex problems, creativity, leadership. Lifelong learning becomes a necessity not only for the employee, but also for the business owner. The lack of qualified labor is already a significant barrier to the development of SMEs in the Slovak Republic. Changes in the method of production, but also procurement and sale of products,

In addition to soft skills, emotional skills also come to the fore. This is, for example, the ability to adapt to different situations, the ability to self-motivate, self-manage, and increase self-confidence. It is also important to teach students to manage their own emotions, or to be able to engage in satisfactory interpersonal relationships.

The key points of this change for Slovakia were summarized as follows:

- Individualized education, focused more on the education of the individual, not on the education of the whole group. One of the changes of Industry 4.0 is that in the future the number of people who will be employed through the so-called freelancing. It is precisely the increasing transition of people to other professions (e.g. in the form of freelancing) that requires an individualized approach on the part of educators. -

- Increased flexibility in the learning process. Strict regulation of the educational process, manifested, for example, in the determination of the scope of the lesson, the exact schedule, or the exact determination of breaks suppresses a creative approach to teaching. For this reason, the flexibility of teaching processes becomes essential.

- Change in evaluation. Each student will be evaluated based on the completion of his own task.

- The teacher is a mentor and a coach. Education 4.0 assumes a shift from the classic perception of the teacher as a "presenter of material" or a "dictator" of notes towards a mentor (especially with regard to greater development of so-called soft skills). Teacher 4.0 should be able to create video and audio content, visually engaging content, use social networks in teaching, use blogs for participatory content and create digital portfolios.

Projects supporting the digitization of education for the needs of Industry 4.0

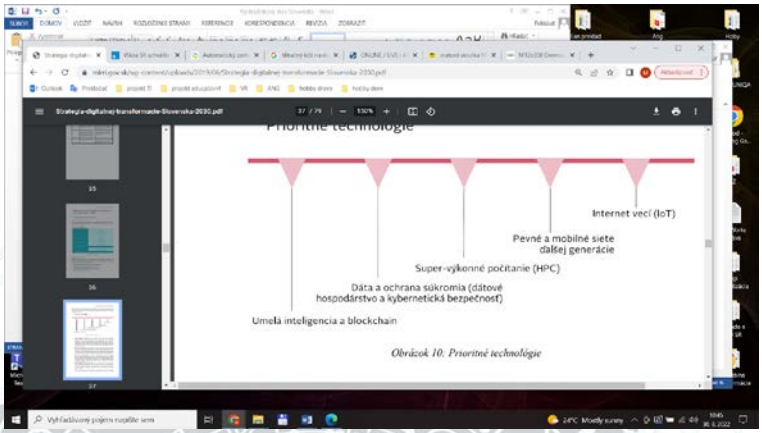
The Ministry of Education and Culture implements individual steps towards the implementation of measures for the digital transformation of education through national and international projects. Projects to support the digital transformation of education include:

	- National IT Academy project - National project "Professional development of teachers (TEACHERS) - National project "Dual education" - International project "Clil in vet" - Project "Ploteus" - VET project for the labor market - International eTwinning project,
Program No. 2	
Program name	• **Recovery and Resilience Plan of Slovakia - EFFECTIVE PUBLIC ADMINISTRATION AND DIGITALIZATION** **Component:**Digital Slovakia (State in mobile, cyber security, fast internet for everyone, digital economy).
Designed for the sector:	Subjects of socio-economic interaction, households, telecommunications companies, municipalities, public administration institutions, academia, research and development institutions, industry.
Period:	**2022 - 2030**
Amount:	EUR 1110 million, of which EUR 309 million euros to improve electronic services of the state (eGovernment), 183 mil. EUR 69 million for the development of the digital economy and digital innovations. EUR for the development of digital skills of seniors and disadvantaged groups and 54 mil. euros to support cyber and information security.
Other indicators:	• Increase the level of digitization of industry, especially SMEs • Increasing the level of digital skills of employees
Comment	By introducing effective tools in public administration, creating prerequisites for the digital transformation of industry and other businesses, and supporting the ecosystem for innovation in the field of digital technologies, the potential for intensive economic growth and the creation of new jobs in industries that will be less sensitive to the ongoing digitization and robotization will be increased. A necessary prerequisite for achieving this goal is the development of electronic public administration (eGovernment), which will provide citizen- and entrepreneur-oriented services, as well as cyber security - processes and principles that will ensure trust in the interactions of citizens, businesses and public administration, digital skills not only for pupils and school students, but also for employees in industry and public administration, or seniors, so that no entity is excluded from the digital age. In the field of eGovernment, the main goal is to increase the number of users of the state's digital services and user satisfaction with them. In recent years, the public administration has made most services available for citizens and entrepreneurs online. Despite this, today the use of electronic communication by citizens with public administration is very low. The most used method of communication is still the written form or a personal visit. The strategic goal of Slovakia is to achieve progress in the DESI index in the field of digital services by 40% by 2026 compared to the current

	state, and in particular: • Increase the level of digitization of industry, especially SMEs Support in this area will be focused on the digitization of industrial production and services, including SMEs, with the aim of increasing their efficiency and competitiveness within the single digital market, as well as the introduction of energy and environmentally efficient production and service provision. • Increasing the level of digital skills of employees Digital innovation centers (CDI) and European digital innovation centers (ECDI) will focus on the development of digital skills and competences of SME employees. This component only partially addresses the challenges of building digital skills. To further support digital skills, which is one of the CSR 2020 recommendations, additional resources will be sought within the state budget as well as within the new programming period 2021-2027.
Program No.3	
Program name	**Digital transformation strategy of Slovakia 2030**
Designed for the sector:	Schools, industrial economy, public administration, healthcare, services
Period:	2019-2022 2021 - 2030
Amount:	1.89 billion euros - A more competitive and intelligent Slovakia
Other indicators:	• A more competitive and intelligent Slovakia • Education of school digital coordinators • Improving citizens' digital skills • National IT Academy project
Comment	**A more competitive and intelligent Slovakia** Investments aimed at a more competitive and intelligent Slovakia in the amount of almost 1.9 billion euros. This money will go to science, research or innovation. Slovakia has serious deficiencies in the key measure of competitiveness. In the 2019 World Competitiveness Ranking, Slovakia was ranked 53rd out of 63 monitored countries. There is also great room for improvement in the field of digitization. Electronic services of the state do not reach the required quality and only 52 percent of citizens use them. The goal also in this area is for people to have jobs with a higher level of skills, i.e. professional jobs requiring professional qualifications or a higher level of education, where there are also higher salaries. If Slovakia fails to realize such a transition from an "assembly workshop" to a higher-level economy, then as a result of automation, i.e. the replacement of workers by machines, there will be a lot of job losses. In Slovakia, up to 64 percent of jobs are currently threatened by automation and robotization. **Education of school digital coordinators** The education of school digital coordinators started last school year as part of the IT

	Academy national project. 278 teachers and principals from 165 primary and secondary schools completed the first run. "In the school year 2021-22, 379 participants from 337 schools participated in the education, of which 225 participants were from schools involved in the edIT 1 and edIT 2 projects. The education ended in December 2021, and the final presentations are being defended until January 31, 2022". The output of the education of school digital coordinators is Action Plans for the digital transformation of the given school for the next 3 years. The creation and implementation of action plans is and will continue to be supported within the Digital Coordinators' Club. The national project IT Academy - education for the 21st century is implemented by CVTI SR in cooperation with other partner institutions. Detailed information is available on the websitehttp://itakademia.sk/. The strategic goal of the project is to create a model of education and training of young people for the current and prospective needs of the knowledge society and the labor market, with a focus on informatics and ICT. This project is implemented thanks to support from the European Social Fund within the Operational Program Human Resources. IT Academy project The IT Academy contributes to increasing the digital skills of students and teachers at all levels of education. Its goal is to create a model of education and training for young people that better responds to the needs of society and the market, focusing on digital skills. The project is implemented in partnership with five Slovak universities and is co-financed by the European Social Fund. The total financing of the project for the period 2016-2021 amounts to EUR 19 million. The project includes a total of 683 primary and secondary schools, five universities, more than 50 thousand primary and secondary school pupils, over 300 primary and secondary teachers and more than 4,000 university students. Some of the main results of the project include: ·1,132 innovative teaching methods of informatics, mathematics, biology, physics, chemistry, geography and other subjects in primary and secondary schools, ·60 new and innovative subjects at five universities aimed at addressing the needs of the labor market and digital transformation in fields such as data science, internet of things, computer networks and business information systems, ·teacher training and professional development (updates, innovation, webinars, consultations) with a focus on the use of created teaching materials and on supporting the digital transformation of education. **Improving citizens' digital skills** For this purpose, the National Coalition for Digital Skills and Occupations of Slovakia was established, which successfully fulfills its goal in the field of improving the digital skills of citizens, IT specialists, all employees and in education through the mobilization of relevant public, private, academic and civic organizations and institutions. The digital coalition, which was founded in 2017 on the initiative of the IT Association of Slovakia, is a successful example of activation across the spectrum of public, private, academic and civic organizations and institutions in Slovakia.

Program No. 4	
Program name	**Priority areas of Slovakia's digital transformation**
Designed for the sector:	Economy, education, public sector,
Period:	2019 - 2022
Amount:	
Other indicators:	• Digital transformation of schools • Digital economy • Modern and efficient public administration • Creating new business models
Comment	The basic mission of this strategy is not only to achieve a significant increase in Slovakia's involvement in the European single digital market, but above all to prepare Slovakia for a comprehensive digital transformation of the economy and society. This process will serve as the necessary impetus for starting the development of the information society and the transformation of traditional industry into Industry 4.0. For the period 2019-2022, the priority areas were determined: ♣Digital transformation of schools and education to improve its quality, improve employment prospects and acquire the competencies necessary for the digital age, ♣Creating the foundations for a modern data and digital economy and for the digital transformation of the wider economy, ♣Improving the capabilities of public administration to use data and innovation for the benefit of citizens. In the context of the long-term time horizon, the priority areas are outlined in the strategy: ♣Innovative digital and data economy, ♣An educated, healthy and safe society, ♣Modern and efficient public administration, ♣Intelligent development of the territory, ♣World-class quality science, research and innovation. Businesses can expect the following relevant support: −support for testing and creating new business models, −support for the introduction of AI solutions in business processes, −support in access to human capital, knowledge and technology A functional and modern public administration is a key factor for the success of the digital transformation of the economy and society. Another advance in electronic public administration will be its European dimension. The European vision is a public administration in the EU that will be open, efficient and inclusive and that will provide cross-border,

	personalized and user-friendly electronic public services to all citizens and businesses in the EU. From the point of view of the current trends that meet these requirements, it appears to be most effective to support the following priority technologies, which are shown in Figure 49.  **Fig. 49 Priority technologies**

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https://ec.europa.eu/education/schools-go-digital

1.5.4 CASE OF SPAIN

Spanish soft skills – Digital skills need for life and work

The European institutions have made a significant effort to establish a reference framework of digital competences that allows all member countries to develop their strategies for the acquisition and development of these skills in a systematic way. In this sense, the Joint Research Center (JRC) of the European Commission launched at the end of 2010 the project "Digital Competence: Identification and European-wide validation of its key components for all levels of learners" (DIGCOMP), which determines a reference framework for digital competences for the citizenship, aligned with the guidelines of the European Digital Agenda, and identifies the components key to digital competencies in terms of knowledge, skills and attitudes.

Since then, the common framework of reference in digital skills has been updated until integrating, in its most recent version, five dimensions and twenty-one competencies structured into eight skill levels as shown in the following figure:

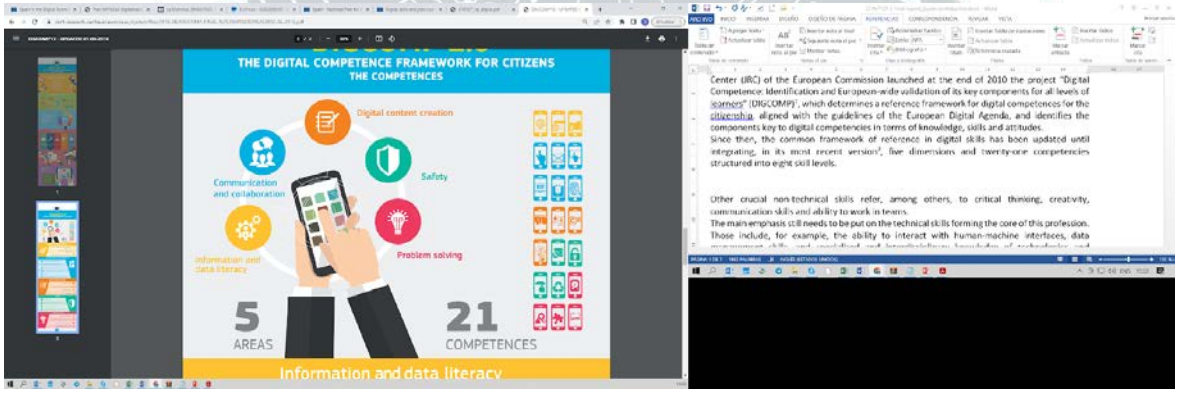

Fig. 50 Digital competence framework. Source: DIGICOMP

As shown in previous figure, the Digital Competence Framework includes the following areas:

(1) Problem Solving
(2) Safety
(3) Digital Content Creation
(4) Communication and Collaboration
(5) Information and Data Literacy

Taking these areas in consideration, Spain has embedded a National Plan for Digital Skills aimed to provide a roadmap in order to identify the measures needed (on a national, regional and local level) to ensure that all citizens have access to relevant resources so they can acquire and develop digital skills. The rapidly advancing technology requires a general mind-set for continuous improvement and lifelong learning. It is no longer just about what one knows, but increasingly about one's ability to adapt to continuously changing circumstances and to constantly advance one's knowledge and skills. Focusing on technical skills only is thus not enough.

In the National Plan for Digital Skills, Spain addresses a variety of challenges related to digital inclusion, access to technology, and lifelong learning for all. Some of its objectives to be address are:

- Ensuring no Spanish citizen is left behind and promoting inclusion in the digital world.
- Bridging the gender digital divide, through actions aimed at increasing the number of women studying, graduating and working in the information and communication technology (ICT) field.
- Supporting the acquisition of adequate digital skills for education, among teachers and students, and at all levels of the education system.
- Fostering the development of more advanced digital skills amongst the working population.
- Ensuring that Spanish companies in general, and specifically small and medium sized enterprises (SMEs), have sufficient digital skills and access to a skilled talent pool of qualified workforce, in order to manage the impact of the digital transformation.

Therefore the National Plan for Digital Skills will include soft skills for life and for work as shown below:

Guarantee digital inclusion. Digital training of citizens (with emphasis on groups at risk of exclusion digital)

This seeks to train citizens in the digital age by universalizing skills digital basics (as defined in the Spanish Digital Agenda 2026) so that all people can ***communicate***, buy, carry out transactions, interact with the administrations using digital technologies with autonomy and sufficiency.
To this end, special emphasis should be placed on those groups that find it more difficult to acquire these skills today, such as older people, people with low levels income, non-urban areas or with low educational level. In addition, there will be part of these groups that due to their age range are considered active population, for this reason this line intends to be oriented towards that 8% of the Spanish population that has never connected to the internet and almost 20 million that have not possesses basic digital skills.

Ensure the digitization of education and the acquisition of skills education for teachers and students at all levels of the system educational

The goal is to guarantee that all students in the educational system acquire the ***digital skills*** necessary for their full social integration and professional development future that will be determined by advanced use of technology and the ability to keep them permanently updated.
Therefore, an identified objective is to promote the use of ICT in schools, to promote the creation and sharing of educational digital content, or programs such as Internet in the Classroom, Internet at School, or the most recent Connected Schools and ***"Educa en Digital"*** also deserves a special mention the collaboration between educational administrations for the elaboration of the Framework of Reference of the Teaching Digital Competence.

The "Digitalization and Digital Competencies Plan of the Educational System" consists of a set of actions to support the digital transformation of the education system by providing of devices to schools and students, digital educational resources, the adequacy of digital skills of teachers and actions that involve the application of intelligence artificial to personalized education. It is carried out by combining different strategies and means, which include the collaboration agreement ***"Educa en Digital"*** for the development of some of its actions, as a result of a collaboration between the Ministries of Education and Vocational Training, Economic Affairs and Digital Transformation, and the Autonomous Communities.

Guarantee the acquisition of advanced digital skills both for unemployed people to improve their employability conditions, and for the employed people

This line aims to intensify the professional training system in digital ***skills professionals*** throughout life in collaboration with economic and social agents so that both employed men and women and unemployed people can develop the skills necessary to fully integrate into the digital economy. Administrations should pay special attention to the rebalancing of digital skills among people employed and unemployed women, as well as rebalancing in gender issues.

At Community level, following the publication of the Digital Single Market Strategy, the European Commission launched an initiative known as the Digital Skills and Job Coalition. More than 400 actors have joined this Coalition from both from the public sector and from the private sector with the aim of promoting training digital in the European Union. In this sense, it is also necessary to collaborate actively with the European Commission in order to align public policies to the strategic framework of action of the European Union in this area.

Around 55% of all jobs in the Spain need at least a basic level of digital skills. These dates reflect that there is a mismatch between demand and supply in digital skills, where supply of ICT-related profiles is not enough to meet a growing demand almost four times faster than the offer. In this sense, the demand for professionals from the information and communication technologies has grown by 4% per year over the last ten years, and yet digital skills are still lacking in Europe at all levels, where 43% of the EU population and 35% of the workforce have insufficient digital skills. In Spain, these figures are 45% and 34%. In addition, 42% of people without digital skills are unemployed, according to the DESI 2020 report.

Furthermore, in relation with soft skills, the Work Economic Forum identified the current skills in Spain in focus on:

a. Existing reskilling/upskilling programmes, and

b. Emerging skills

In this context the skills will be shown in priority rank in the following tables.

a. Existing reskilling/upskilling programmes

Related to current skills in focus of existing reskilling/upskilling programmes, information share of companies surveyed identifying this skills as being in focus across their reskilling or upskilling programs, these current skills are showed in the following table:

Table 1: Reskilling/Upskilling Skills in Spain. Source: World Economic Forum

	Reskilling/Upskilling Skills
1	*Analytical thinking and innovation*
2	*Active learning and learning strategies*
3	*Critical thinking and analysis*
4	*Technology use, monitoring and control*
5	*Leadership and social influence*
6	*Complex problem-solving*
7	*Management of personnel*
8	*Systems analysis and evaluation*
9	*Service orientation*
10	*Quality control and safety awareness*

Most of these mentioned skills are related with social behaviors of personnel in working environments.

b. Emerging skills in Spain

The WEF also identified the emerging skills. These skills are identified as being in high demands with their organization in Spain, ordered by frequency and showed in the following table:

Table 2: Emerging Skills in Spain. Source: WEF

	Emerging Skills
1	*Analytical thinking and innovation*
2	*Active learning and learning strategies*
3	*Critical thinking and analysis*
4	*Creativity, originality and initiative*
5	*Complex problem-solving*
6	*Technology use, monitoring and control*
7	*Resilience, stress tolerance and flexibility*
8	*Leadership and social influence*
9	*Technology design and programming*

10	*Emotional intelligence*
11	*Systems analysis and Evaluation*
12	*Persuasion and negotiation*
13	*Troubleshooting and user experience*
14	*Service orientation*
15	*Reasoning, problem-solving and ideation*

Most of these mentioned skills are related with problem solving situations in working environments.

Spanish hard skills – Digital skills and education

The European Union Publication Office (OPEU) announced in their website the skills for industry curriculum guidelines 4.0. This document claims there are four key technological developments that can be distinguished within Industry 4.0 such as:

(1) digitisation and integration of vertical and horizontal value chains;
(2) digitisation of product and service offerings;
(3) digitisation of business processes and way of working, and
(4) digitisation of business models and customer access

These four key technological developments can be as seen in the following figure:

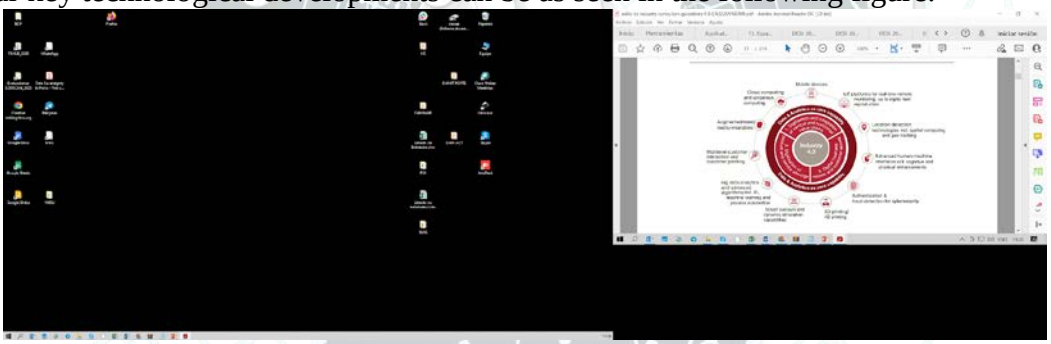

Fig. 51: Industry 4.0 framework and contributing digital technologies. Source: OPEU

From these key technological developments there are core digital and technical skills to enhance the Industry 4.0.

Table 3: Digital technologies. Source: WEF

Technology Adoption in Companies
Mobil devices
IoT (platforms for real-time remote monitoring, up to digital twin reproduction
Location detection technologies including spatial computing and geo-tracking
Advanced human-machine interface including cognitive and physical enhancements
Authentication & fraud detection for cybersecurity
3D printing/ 4D printing
Smart sensors and dynamic simulation capabilities
Big data analytics and advanced including AI, machine learning and process automation
Multilevel customer interaction and customer profiling
Augmented/mixed reality/wearables
Cloud computing and ubiquitous computing

Spain has reinforce these technological trends at national level created the Digital Enabling Technologies (THD) that have become essential for promoting innovation and digitalization of SMEs. The THD will have a significant impact on all productive sectors and on citizens, presenting a great opportunity for employment, innovation and entrepreneurship. The Digital Enabling Technologies (THD) are:

IoT, Bigdata, Artificial Intelligence, Blockchain, supercomputing and future 5G networks, among others.

These THDs have a high capacity for disruption and impact, in addition to having an enabling, horizontal and strategic nature for the digital transformation of any productive sector. The availability of a competitive offer of THD products and services constitutes a catalyst for accelerating digital transformation processes, but also a great opportunity for the industrial sector of digital technologies.

In this scenario, Spain has taken action with the strategic objectives of public intervention to:

- Promote a competitive national ***industrial sector*** in the THD, which assumes a necessary leadership and tractor agent of the digital transformation processes in the different productive sectors.
- Contribute to accelerating ***transformation processes*** in sectors of the economy that are less digitally mature, with greater inertia and complexity, or that present barriers with greater impact, cooperating with competent and leading sectoral agents.
- Through different programs and plans, SEAD has been developing these objectives, using instruments such as:
  > Public aid in ***competitive competition*** for the financing of projects.
  > Public p***rocurement of innovation*** for the development of pilots and demonstrators.
  > ***Technical standardization activities*** (standards, guides and reference models) and their international promotion.

Furthermore, Spain has also include a strategy called the National Plan for Digital Skills, referring to hard skills for employees and working conditions with the aim to:

Reduce the digital gap due to gender, increasing the number of women ICT specialist

This line seeks to close the digital gender gap (which grows as more advanced and specialized is the use of technology) to ensure the full participation of women in digital society and economy, encouraging training in ***digital skills for women and girls***.

The digital gender gap can be explained by the late and slow incorporation of women into successive digital transformation processes over time: it began in the 1990s, when ICTs begin to be part of everyday life, continues in the first decade of the 21st century, when the use of the Internet to carry out activities such as making purchases online, operating with banks or communicate was generalized. Currently, and even more so after the situation generated by the
COVID-19 pandemic, ICTs have become an element present in all activities of daily life and, therefore, the lack of digital skills, generates a risk of exclusion, social and economic.

According to DESI (2020), only 3.9% of Spanish professionals can be considered ICT specialists; and even more: only 1.4% are women. Furthermore, while the number of ICT specialists has been increasing in the last 5 years, the number of women ICT specialists is stagnant. On the other hand, considering the sustained growth of job opportunities For ICT specialists, the low presence of women in this area reduces their chances of future employability.

Ensure that Spain has ICT specialists. Training in digital skills of people at the service of Public administrations

The public sector, which currently exceeds 50% of GDP, plays an essential driving role in the ***digitization process of Spanish society*** and will be the protagonist in the recovery project social and economic after the COVID-19 crisis. That is why training in digital skills for public employment, it has a separate and differentiated entity from the private sector given that:

a. it is essential to develop the ***digital skills of employees public***, both those of a general nature and those of specialized ICT personnel, so that the Administration carry out an internal transformation (in procedures, relationship with managed and organizational culture) that allows it to properly develop its role as regulator, promoter and facilitator of the digital transformation of Spain, and;

b. ***training in the field of Public Administrations*** forms a subsystem with specific characteristics, as set out in Law 30/2015, of September 9, which establishes regulates the Vocational Training System for employment in the workplace, and in the Agreement Training for the Employment of Public Administrations.

Guarantee that Spanish companies in general, and SMEs in particular, have the necessary digital skills to tackle their digitization

This line aims to join the digitalization of SMEs, serving as a guide in the definition of ***digital transformation processes, identifying digital skills necessary*** (both by entrepreneurs and management personnel, as well as by of workers) to address these processes, integrating public policies of employment and promotion of the industry, and incorporating young people as agents of digital transformation. The importance of digitization as a driver of innovation, of the transition ecological, and a vital element to improve competitiveness and productivity is collected within the Strategic Framework in SME Policy 2030, where the following lines are proposed, among others of action for the digitization of SMEs:

1. Incorporate ***digital tools*** in relation to SMEs with the Administration.
2. ***Facilitate the digital transformation*** of SMEs as a key element in their life cycle.
3. ***Improve the availability*** of various financing channels for the digitization of SMEs.
4. ***Develop assistance programs for SMEs in industry 4.0***, which allow diagnosing the degree of maturity of SMEs in this field and design a digital improvement plan to from diagnosis.
5. ***Support for the incorporation of enabling technologies – KET*** (nanotechnology, micro and nanoelectronics, photonics, advanced materials, advanced manufacturing systems and

industrial biotechnology) in the manufacture of its products, whether in the processes of manufacturing, in the materials they use or in the products they market).

6. Establish mechanisms that promote the incorporation of SMEs into the circuit of vocational training.

The KET technologies are those trends identified by GARNER, which are critical to business and innovation from 2022, and shown in the following figure:

Fig. 52: Technology Trends 2002. Source. GARTNER

These are the top 12 strategy technology trends for 2022 in order of priority:

Table 4: KET. Source: Gartner

Trends	Technology Trends
Trend 1	*Data Fabric*
Trend 2	*Cybersecurity Mesh*
Trend 3	*Privacy-Enhancing Computation*
Trend 4	*Cloud-Native Platforms*
Trend *5*	*Composable Applications*
Trend *6*	*Decision Intelligence*
Trend *7*	*Hyperautomation*
Trend *8*	*AI Engineering*
Trend *9*	*Distributed Enterprises*
Trend *10*	*Total Experience*
Trend *11*	*Autonomic Systems*
Trend *12*	*Generative AI*

Gartner identifies technology trends critical to business and for companies in Spain to consider and to take action. From this strategic value of these technology trends we can foresee the digital transformation of companies is a transversal process that affects all activities that are developed linked both to the production processes, as well as to the sale, diffusion, marketing, people or economic management to name a few.

According to a study on digital skills in Spanish companies, there is a significant digital gap between large companies and SMEs, highlighting that 86% of SMEs Spanish women do not have a digitization plan, and only 2% are concerned about this fact, according to the DESI index. This represents a significant brake on the competitiveness of the Spanish economy, given that, according to OECD data, a 10% increase in the digitization of companies could generate an increase of 3.2% of annual GDP.

Promotion of ICT specialists (both vocational training graduates such as university students)

The goal of this line is to satisfy the current and future needs of specialists in digital technologies, both above the basic level and specialized, attending to the demands of the productive sector and the needs for innovation in new products and services digital.

In the area of training, the State has exclusive jurisdiction in regulating the conditions of obtaining, issuing and homologation of academic and professional titles, the programming general education and the design of the basic curriculum in order to ensure common training and the official nature and validity throughout the national territory of the different qualifications.

For this reason, several measures are proposed to collaborate in the curricular programming in the university and vocational training incorporating specific digital skills (cybersecurity, artificial intelligence, data analysis, web design, user experience design) users, block chains, fintech…) most demanded by the industry, adapting the degrees already existing or creating new ones when necessary.

In order to have a general overview of the ***hard skills adopted in Spain*** as well as the emerging skills, emerging jobs and redundant jobs based on these skills , the information is gathered from the Work Economic Forum (WEF), from their document called as ***The Future of Jobs Report***, published on October 2020. In this section we will show:

a. Technology adoption in Spain

b. Emerging and redundant job roles in Spain

a. Technology adoption in Spain

The WEF identified the technology adaption in Spain, as the e percentage of technology adopted in companies, information shared from companies surveyed:

Table 5: Technology Adoption in Spain. Source: WEF

	Technology Adoption in Companies	Percentage
1	*Big data analytics*	*96%*
2	*Artificial intelligence (e.g. machine learning, neural network, NLP)*	*96%*
3	*Cloud Computing*	*92%*

4	*Encryption and cyber security*	*88%*
5	*E-commerce and digital trade*	*88%*
6	*Text, image and voice processing*	*84%*
7	*Augmented and virtual reality*	*77%*
8	*Distributed ledger technology (e.g. blockchain)*	*74%*
9	*New materials (e.g. nanotubes, graphene)*	*70%*
10	*Robots, non-humanoid (industrial automation, drones, etc.)*	*68%*

b. Emerging and redundant job roles in Spain

The WEF also published the emerging and redundant job roles, identified as being in high demand or increasing redundant within their organization. These emerging and redundant job roles are:

Table 6: Emerging and Redundant Jobs in Spain. Source: WEF

	Emerging Roles	Redundant Roles
1	*Internet of Things Specialists*	*Data Entry Clerks*
2	*Data Analysts and Specialists*	*Administrative and Executive Secretaries*
3	*Big Data Specialists*	*Accounting, Bookkeeping and Payroll Clerks*
4	*AI and Machine Learning Specialists*	*Accountants and Auditors*
5	*Digital Transformation Specialists*	*Statistical, Finance and Insurance Clerks*
6	*Software and Applications Developers*	*Business Services and Administration Manager*
7	*Project Managers*	*Financial Analysts*
8	*Process Automation Specialists*	*Client Information and Customer Service Workers*
9	*FinTech Engineers*	*Claims Adjusters, Examiners, and Investigators*
10	*Assembly and Factory Workers*	*Assembly and Factory Workers*

Spanish digitalization

To measure Spain's situation and progress in the field of digitalization, we use the DESI indicator (Digital Economy and Society Index), published by the European Commission, which also allows us to compare Spain with the main EU countries. This is a synthetic indicator that takes into account five pillars: connectivity, human capital, integration of digital technology in companies and digital public services.

Spain ranks 7th of 27 EU Member States in the 2022 edition of the Digital Economy and Society Index (DESI). The country is making relative progress and overperforming versus previous years, especially on integration of digital technology (ranking 11th, 5 positions above 2021), and also on digital public services (5th compared to the 7th place in 2021) and human capital (10th compared to 12th). Spain is an EU leader in connectivity and ranks 3rd for the second consecutive year.

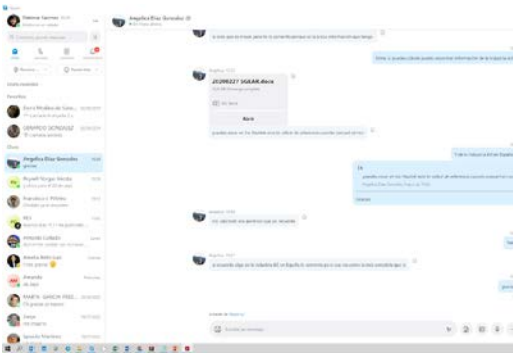

Fig. 53 Digital Economy and Society Index (DESI) 2022. Source: DESI

The following figure compares Spain with the European average taking into consideration the five pillars (connectivity, human capital, integration of digital technology in companies and digital public services):

Fig. 54 Spain rank in DESI. Source: DESI

If we analyze the components of the DESI index, we see that Spain stands out in one of the five pillars: digital public services, however regarding the rest of the four pillars: human capital, connectivity and digital integration of digital technology Spain remains above the European averages.

On ***the human capital dimension***, Spain is a relatively good performer on basic digital skills whereas it is below the EU average as regards the proportion of ICT specialists and of ICT graduates. The rate of people in Spain having at least basic digital skills is above the EU average (64% compared to 54%) and has significantly increased during the last years. The number of ICT specialists in employment in Spain is 4.1% compared to the EU average of 4.5%. Several measures outlined in Spain's Recovery and Resilience Plan (RRP) support the acquisition of digital skills, especially for employees of SMEs. Those measures, together with other technology-specific initiatives such as for cybersecurity or artificial intelligence (AI), are expected to reduce the labour market gap for ICT specialists as well as the ICT gender gap.

On ***digital connectivity***, Spain is one of the top EU performers. It continues its steady progress in the roll-out of very high capacity networks (VHCN) and is pursuing strategic reforms and

investments under the Recovery and Resilience Facility (RRF) to help achieve the Digital Decade connectivity targets and reduce the digital gap between urban and rural areas.

On ***integration of digital technologies***, the percentage of SMEs with a basic level of digital intensity and using social media is above the EU average. But Spain's enterprises are still lagging behind on new and advanced technologies such as cloud or big data. The lack of a critical mass of digitally-trained workers hinders the integration of digital technologies into Spain's enterprises in general, and SMEs and micro-enterprises in particular, who need digital-skilled professionals to develop further and become more competitive in the digital economy. The SME Digitalisation Plan 2021-2025 will help boost disruptive innovations and entrepreneurship in digital fields, together with other relevant policies and strategies already in place

Finally, ***on digital public services***, Spain has traditionally been a front-runner and it continues to put in place new services and infrastructures to respond to the rapid development of technology and to people's needs. Spain is committed to modernize its public administration in order to make it more accessible for enterprises and the public.

Following Russia's invasion of Ukraine, Spain adopted a national response plan setting out urgent measures (e.g., updated and strengthened the national cybersecurity strategy, and the adoption of measures aligned with EU recommendations to secure 5G deployment). Several important communication campaigns have been put in place to promote cybersecurity awareness and combat disinformation. One campaign was also launched to help people fleeing Ukraine to Spain. In addition, Spain adopted the measures set out in the Council Decision (CFSP) 2022/351 concerning restrictive measures in view of Russia's actions destabilizing the situation in Ukraine.

Spanish innovative skills – Research on innovative skills to enhance students employability

Spain has progressively increased its participation in the successive European Framework Programs, which demonstrates the interest, experience and potential participation of the Spanish scientific and technological community in these programs. Parallel to the definition of the Horizon Europe Program, the Spanish Strategy for Science, Technology and Innovation (EECTI) has been developed, concurring with European Framework Program period of 2021-2027. The EECTI is considered as the basic instrument to consolidate and strengthen the Science, Technology and Innovation System (SECTI).

The ECCTI is specifically designed to facilitate the articulation of the research, development and innovation policy of Spain with the policies of the European Union. The way out of the global crisis suffered by COVID-19 and the reestablishment of a powerful national R+D+i system, after the last decade of difficulties, are urgent actions that need to be addressed. Therefore the Spanish strategic has included to target the following sectors, to enhance the employment rate and the economy of the nation:

1. ***Health***: new therapies, accurate diagnosis, cancer and aging, and special emphasis on infectious diseases.
2. ***Culture, Creativity and Inclusive Society***: genesis of the human being, cognition and language

3. ***Security for Society***: inequality and migrations; the market and its tensions; the protection of society and cybersecurity.
4. ***Digital world, Industry, Space and Defense***: AI, next generation internet, robotics, physics, mathematics, communication networks
5. ***Climate, energy and mobility***: climate change, decarbonisation, mobility and sustainability
6. ***Food, Bioeconomy, Natural Resources and Environment***: from biodiversity to food use of land and seas.

The strategy promotes the coordination and complementation of national and sectoral R&D&I policies with others at a European, regional and local level, fostering support for other countries in the preparation of their policies in this field, as well as that of addressing the development of a system of governance and indicators that facilitates the analysis, monitoring and evaluation of the results with respect to the objectives set.

The Statistical Office of the European Union Eurostat is used to analyze the R&D&i indicators in Spain, which provides statistics and high-quality data on R&D throughout Europe based on collecting data and reporting data on research and experimental development using Frascati Manual. In this sense, the statistical office collects a series of data at the European, national and regional level, for a series of specific indicators in national level we summarized in the following table:

Table 1: Main Eurostat Indicators referring to R&D&i at the national level. Source: EUROSTAT

Indicador	Description
Indicador 1	*R&D intensity - gross domestic spending on R&D*
Indicador 2	*Percentage of people employed in high technology referred to the total employment*
Indicador 3	*Percentage with respect of R&D personnel referred to the active population*
Indicador 4	*Patent application per million inhabitants*

In the case of R&D intensity, if we look at the latest data available for the Spain with respect of Europe (year 2020), it is possible to see that the gape in R&D expenditure as % of gross domestic spending (GDP) has decrease from 0,98% on 2019 to 0,91% on 2020, as shown in the following figure:

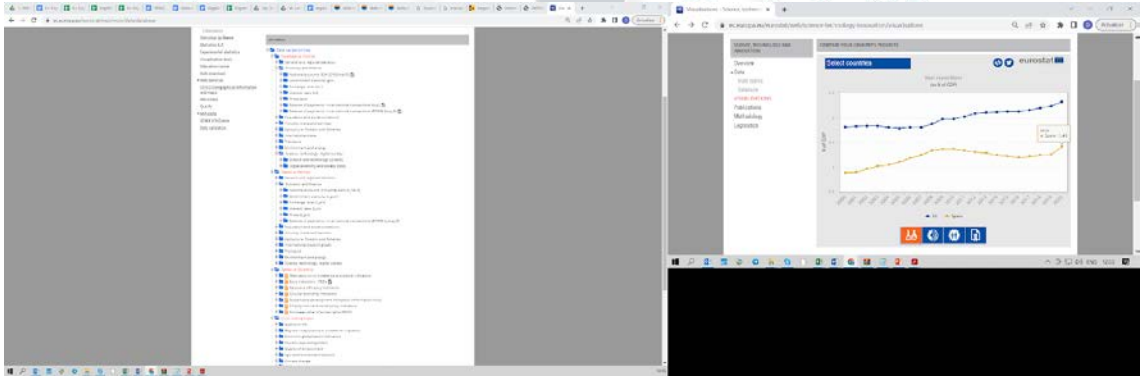

Fig. 55: R&D intensity - gross domestic spending on R&D. Source: EUROSTAT

Regarding the percentage of total employment referred to high technology, a very positive trend can be seen in the case of the Spain from 2018 to 2020 comparing to Europe, as shown in the following figure:

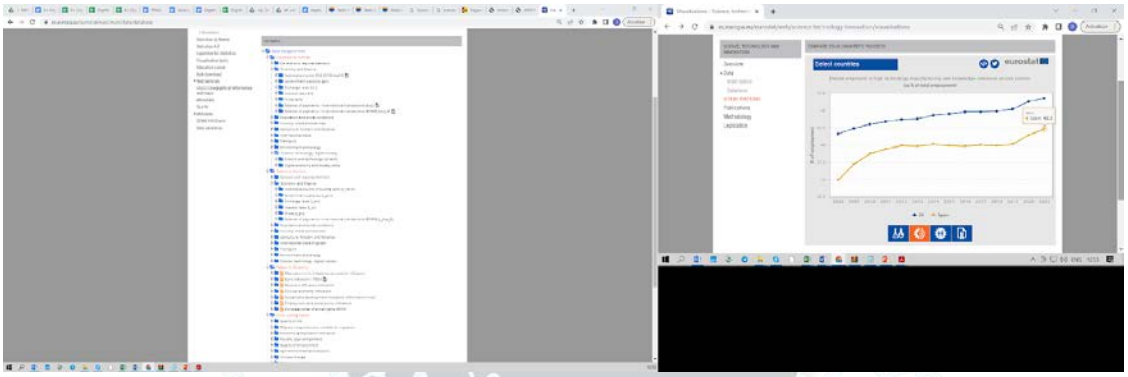

Fig. 56: People employment referred to high technology. Source: EUROSTAT

It can be noticed from previous figure, a very pronounced rise from 40,1% to 42,3% in Spain and 45,2% to 46,8% in Europe in the same period of time (2018-2020). A close rate of people employed, in Spain with respect of Europe, in high technology manufacturing and knowledge-intensive service sector is a good sign that shows Spain´s roadmap for R&I&i is aligned with the European Commission initiatives to a more sustainable economy.

A less notable evolution than in relation to the Spain level in R&D personal related to the percentage of activate population is shown in the following figure:

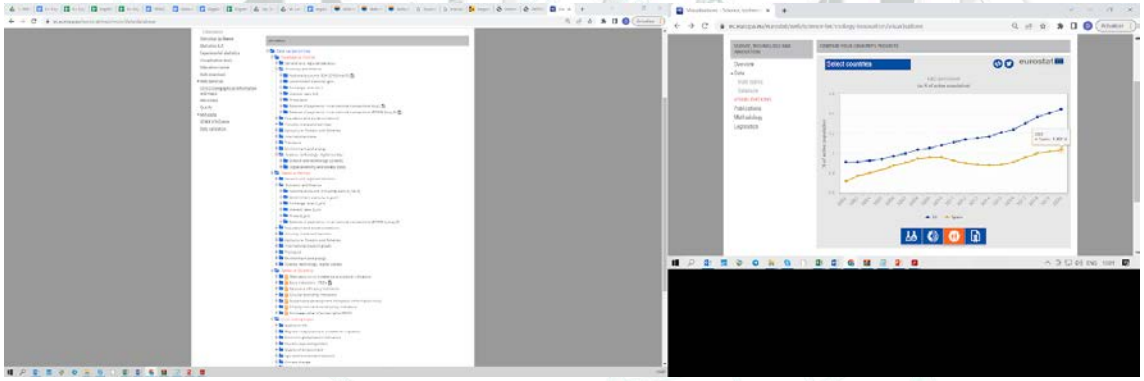

Fig. 57: R&D as % of active population. Source: EUROSTAT

A much more similar evolution, of Spain versus Europe, with the application of patents per million inhabitants than in relation to the national level, is shown in the following figure:

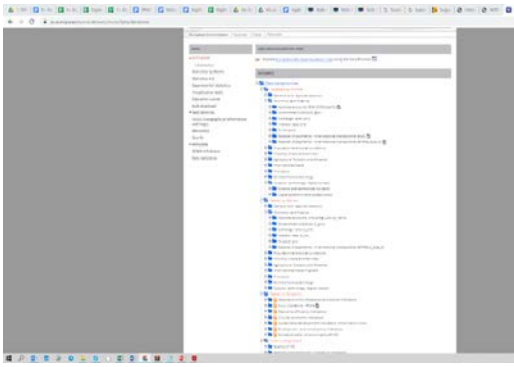

Fig. 58: Patents application per million inhabitants. Source: EUROSTAT

It can be concluded, therefore, that although it is true that Spain have a positive trend in terms of employment in R&D, it is necessary to continue giving a boost, especially in terms of patents application.

2 INNOVATIVE SKILLS OF DIGITALIZATION AND INDUSTRY 4

2.1 Digital Skills Need For Life and Work

The World Development Report (WDR) 2019 examines how the nature of work is changing as a result of advances in today's technology. Work is constantly changing with technological progress. Companies are adopting new production methods, markets are expanding and companies are evolving. Technologies in general provide opportunities that pave the way for job creation, increased productivity and the provision of efficient public services. Businesses can grow rapidly through digital transformation, expanding their boundaries and transforming traditional production models. The rise of the digital platform means that technological effects will reach more people faster than ever before. Technology is changing the skills that employers are looking for. *Employees need to be better at comprehensive problem solving, teamwork and adaptability*. Digital technologies are also changing the way people work and the conditions in which they work. Regardless of the importance of individual technologies and their applications, they are driving the next level of advanced digitization.

New technologies are here and we cannot ignore them. Companies that want to remain competitive can not exist without them in the future. *It should be emphasized that the implementation of new technologies, but especially artificial intelligence and robotics, is not intended to replace employees, but to relieve them and multiply their added value.* Companies rely on new technologies to make better use of capital, overcome information barriers, outsource and innovate.

Industry 4.0 enables the creation of smart factories, vertical networks and horizontal networks. Smart factories enable cyber physical systems and the Internet of Things. Cyber systems create a

virtual copy of the factory through sensors and actuators, enabling decentralized decision making. Interconnections enable cooperation between machines, between machines and people, and between people. The intelligent factory has an element of "consciousness" through artificial intelligence, which allows it to decide on its own maintenance and production processes (self-optimized). Smart factories will expand the roles of workers, moving beyond routine work that will require decision-making and a wider range of skills, thus changing the way people work. The role of the operator is changing and becoming more complex as it becomes more about decision-making and troubleshooting than mechanical work.

Industry 4.0 enables real-time information sharing between different organizations, leading to more efficient use of resources. This will enable new types of business processes and business models and digital services for consumers, industries and public services. As business models change and new ones emerge, it is important to understand new ways of using digital products and services and to integrate after-sales services and / or product servicing into the business model.

The debate on digital technologies and their impact on the future world of work intensified during the coronavirus pandemic. Under its influence, the adoption of new technologies is accelerating and the very essence of how we will work is changing.

Creating digital platforms and automating operations requires not only the creation of new jobs, but also the formation of new professions. However, in order to turn technology into job creators, it is important to understand exactly what the current wave of technology in manufacturing is changing and how industrial, education and employment policy makers can adapt to it. There will be a radical change:

1. **Environment change**
   Prior to the corona, technologies entered production processes by expanding digital platforms. *Digital transformation is changing the traditional boundaries of companies, creating global value chains and changing the geography of jobs. New business models are emerging that are able to evolve rapidly from local start-ups to global giants. Digital platforms thus make it possible to create business clusters even in less developed industrial areas.*

2. **Employee skills**
   Technologies have also caused drastic changes in the skills requirements needed to enter the labor market. As "routine" occupations began to fade, skills that could not be replaced by technology began to be sought after. These include, for example, cognitive skills - critical thinking, or socio-behavioral skills - managing and recognizing emotions that improve teamwork. The changing world of work requires skills that allow workers to move more easily from one task to another, flexibility and a broader scope of knowledge.

3. **Working conditions**
   Digital technologies also affect working conditions. *The nature and method of work change "standard" long-term employment contracts into shorter-term contract or project contracts,*

which are often implemented through online job platforms. Thanks to these concepts, some types of work are more accessible and flexible. This creates new job formats, platforms and labor markets that are changing traditional approaches to team formation and working conditions.

The World Development Report (WDR) 2019 examined how Europeans view the benefits of new technologies. Survey respondents believe that technologies improve the European economy, society and quality of life, fig. 58.

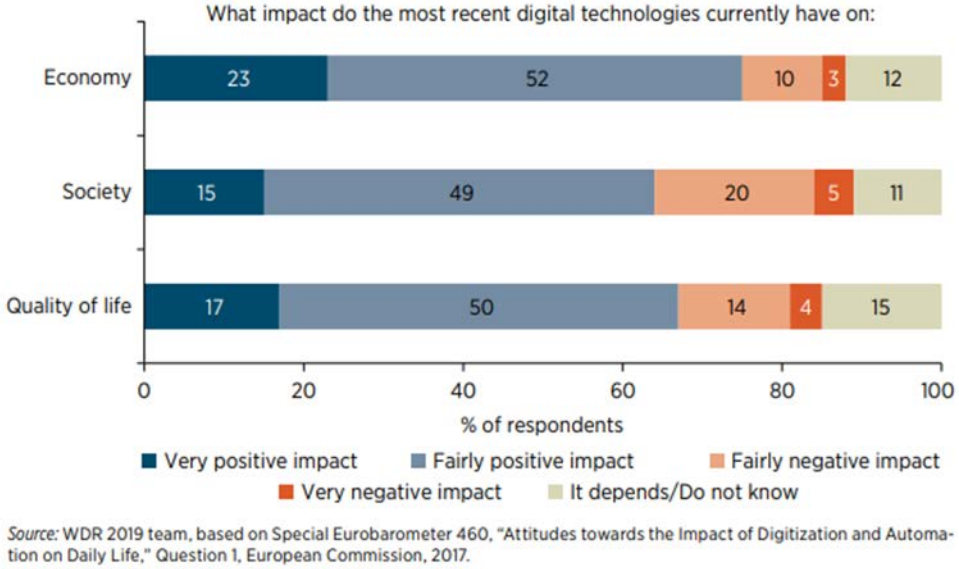

Fig. 59 Survey respondents believe technology is improving the European economy, society and quality of life

In order to meet the challenges, manufacturing companies need to start improving education and training programs to equip their workers with the best skills.

Investing in human capital is a priority to make the most of this evolving economic opportunity. **Three types of skills are becoming increasingly important in the labor market:**

- advanced cognitive skills, such as problem-solving,
- socio-behavioral skills, such as teamwork,
- and combinations of skills that predict adaptability, such as reasoning and self-efficacy.
-

These changes are reflected not only through new jobs replacing old jobs, but also through the changing skills profile of existing jobs. *Since 2001, the proportion of occupations in intensive non-routine cognitive and socio-behavioral skills has increased from 19 to 23 percent in emerging economies and from 33 to 41 percent in advanced economies*. Building these skills requires a solid foundation of human capital and lifelong learning.

The pace of industry transformation is fast and intelligent factories are beginning to be a reality in the world, as well as demands for new job skills and the formation of new jobs. *The World Economic Forum (WEF) forecasts that up to 65% of children entering primary school will one day work in occupations that do not yet exist today. According to Deloitte, up to half of the current jobs will be lost in the next 10 years. The ratio of the number of jobs worked by workers and machines will also change. Today, work tasks are performed at a ratio of 71% to 29% with a higher share on the part of the human implementer.* However, the WFE report predicts that by 2025, the ratio will change to 48% of the tasks performed by humans to 52% performed by machines.

2.2 Digital skills and education

Even the current demand for workers with qualifications responding to the new definitions of production far exceeds supply. There is a worrying gap between the demand and supply of skilled industry professionals, which will continue to widen without a drastic start to education reform. According to the National Association of Manufacturers' global production perspective, almost 80% of manufacturers already have a slight or severe shortage of qualified candidates. Gap in employee qualifications thus becomes the primary threat to the future development of companies.
The lack of workers with the necessary education and skills affects all industries and companies, regardless of size. Without skilled workers, it is highly likely that manufacturers will not be able to fulfill and exploit the potential of the new industrial revolution. A Deloitte study estimates that nearly 4.6 million jobs will need to be filled in production over the next decade. However, due to insufficient skills, up to 2.4 million of these jobs may remain vacant. The looming skills crisis due to skills shortages can no longer be overlooked.

The future workforce needs to acquire the skills that smart practice needs. The current one must immediately start increasing and retraining it in order to remain competent for the new era. Businesses no longer just need good developers, engineers or IT staff. In addition to the fact that Industry 4.0 increases the demand for interdisciplinary cooperation, soft skills - communication, negotiation, leadership and management, or adaptation skills - are also becoming increasingly important. Analyzes point out that by 2030, demand for cross-cutting soft skills in Europe will increase by 22% in all sectors. As new jobs are created to implement the Industry 4.0 concept, employers will require new, especially digital skills and competences from employees.

It is indisputable that the entire educational infrastructure, content and didactics, as well as the teaching of teachers must undergo a transformation. Curricula must be planned, developed and implemented in line with industrial development. Students will not be prepared to work in technologically advanced factories unless educational programs are aligned with the needs of developing workplaces. **All stakeholders must realize that it is the education system that will play a key role in GDP growth and competitiveness in the coming years.**

The OECD report "The Future of Education and Skills 2030", published in 2019, highlighted the growing importance of soft skills in education due to trends such as globalization and rapid advances in technology and artificial intelligence, which require changes in the labor market and skills that future workers need to succeed. It says that "in order to remain competitive, workers will need to constantly acquire new skills, which requires flexibility, a positive approach to lifelong learning and curiosity".

2.3 Which skills will disappear and which new ones will appear

Siemens, Microsoft, Caterpillar and GE, in collaboration with ManpowerGroup, have created a taxonomy that defines the digital manufacturing jobs of the future. They named the 10 most popular professions for the following years.

Jobs in future production

- Digital Production Engineer
- Expert in predictive maintenance systems
- Production Cybersecurity Strategy
- Expert in collaborative robotics
- Expert in digital biomimetic production
- Change management strategy
- Digitizer for digitization
- Virtual reality systems specialist
- Architect user experience
- Virtual simulation specialist

In advanced economies, employment grew the fastest in highly skilled cognitive occupations. On the contrary, lower employment occurred in medium-skilled occupations, such as machinery operators.

The following are considered key competencies for Industry 4.0:

- Ability to optimize workflow (planning skills);
- Reading and evaluating data
- Data security
- Using data to optimize the workflow
- Use of knowledge and documentation systems
- Cooperation and communication in teams
- Use system know-how to optimize processes
- Decision making skills

ICT - related competences for Industry 4 are:

- Use of databases
- Device programming
- Setting device parameters
- Using and understanding digital drivers
- Service of automated equipment
- Use of digitized networks
- Participation in software design and programming
- Use cloud computing.

Industry 4.0 competencies are:

1.) Analyze, supervise, optimize and develop production systems and networks, including optimization of legacy devices by interconnecting various interfaces, MES, SAP, CAD-CAM, data processing units.

2.) Apply and set up IT-based assistance and diagnostics systems, which requires a comprehensive approach to the application of network technologies, firewalls, router configurations, as well as the ability to analyze and develop data processing, identify and troubleshoot.

3.) Analyze, interpret and document production data using knowledge and documentation systems.

4.) Understand and optimize the process structure, content and networking by ensuring process integration and synchronization of the various processes of the production cycle, which requires the ability to calculate the parameters and functions of intelligent devices, document them in the network and control them.

5.) Perform equipment maintenance and ensure process optimization, to obtain the required information and use various media resources.

6.) Ensuring the functionality of the equipment by reading and interpreting process data of equipment and components, identification of failures and faults of mechanical components, actuators, sensors, signaling devices, as well as performing routines of service and maintenance operations and repairs.

The trend shows that workers with Industry 4 competencies are gaining, while low-skilled workers – especially those with manual jobs – are losing.

2.4 Research on Innovative Skills to Enhance Students Employability.

The employability of graduates is a challenge for universities, as many do not meet the current expectations of the labor market. Universities are accused of producing graduates who do not meet the employment requirements of the labor market. It seems clear that a diploma alone is not enough to be applicable in practice. Despite the value of the diploma, it is necessary to focus on enriching graduates with key skills that are valued by employers.
In a competitive labor market, employees who demonstrate a good combination of hard and soft skills often see greater demand for their services. In the era of digitization and the effective application of the philosophy of the Industry 4 concept, soft skills are considered irreplaceable.

Examples of soft skills include the ability to communicate with potential clients, mentor your co-workers, lead a team, negotiate a contract, follow instructions, and perform timely work.

Workers with good soft skills can help companies achieve higher levels of efficiency and productivity.

When hiring people, employers look for a balance between hard and soft skills. For example, employers value skilled workers who know how to do tasks on time. Employers also value employees with strong communication skills and a strong understanding of the company's products and services.

Another award-winning soft skill is the ability to coach colleagues in new tasks. Company leaders are often most effective when they have strong soft skills. For example, leaders are expected to have good speaking skills, but good leaders are also good at listening to workers and other leaders in their fields. Negotiation is a big part of the work of many company leaders. When negotiating with employees, clients or co-workers, leaders must be skilled at staying considerate of what others want, while focusing on promoting what they want. Good leaders also need to know how to streamline their work by strategically delegating tasks to employees. Companies often like to hire employees who have soft skills that fit well with the rest of the staff.

Coaching is one of the most common and effective methods for improving soft skills.

Among the most sought-after soft skills that are gradually reaching the profiles of employees in engineering and other industries are:

1. **Adaptability**

The ability to adapt to different situations and planned or unexpected changes is one of the most important skills that a future production worker should have. With the developed ability to adapt, it is easier to adapt to a new situation, a new environment, new workflows or technologies. Find solutions to unforeseen problems and make necessary adjustments. The success of projects in the future will be even more dependent on a quick assessment of the problem and finding a flexible and thoughtful solution.

2. **Cooperation**

Changes in the production environment will also bring a higher share of teamwork. It develops not only within the department, but also across departments. It requires working and integrating with different co-workers, colleagues, within different levels of the company's internal management chain, as well as the external environment. In such cases, the ability to apply skills such as verbal and nonverbal communication, helpfulness, or empathy is crucial.

3. **Communication**

Communication skills are a crucial factor for the success of cooperation. However, many, especially managers, underestimate the importance of improving their communication skills. They believe that technical skills are the only ones that matter in their profession. Being an appropriate speaker and listener, but being able to express yourself in writing, is especially important in the field of mechanical engineering, because accuracy and comprehensibility are needed in managing teamwork and setting up processes. Interaction with suppliers, partners and clients must take place without misunderstanding.

4. **Ability to motivate others**

It is especially desirable in leadership positions. Leaders or team leaders must constantly look for ways to motivate others to pass on their enthusiasm for achieving a set goal. There is also a sense of what we do with motivation. If team members make sense of the assignment, they know why to do the thing, if the leader is really an example and enthusiastic about the matter, and if we add that it is also beneficial for the team members, then the right combination of motivational factors will be created.

5. **Emphasis on details**

Complex projects are being worked on, especially in leadership positions at various levels of management. Keeping track of details that, if we don't notice them, could cause the project to fail in the future is an important element of the soft skills of smart business employees. If this failure occurs in manufacturing or construction, it can be fatal and cause not only financial losses but also endanger human health.

6. **Creative thinking**

It is necessary to think "out of the box" and look at things from a different perspective. Creative thinking is a skill that requires a lot of jobs in different industries. It is becoming especially important in mechanical engineering. Finding ways to apply existing knowledge in new and creative ways, to adapt to new technological trends, to the dynamic development of smart devices, will move businesses forward.

Productivity is found to increase in environments where soft skills are good. Due to their growing importance, the need to learn soft skills has become a major concern for educators and employers around the world. When it comes to teaching, assessing soft skills is more difficult than assessing technical skills. Developing soft skills is much more difficult than developing hard skills because it

requires active interaction with others on a continuous basis and a willingness to accept behavioral feedback.

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3 BEST PRACTICES OF DIGITAL TRANSFORMATION

3.1 BEST PRACTICES- BULGARIA

Best practices for digital transformation and implementation of the Industry 4.0 concept

1. Best practice for digital transformation and implementation of the Industry 4 concept in Bulgaria.		
1	**Best practice name:***	Asarel-Medet AD and Asarel Mining and Processing

		Complex - X-Mine project
2	**Sector:***	Copper extracting and processing factory
3	**Organization implementing/disseminating the practice:***	Address: locality Asarel Panagyurishte, 4500 Bulgaria ASAREL-MEDET AD has 1,200 employees at this location and 400 more employed in subsidiaries and joint ventures. Website: www.asarel.com
4	**The goal:* (up to 100 words)** **Reason to introduce digitalization**	By implementing new technologies and integrating Industry 4.0 elements, the company aims to improve their technological processes on different levels and across all its ventures and subsidiary structures. Moreover, such systems and technologies help the company to minimize the human mistakes, to save time for production and improve the communication and exchange of information across different structures.
5	**Description / Focus:***	This is the largest Bulgarian mining company for open pit and copper ore processing. In 2021 the company has completed the renovation process of their entire technological chain. The Asarel mine and Asarel concentrator plant for copper concentrate recovery are two of the major production workshops of the Asarel-Medet JSC Mining and Processing Complex. The modern interstructure also includes a Return Water Sector, Copper Microbiological Leaching Facility, and Cyclic Flow Conveyor Technology for mined material transportation, SX-EW Facility, Purification Stations, etc. In 2019 the company started to work on upgrading their existing ERP system, which, thanks to thousands of sensors, allows them to gather a huge flow of information which can then be literally traced via the manager's phone. The system shows, for instance, micro-cracks in the machine, long before it breaks, so that it can be replaced just in time. It also measures production in real time – what goes in and out of the factory, etc. The new ERP system is one of the main projects that take part of the digital transformation strategy of the company. The systems used is from the series SIMATIC PCS7 by Siemens - Bulgaria and allows to control the entire production process along the chain. This significantly improves the efficiency and safety on different levels as well. Another digitalization process implemented by the

		company is the adoption of Integrated Information System that supports mine planning at the Asarel Mine. According to official announcement by the Mine Manager, Ivan Andreev published on the official website of the company this is "*A unique project on the Balkans that integrates into a common information system the drilling and blasting mining activities with a digital geological, structural and hydrogeological model of the Asarel deposit*". At Asarel-Medet, the system will encompass all processes which the Mine Engineering department and Drilling and Blasting Activities unit at the Asarel Mine are in charge of, that are: geological explorations and geological block model development of the deposit, mining activity planning and drilling and blasting works designing to reporting the mined material and assessing the wall slope and wall stabilities. The implementation of the digital system for drilling and blasting activities was completed in 2020 and now allows faster, more efficient and safe operations. Asarel-Medet is the only Bulgarian company which forms part of the large-scale research X-Mine project coordinated by VTT, Technical Research Centre in Finland. The international innovation consortium unites scientific institutes, equipment manufacturers and mining companies from various European countries. The X-Mine develops new geological exploration sensor technologies and implements digital applications for deposit modelling and more efficient ore processing. As a result the company uses a sensor scanner for drill cores from specialized geological exploration, automated mineral sorting equipment and a new specialized software for result assessment and analysis. This improves ore mining and processing efficiency and has a favourable environmental protection impact according to Desislav Ivanov and Stanislava Milusheva who are part of the Mine Engineering department team at Asarel-Medet. The new sensor technologies are based on X-ray fluorescence (XRF), X-ray transmission (XRT) and 3D visualization technologies. All of them are incorporated to mineral sorting equipment as well as ore deposit modelling and mining operations planning software systems.
6	**Target groups:***	The employees and staff members at Asarel-Medet AD and all its subsidiaries and joint ventures. Students who participate in the company`s summer

		internship program.
7	**Dissemination / implementation method:** *Note: If needed.*	
8	**Results / impact with a focus on:** **1. sector** **2. individuals, like students or employees** *Note: If needed, if we have results we can write.*	X-Mine is a project funded under Horizon 2020 program of the European Commission. Thanks to it, the mining companies who participate in this project (including Asarel-Medet) are anticipated to achieve up to 20% reduction of their transportation costs, 7% reduction of handled waste, from 10 to 30% lower power consumption and carbon emissions reduction. The schedules envision that the products would be commercialized within two years after the project completion when other companies will have access to these technologies as well. By applying new methods and technological operations, the mineral grain size, their distribution and the entire structural, geological, geochemical and mineralogical information will become known even at the geological exploration stage. As a result, the mining will become more efficient. Furthermore, the environmental impact will also be reduced because less mining waste will be generated and mining locations will be more accurately selected.
9	**Sustainability:** *Note: If needed, if we have results we can write.*	
10	**What were the obstacles?** *Note: If needed, if we have results we can write. What were the difficulties in introduction?*	Although the time needed for completion of all systems was not stated as an obstacle, it can be considered as one. Due to the complexity of the processes and the big infrastructure included in the projects, the completion and full integration of digital systems took few years.
11	**What innovative skills (if any) the described above best practice might have developed to enhance students' employability?** *Note: Please list skills only we mark the skills.*	Skills how to work and operate with ERP system by Siemens - SIMATIC PCS7 Skills for data processing and management Skills for analysing data Skills to work with specific equipment and sensor technologies
12	**References (pls insert a link to more data on the practice)**	http://www.asarel.com/en/Default.aspx https://amcham.bg/2019/10/03/dimitar-tsotsorkov-capital-goes-where-investment-conditions-exist/ https://www.xmine.eu/inside-project/project-summary/ https://miningdigital.com/company-reports/assarel-

		medet

2. Best practice for digital transformation and implementation of the Industry 4 concept in Bulgaria		
1	**Best practice name:***	Plovdiv Innovation Hub & Smart Factory
2	**Sector:***	Digital technologies and digital solutions
3	**Organization implementing/disseminating the practice:***	The Schneider Electric Smart Factory is located in Plovdiv and occupies an area of 12,000 square meters. Address: Industrialna Str., 4201 Plovdiv https://www.se.com/bg/bg/about-us/alliances/
4	**The goal:* (up to 100 words)**	Schneider Electric, a leader in digital transformation of energy management and automation, opened its first Innovation Hub in the region of Eastern Europe. The Innovation Hub is a demo space that allows visitors to experience live the company's IoT technology. The facility is located in Schneider's showcase plant in Plovdiv, Bulgaria, that meets the highest internal standard of the Schneider Group for industrial production, automation and effective process management.
5	**Description / Focus:***	The Smart Factory in Plovdiv manufactures 42 million circuit breakers per annum. Through them the company provides electrical distribution and protection to people from about 30 countries. Nearly 70% in the manufacturing facility are fully automated and operational processes are digitalized through the company`s applications. Moreover, the team of Smart Factory continues to implement new technologies including creation of digital solutions on the spot in case the corporate tools do not offer such solutions. Productivity and efficiency are managed through data collection and visualization in user-friendly dashboards that enable quick and informed decision-making process. Maintenance is done with the help of augmented-reality-based solution that saves time and make the process completely paperless. As a result, the workforce is more empowered, and people's knowledge is constantly advancing. In 2019, the production site in Bulgaria received the highest level of industrial certification in the company – Smart Factory. It is one of the biggest and most modern plants in Europe in the digital transformation of energy management and automation systems. The enterprise became the first Smart Factory of the Schneider Electric across Eastern Europe and the second one in the whole of Europe. The Smart Factory certificate attests to the highest level of

		technological maturity of Schneider Electric manufacturing. The premises of the factory are managed with a BMS (Building Management System) and are equipped with a power management system. These have allowed the enterprise to become the first in Bulgaria with an ISO 50001 power management standard. Maintenance of machines and facilities is carried out based on the software application Augmented Operator Advisor – an application that allows the maintenance staff to see technical information and suggestions for replacement and prophylaxis of parts visualized as an element of a snapshot of the inspected equipment. All this was achieved thanks to Schneider's IoT platform EcoStruxure. It makes possible connecting devices in various architectures depending on the scale necessary for the particular site; data management and collection, as well as work with tools for preventive and predictive maintenance. EcoStruxure consists of three main layers – connected devices, edge control and software, applications and services – and allows building of different architectures to the scale required for each site, managing and collecting data, as well as working with preventative and predictive maintenance tools.
6	**Target groups:***	Businesses and companies Students and teachers People interested in Industry 4.0, digital transformation and application of new digital technologies
7	**Dissemination / implementation method:** *Note: If needed*	Apart from the application of new technologies, applications and systems related to digital transformation, the Smart Factory in Plovdiv organizes webinars and organized visits of the facilities. During these visits people can see in practice how new technologies are integrated and used in the production processes of the factory.
8	**Results / impact with a focus on:** **1. sector** **2. individuals, like students or employees** *Note: If needed, if we have results we can write.*	The achievements and new technologies used by the Smart Factory have a positive direct impact on the companies and businesses in the area, because it gives a good example how digitalization of operational processes can save resources and improve the overall performance of the company. Through the webinars and organized visits of the facilities, the factory have also direct impact on students and other people interested in Industry 4.0 and digital transformation.
9	**Sustainability:** *Note: If needed, if we have results we can write.*	Also, the facility gives good example how Industry 4.0 and digital transformation can foster the sustainability in operational processes.

10	**What were the obstacles?** *Note: If needed, if we have results we can write. What were the difficulties in introduction?*	
11	**What innovative skills (if any) the described above best practice might have developed to enhance students' employability?**	Knowledge and skills related to digital transformation and creating digital ecosystem. Knowledge and skills related to industrial digitalization and smart solutions. Knowledge and skills related to building management and automation solutions.
12	**References (pls insert a link to more data on the practice)**	https://www.se.com/bg/bg/about-us/alliances/ https://www.se.com/bg/bg/work/campaign/case-study/local/smart-factory-plovdiv.jsp https://www.se.com/bg/bg/work/campaign/innovation/overview.jsp https://amcham.bg/2020/08/14/schneider-electric-to-open-its-first-innovation-hub-in-eastern-europe/ https://tekdeeps.com/schneider-electrics-smart-factory-the-place-where-the-digital-transformation-begins/

3. Best practice for digital transformation and implementation of the Industry 4 concept in Bulgaria		
1	**Best practice name:***	Software University - SoftUni
2	**Sector:***	Tech Education
3	**Organization implementing/disseminating the practice:***	Software University – SoftUni organizes online and onsite courses and training programs. Address: Aleksandar Malinov Boulevard 78, 1799 American college, Sofia Website: https://softuni.bg/ (Bulgarian) and https://softuni.org/ (International)
4	**The goal:* (up to 100 words)**	SoftUni is the biggest tech education provider for business and software development in South-Eastern Europe. It offers study programs and courses in software engineering, prorgamming and other IT topics. By collabortaion with tech and IT companies

		and proffesionals SotUni continuously updates their study programs in order to meet the current market needs and equip threir students with relevant knowledge and competitive skills. SoftUni is a Bulgarian licensed training center under the Vocational Education and Training Act. After each successful course (with a grade equal to or higher than 3.00 in theory and practice), students receive a state-recognized "Vocational Training Certificate", as well as an application valid throughout the European Union.
5	**Description / Focus:***	SoftUni organizes in-depth professional program in software engineering in Bulgaria, providing students with the opportunity to acquire the profession of "software engineer". The curriculum has been developed with direct participation of IT companies and experts and is based on the „learning by doing" approach. Thus, the study program includes working with the latest software technologies and learning best practices in the field of programming. In addition to the curriculum in software engineering, SoftUni organizes a number of courses on various topics in the IT and digital field such as Systems Administration, AI (artificial intelligence), Cloud, Blockchain, Cybersecurity, Robotics and many others. Although students have the possibility ot attend classes online, it is usually recoomeded for those enrolled in Programming Basics course to attend the classes physically in the SoftUni classrooms. Depending on the topic, classes have duration of 3 to 4 hours. Classes include a lecture with live demonstrations, questions and exercises in class under the mentorship of the lecturers. In most of the cases, homework tasks have to be uploaded in the automated Judge system. The same system is used also during the exams. Students are are asigned with tasks that they have to solve and upload. Their assessment is done authomatically and immediatelly by Judge system, i.e. students receive a real-time feedback. Thus, the exam and evaluation processes are entirelly automated, which saves time and

		reduces teh risk of mistakes. Software University offers to its students to take advantage of their Career Center, that was created in order to support and assist students and graduates to find a job. According to the published information in SoftUni website, the Career Center helps students to find a job within the period of 2 weeks to 2 months. Depending on the specifics of hiring processes and number of candidates in different companies this period may require longer time. In addition to the couses offered in Bulgaria, in 2019, SoftUni successfully organized trainings in Romania, Singapore, the Philippines and Poland, providing free training in programming, as well as a comprehensive software engineering curriculum. Furthermore, in 2021 it was launched the SoftUni Global initiative, which aims to provide quality learning content to those wishing to enter programming from anywhere in the world.
6	**Target groups:***	Students Professionals in IT sector who want to aquire additional knowledge and/or qualifications Young emplyees who want to build additional competences in IT sector and topics Companies and businesses who want to provide additional training to their staff members to improve their digital skills.
7	**Dissemination / implementation method:** *Note: If needed.*	
8	**Results / impact with a focus on:** **1. sector** **2. individuals, like students or employees** *Note: If needed, if we have results we can write.*	According to the information pubclished on the official website of SoftUni Global the comany acheived the following results: • 97% of graduates begin work in the IT sector • Over 15 200 graduates • Community of more than 300 000 students • More than 100 partnerships with leading companies in the IT sector • Organized and implemented trainings in

		more than 40 cities in Bulgaria • Created 23 000 video lessons lasting over 70 000 hours • Organized over 2 000 training sessions and over 1 500 seminars and events • Over 12 000 created projects • Over 26.6 million exercise submissions
9	**Sustainability:** *Note: If needed, if we have results we can write.*	
10	**What were the obstacles?** *Note: If needed, if we have results we can write. What were the difficulties in intruduction.*	
11	**What innovative skills (if any) the described above best practice might have developed to enhance students employability?** *Note: Please list skills only we mark the skills.*	Each program and course offered by SoftUni focuses on developing particular skills in certain areas. Some of these skills are in the fields of: Software engineering Programing
12	**References (pls insert a link to more data on the practice)**	https://softuni.bg/ https://softuni.org/

4. Best practice for digital transformation and implementation of the Industry 4 concept in Bulgaria		
1	**Best practice name:***	Technological park at the Technical University of Gabrovo.
2	**Sector:***	Higher education
3	**Organization implementing/disseminating the practice:***	Technical Univeristy of Gabrovo
4	**The goal:* (up to 100 words)**	The technology park and the laboratories that are part of it imply the implementation of scientific and applied research of scientists from the partner organizations, including for the needs of business. Moreover, the modern equipment

		provides opportunities for the universtity to develop and intergate sustainable and modern learning practices in the training of undergraduate and graduate students. The tecnology park provides opportunities for lecturers, postgraduates, researchers and students to work and excel their knowledge and practical skills in various aspects in the field of Industry 4.0.
5	**Description / Focus:***	Technical University - Gabrovo is an educational and scientific institution that has a modern base and manages one of the most modern technology parks in Bulgaria that was established in 2020. The Technology Park of the Technical University of Gabrovo has in total 18 laboratories of the Competence Centre "Intelligent, Mechatronic, Eco and Energy Saving Systems and Technologies", Centre of Excellence "National centre of mechatronics and clean technologies", Competence Centre "Quantum Communication, Intelligent Security and Risk Management Systems (QUASAR)" and the Centre for Competence "Digitalisation of the Economy in Big Data Environment", funded by the Operational Program Science and Education for Smart Growth, co-financed by the European Regional Development Fund. Various institutions, associations, universities, and entities partner with TU Gabrovo in the establishment of the laboratories. The Centre for Competence laboratories "Intelligent, Mechatronic, Eco - and Energy Saving Systems and Technologies" are the basis of the Technology Park of the Technical University of Gabrovo. The laboratory complex Energy saving systems and technologies for design and production of high-tech products includes 4 laboratories. At the CAD/CAM systems for design and production of high-tech products laboratory is performed scientific and applied research related to the development, modelling and optimization of technological processes and new designs of cutting and combined tools. A 5-axis lathe-milling machining centre was purchased for the production of complex parts. A 3D metal printer and specialized software for additive technologies were purchased within the Laboratory Additive and Energy Saving Technologies and Equipment. Laboratory Intelligent Technologies Based on Intensive Energy Flows is implemented as a result of the partnership between the Technical University of Gabrovo and the Institute of Electronics at BAS. The laboratory

		performs scientific and applied research in the field of electron-beam welding and surface modification of metals and alloys for the mechatronics needs. A machine for dynamic and static tests and a semi-automatic microhardness tester have been installed at the laboratory Energy saving technologies for prolonging the life cycle and increasing operational safety. The equipment performs static or dynamic load tests according to the requirements of international standards of metallic and non-metallic materials. Two laboratories, equipped with unique equipment and specialized software are built at the laboratory complex Intelligent mechatronic systems for measurement and control. At the laboratory Intelligent mechatronic systems for measuring static and dynamic quantities can be performed measurements with proven accuracy of the geometric parameters of machine-building products, study of the accuracy and calibration of measuring instruments and systems in accordance with the industry needs. X-ray diffractometry of monolithic materials and thin layers, qualitative and quantitative analysis of structural, phase and composite polycrystalline materials, as well as measurement of residual stresses in monolithic polycrystalline materials and residual austenite are performed at the laboratory Intelligent systems for studying the structure and properties of materials. Laboratory complex Intelligent energy saving systems and technologies has 6 new laboratories – Development of eco and energy saving, contactless electricity transmitters; Development of methods and tools for solving energy and infrastructure problems related to mass electric mobility; Environmental, energy saving and electromagnetically compatible lighting, LED and RES components and technologies; Energy efficient systems and technologies using heat and hydraulic energy and secondary and renewable energy sources; Electric drive and electrical equipment - contemporary energy-efficient electrical components and systems with application in the industrial sector. The laboratory complex Electronics and Sensors has 2 laboratories Microelectronic and microprocessor devices and systems and Sensors and sensor systems for development of sensor elements for humidity, gases and temperature and microelectronic and microprocessor devices and systems. Within the Centre for Excellence "National Centre for

		Mechatronics and Clean Technologies" was built the laboratory "Accurate measurements of dynamic quantities in mechatronics", part of the laboratory complex "Robotic mechatronic technologies". This is the only laboratory in the country, which has a mechatronic system with six degrees of freedom to study dynamic characteristics, with reference properties, which will experimentally determine and study the dynamic characteristics of machines and equipment subjected to alternating mechanical effects (land vehicles, ships, and aircraft). Two laboratories are built on the territory of the Technical University of Gabrovo within the project "Quantum communication, intelligent security and risk management systems" (QUASAR). The Quantum Communication Laboratory has a CLAVIS quantum communication platform, which includes a complete quantum key sharing system (QKD system), supporting a coherent one-way protocol (COW protocol), quantum random number generators, switches and service equipment with specialized measuring equipment. The Innovative sensor technologies laboratory has specialized equipment and software for design, measurement, diagnostics and analysis of sensors and electronic products. The Technology Park also includes a laboratory Digitalization of the economy in a big data environment that examines problems of the economy digitalization in a Big Data environment.
6	**Target groups:***	Students and researchers of all levels and academic staff at the university Partner organisations and institutions Businesses Other organisations – public and non-governmental interested in projects and topics related to Industry 4.0 and relevant to the fields of research of the laboratories inside the Technology park.
7	**Dissemination / implementation method:** *Note: If needed.*	
8	**Results / impact with a focus on:** **1. sector** **2. individuals, like students or employees**	The access to the laboratories and the opportunity to work with these technologies and systems allow students, researchers, and other academic staff to better understand theory and to gain practical experience.

	Note: If needed, if we have results we can write.	Partner institutions, organisations, and businesses develop projects related to Industry 4.0 and relevant to the fields of research of the laboratories inside the Technology park.
9	**Sustainability:** *Note: If needed, if we have results we can write.*	
10	**What were the obstacles?** *Note: If needed, if we have results we can write. What were the difficulties in intruduction.*	
11	**What innovative skills (if any) the described above best practice might have developed to enhance students employability?** *Note: Please list skills only we mark the skills.*	Thechnology park implements vairous projects that are entirely focues on businesses. Students and PhD students can participate in these projects as well. In this way they further develop their practical skills and knowledge in the filed of Industry 4.0. The exersices and work at the laboratories on different business-related projects equip students with more practical skills related to automation technology solutions. They gain knowledge and experience in working on specific tasks. Not only students improve their professional skills, but they also improve and develop various soft skills, such as team work, business communication, meeting deadlines, work on projects that are very improtant for becoming more successfull on labour market.
12	**References (pls insert a link to more data on the practice)**	https://www.tugab.bg https://gabrovo.bg/bg/news-article/10499 https://www.tugab.bg/novini/posledni-novini/1330-tehnologichen-park-na-tehnicheski-universitet-gabrovo https://www.youtube.com/watch?v=MqEfBCZ7gAk

3.2 BEST PRACTICES-LATVIA

Best practices for digital transformation and implementation of the Industry 4.0 concept

1. Best practice for digital transformation and implementation of the Industry 4 concept in Latvia

1	**Best practice name:***	Training materials in the Latvian language for the implementation of Industry 4.0 in the metalworking industry
2	**Sector:***	Metalworking industry
3	**Organisation implementing/disseminating the practice:***	The consortium of the Erasmus+ (Key Action: Cooperation for innovation and the exchange of good practices, Action Type: Sector Skills Alliances in vocational education and training) project No. 575813-EPP-1-2016-1-LT-EPPKA2-SSA "Industry 4.0 CHAlleNGE: Empowering Metalworkers for Smart Factories of the Future" (2016-2020). Partners from Latvia: Association of Mechanical Engineering and Metalworking Industries of Latvia, Zemgale Region Human Resource and Competences Development Centre, National Centre for Education Republic of Latvia.
4	**The goal:* (up to 100 words)**	The project's main goal was to increase metalworkers' skills and prepare them for Industry 4.0 challenges. Therefore, the project addressed the problem of the lack of qualified employees and an inadequate level of employees' skills in the metalworking and mechanical engineering industry regarding introducing and developing Industry 4.0. [1,2]
5	**Description / Focus:***	The project developed an interactive e-learning platform (www.cnc4change.org) and training materials, among other results. [1,2]
6	**Target groups:***	The target groups of training materials are the following [1,2]: • workers in the metalworking and mechanical engineering industries; • CNC machine tool operators and adjusters; • engineers - technologists who develop CNC machine tool processing programs; • engineering students and learners in all types and levels of education and training; • academic staff. • all persons involved in computer-aided manufacturing solutions.

7	**Dissemination / implementation method:**	The training materials as other project results were disseminated using the following channels [1,2]: • press articles in local/regional/special newspapers; • brochures printed and distributed to VET providers, associations, labour exchange, and the specialised public to spread the word about the project's added value and outcomes; • project website.
8	**Results / impact with a focus on:** **1. sector** **2. individuals, like students or employees**	The developed training materials include [1,2]: • one model modular VET programme and four country-specific training programmes, which were specifically developed for youth, older people, unemployed, migrants, other adults, Qualification authorities, VET schools, and trainers; • set of assessment tests; • training material, which was developed for learners (youth, older people, unemployed, migrants, and other adults), includes one textbook for learners, one workbook for learners and one trainer manual for trainers; • a set of 3D posters representing processes in the metalworking industry visually. Therefore, the project provides the ready-to-use materials for education employees in the metalworking industry.
9	**Sustainability:**	Not specified
10	**What were the obstacles?**	Not specified
11	**What innovative skills (if any) the described above best practice might have developed to enhance students employability?**	Not specified
12	**References (pls insert a link to more data on the practice)**	1. https://erasmus-plus.ec.europa.eu/projects/search/details/575813-EPP-1-2016-1-LT-EPPKA2-SSA 2. https://www.masoc.lv/jaunumi/masoc-zinas/izdoti-jauni-macibu-materiali-industrijas-40-ieviesanai (in Latvian)

2. Best practice for digital transformation and implementation of the

Industry 4 concept in Latvia		
1	**Best practice name:***	SME Digital Maturity Recommender
2	**Sector:***	Any SME
3	**Organisation implementing/disseminating the practice:***	Latvian Information and Communications Technology Association, together with partners (Edisoft, Microsoft Latvia, Lursoft, Fitek, ELVA, VISMA, Bregards, Komercizglītības centrs, Baltic3d.eu), implemented a national initiative [1, 2, 3]
4	**The goal:* (up to 100 words)**	The digital maturity test aims to allow SME management to assess the current state of use of IT solutions in companies and think about their further development and integration. [1, 2, 3]
5	**Description / Focus:***	The tool provides the following possibilities [1, 2, 3]: • answering questions about the use of IT solutions in the company's internal and external processes; • in-depth assessment of the company's digital maturity and comparison with competitors in the industry and the region; • recommendations on which IT solutions would help the company to work more efficiently. The tool measures digital maturity across ten business dimensions [1, 2, 3]: • digital transformation and competition; • financial data management; • human resources environment; • customer relationship management; • resource management; • communication and customer relations; • digitalisation of processes; • security policy and practices; • digitalisation in production; • innovation and growth perspectives.
6	**Target groups:***	Management of SMEs companies
7	**Dissemination / implementation method:**	The test is available on the web: https://www.diginnotool.eu/ It is promoted by the Latvian Information and Communications Technology Association and partners.

8	**Results / impact with a focus on:** • **sector** • **individuals, like students or employees**	Any SME has a tool to assess it digital maturity and to decide which new technologies to introduce. It can raise the level of digitalization in the country
9	**Sustainability:**	Not specified
10	**What were the obstacles?**	Not specified
11	**What innovative skills (if any) the described above best practice might have developed to enhance students employability?**	Not specified
12	**References (pls insert a link to more data on the practice)**	1. https://digital-skills-jobs.europa.eu/en/inspiration/resources/diginno-tool-sme-digital-maturity-recommender 2. https://www.diginnotool.eu/ 3. https://likta.lv/digitala-brieduma-tests/ (in Latvian)

3. Best practice for digital transformation and implementation of the Industry 4 concept in Latvia

1	**Best practice name:***	"Introduction to the IoT: Coursebook in Latvian"
2	**Sector:***	Education
3	**Organisation implementing/disseminating the practice:***	The consortium of the Erasmus+ (Key Action: Cooperation for innovation and the exchange of good practices, Action Type: Strategic Partnerships for higher education) project No.2016-1-PL01-KA203-026471 "Innovative Open Education on IoT: improving higher education for European digital global competitiveness" (2016-2019). Four researchers of the Riga Technical University represented Latvia in the project and participated in developing the coursebook.
4	**The goal:* (up to 100 words)**	The coursebook aims to introduce the Internet of Things, one of the pillars of Industry 4.0.[1,2]

5	**Description / Focus:***	The coursebook addresses such topics as a definition of IoT, enabling technologies, IoT hardware, networking basics, IoT security and others. It contains 352 pages. [1,2]
6	**Target groups:***	The book is targeted at [1,2]: • bachelor's and master's students; • technology enthusiasts; • engineers; • educators who are willing to expand their knowledge or develop a course on IoT; • adults for further development of previously acquired technical knowledge and skills.
7	**Dissemination / implementation method:**	The book is available on the web: https://ec.europa.eu/programmes/erasmus-plus/project-result-content/92252e46-43c8-4ccc-9935-590bdb8ba9fe/iot-open.eu-LV.pdf
8	**Results / impact with a focus on:** • **sector** • **individuals, like students or employees**	Therefore, the project provides the ready-to-use materials to educate everyone interested in IoT technologies. It can raise the level of awareness of society about Industry 4.0.
9	**Sustainability:**	Not specified
10	**What were the obstacles?**	Not specified
11	**What innovative skills (if any) the described above best practice might have developed to enhance students employability?**	Not specified
12	**References (pls insert a link to more data on the practice)**	1. http://iot-open.eu/download/iot-open-eu-introduction-to-the-iot-coursebook-in-latvian/ 2. https://erasmus-plus.ec.europa.eu/projects/eplus-project-details#project/2016-1-PL01-KA203-026471

4. Best practice for digital transformation and implementation of the Industry 4 concept in Latvia

1	**Best practice name:***	AR headsets

2	**Sector:***	Technology, engineering
3	**Organisation implementing/disseminating the practice:***	Lightspace Technologies
4	**The goal:* (up to 100 words)**	The company has invented the world's first multi-focal technology - AR headsets - that uses multiple screens for eye accommodation that comes as close to natural viewing as possible [1,2]
5	**Description / Focus:***	The developed technology can be used in many fields (surgery, digital manufacturing, materials engineering, diagnostic imaging, and other files demanding high precision activities). The technology was developed and used in many projects (ERDF fund supported by the Ministry of Economics of Latvia project No. 1.2.1.1/18/A/006 No 1.16 "Development of integrated electronics for head position tracking and remote assistance functionality" and Project 1.2.1.1/18/A/006 No 1.22 "Precise positioning of the head-mounted display in industrial applications", as well as No. H2020-EIC-SMEInst-2018-2020-3 "Next Generation Enhanced Augmented Reality 3D Glasses for medical education, pre-procedural planning, intra-procedural visualisation, and patient rehabilitation") [1,2]
6	**Target groups:***	Professionals in surgery, digital manufacturing, materials engineering, diagnostic imaging, and other files demanding high-precision activities [1,2]
7	**Dissemination / implementation method:**	The technology is disseminated in marketing and technology events.
8	**Results / impact with a focus on:** • **sector** • **individuals, like students or employees**	The company has developed a new tool for industry fields completing high-precision activities
9	**Sustainability:**	Not specified
10	**What were the obstacles?**	Not specified
11	**What innovative skills (if any) the described above best practice might have developed to enhance students employability?**	Not specified

12	**References (pls insert a link to more data on the practice)**	1. https://lightspace3d.com/products/ 2. https://cordis.europa.eu/project/id/960828

5. Best practice for digital transformation and implementation of the Industry 4 concept in Latvia

1	**Best practice name:***	Energy Management System
2	**Sector:***	Energetic
3	**Organisation implementing/disseminating the practice:***	AdvanGrid
4	**The goal:* (up to 100 words)**	The company provides an energy management system that, based on sensors, measures energy consumption on a machine level and stores the data in the energy management software platform for further analysis. Based on data, a specific action plan can be developed that helps to eliminate energy waste, boost efficiency and cut costs.[1]
5	**Description / Focus:***	The solution is used in many countries in Europe, North America, Australia, and Asia by more than 200 companies. On the website, many case studies are described. Users can use different plans to buy the solution.[1]
6	**Target groups:***	Any company that is interested in energy saving.
7	**Dissemination / implementation method:**	The company sells the system and its support based on different payment plans.[1]
8	**Results / impact with a focus on:** • **sector** • **individuals, like students or employees**	Not specified
9	**Sustainability:**	Not specified
10	**What were the obstacles?**	Not specified

11	**What innovative skills (if any) the described above best practice might have developed to enhance students employability?**	Not specified
12	**References (pls insert a link to more data on the practice)**	1. https://www.advangrid.com/#3-steps-header

3.3 BEST PRACTICES- ITALY

DigiWork. Best Practices of Digital Transformation

1. Best practice for digital transformation and implementation of the Industry 4 concept in Italy		
1	**Best practice name:***	National Strategy for Digital Skills 2021-2026 in Italy
2	**Sector:***	e-skills in both the private and public sectors, including e-leadership skills and digital jobs
3	**Organization implementing/ disseminating the practice:***	Department for Digital Transformation - Presidency of the Council of Ministers of Italy https://innovazione.gov.it
4	**The goal:* (up to 100 words)**	This national strategy is implemented jointly with the collaboration of Ministries, Regions, Provinces, municipalities, universities, research institutes, companies, professionals, the National Public Broadcasting, associations and the various public sector organizations, the organisations belonging to the Italian Coalition for Digital Skills and Jobs under the direction of the Technical Steering Committee of the 'Repubblica Digitale' programme coordinated by the Department for Digital Transformation.
5	**Description / Focus:***	The Italian Strategy for Digital Skills is aimed to fight the cultural digital divide affecting the Italian population through supporting digital inclusion, to support the e-skills development throughout the higher education and training cycle, to promote key competences development for the future and increase the percentage of ICT specialists (especially in emerging technologies). Another objective is

		to ensure that the entire working population has basic digital skills for the new needs and ways of working. This Strategy has been drafted jointly with the collaboration of Ministries, Regions, Provinces, municipalities, universities, research institutes, companies, professionals, the National Public Broadcasting, associations and the various public sector organizations, the organizations belonging to the **National Coalition**, and with the informal exchanges with the European Commission, under the direction of the Technical Steering Committee of the **"Repubblica Digitale"** initiative and the coordination of the Department for Digital Transformation. It develops some of the objectives of the 2026 Digital Italy strategy of **the Minister for innovation and digital transition.** The strategy identifies four lines of intervention, coherently with the four pillars of the European Coalition for Digital Skills and Jobs: • **Higher Education and Training** - for the development of e-skills for young people within the mandatory education cycles (working group is coordinated by the Ministry of Education and the Ministry of University and Research) • **Active workforce** - to ensure adequate e-skills in both the private and public sectors, including e-leadership skills (working group is coordinated by the Ministry of Economic Development and Department for Public Administration) • **ICT specialist skills** - to enhance the country's ability to develop skills for new markets and new jobs, with a specific focus on emerging technologies and key competencies for future jobs (working group is coordinated by the Ministry of University and Research and the Ministry of Economic Development) • **Citizens** - to develop the digital skills needed to exercise citizenship rights and promote active participation in the democratic life (working group is coordinated by the Department for Digital Transformation). For each line of intervention are associated priorities and lines of action. The Strategy has then been complemented by an **Operational Plan** including **targets for 2025**, based mainly on both DESI and Eurostat indicators like the following:

		• Equip 70% of the population with at least basic digital skills and bridge the gender skills gap in the ICT sector. • To double the rate of Italian citizens with advanced digital skills (78% of young people with higher education, 40% of workers in the private sector and 50% of civil servants). • Increase the number of graduates in ICT three times; and four times for the number of female graduates and increasing twofold the share of companies active in the field of big data. • Double the share of companies that uses big data; and double the employment of digital experts and ICT specialists in small and medium sized enterprises (SMEs). • Increase five times in the share of the population using public digital services (64%). • Increase in the use of the Internet and the ability to use computers also for older people: 84% in the 65-74 age group. The Plan addresses the **41** lines of action identified in the Strategy through **111** actions and provides a dashboard of over **60** indicators to monitor the impact on the 4 lines of intervention. Each action also includes appropriate milestones, result indicators and target values. The dashboard is based on the indexes included in the Digital Economy and Society Index (DESI) of the European Commission and the Digital Maturity Indexes (DMI) elaborated by the Digital Agenda Observatory.
6	**Target groups:***	Digital skills for the labour force. Digital skills for ICT professionals and other digital experts. Digital skills in education. Digital skills for all
7	**Dissemination / implementation method:** *Note: If needed.*	The **implementation model** of the Plan allows to update the operational plan on a six-monthly basis, evaluating the general impact of the whole plan and the effectiveness of the actions and improving them where necessary, and considering the ever-changing context according to the Plan-Do-Check-Act (PDCA) continuous improvement model.
8	**Results / impact with a focus on:** **1. sector** **2. individuals, like**	

	students or employees *Note: If needed, if we have results we can write.*	
9	**Sustainability:** *Note: If needed, if we have results we can write.*	
10	**What were the obstacles?** *Note: If needed, if we have results we can write. What were the difficulties in introduction?*	Difficulties in investments on digitalization. Financial costs. Lacking digital culture at managerial level. Sustaining private investments in advanced digital technologies. Diffidence on innovative working processes supported by digital tools.
11	**What innovative skills (if any) the described above best practice might have developed to enhance students employability?** *Note: Please list skills only we mark the skills.*	Digital strategies Digital Skills Innovative operational plans Stakeholders involvement in digital reorganisation New digital jobs Digital transformation in workplaces
12	**References (pls insert a link to more data on the practice)**	https://digital-strategy.ec.europa.eu/en/policies/digital-skills-coalition https://digital-skills-jobs.europa.eu/en/about/national-coalitions/italy-national-coalition-digital-skills-and-jobs-repubblica-digitale https://digital-strategy.ec.europa.eu/en/policies/desi https://digital-skills-jobs.europa.eu/sites/default/files/2021-09/DSJC%20Community-led%20Event%20Outcome%20Italy%20v1.0.pdf https://ec.europa.eu/eurostat https://ec.europa.eu/info/strategy/recovery-plan-europe_en

2. Best practice for digital transformation and implementation of the Industry 4 concept in Italy

1	**Best practice name:***	Industry 4.0, Enterprise 4.0 and Digital Transition 4.0 (2020-2025) in Italy
2	**Sector:***	e-skills in both the private and public sectors, including e-leadership skills and digital jobs
3	**Organization implementing/ disseminating the practice:***	Ministry of Economic Development - https://www.mise.gov.it Ministry of Economy and Finances https://www.mef.gov.it
4	**The goal:* (up to 100 words)**	Industry 4.0 national program has set up a series of policy instruments that can tackle the low level of penetration of digital technologies in the country. Firms cannot fully benefit from advanced technologies if they do not also have a sufficiently skilled workforce. The Training Tax Credit 4.0 and the tax credit for activities of R&D, innovation, or design recognise a tax discount to firms that invest in human capital, either by offering structured training to their workers, or by hiring a more skilled workforce. The range of eligible expenses is broad and therefore can adapt well to the company's actual needs. The Training Tax Credit 4.0 further contains special provisions for SMEs, including the possibility to post expenses sustained by the employer in training. Some SMEs, however, may be reluctant to apply because of the costly requirements in terms of documentation to be submitted for support. Other provisions of the Industry 4.0 reform package which more explicitly aim at supporting firms in their technological investment can also be a source of learning within the firm. Often this takes the form of learning from suppliers.
5	**Description / Focus:***	The Italian Government has recently introduced a set of ambitious industrial policy projects with the objective of igniting a radical shift of the Italian productive system towards the use of new and high value-added technologies. The set of reforms goes under the name of Industria 4.0, then amended by Enterprise 4.0 and Transition 4.0 follow-up plans. The reforms tackle a major challenge of the Italian production and skills system, i.e. the average low productivity and limited product diversification of Italian firms, which in turn translates into weak demand for skills in most sectors, and skill shortages in others. Industria 4.0 can positively affect the demand for skills in the country by helping smaller firms to become more innovative, connected to the world technology frontier and open to international markets (OECD, 2018). To achieve these results, Industria 4.0 policy initiatives have put in place a series of tools and instruments that include: incentives for technological acquisitions, tangible and intangible capital (including R&D, design and innovation) tax credits, tax incentives for training activities in

		the digital technologies, credit schemes for SMEs, the creation of digital innovation hubs and competency centres. A review of all Industry 4.0 measures would go well beyond the scope of the present study, but it is important to highlight that the Plans are built around the rationale that firms cannot adopt or benefit fully from advanced "Industry 4.0" technologies if they do not also have a sufficiently skilled workforce and a suitable organisational structure. In this light, two of the proposed Industry 4.0 financial instruments have special interest for the purpose of this study: the Training Tax Credit 4.0 ("Credito Formazione 4.0") and the R&D, Innovation and Design Tax Credit ("Credito d'imposta ricerca, sviluppo, innovazione e design"). With the Training Tax Credit 4.0, the Government seeks to foster investment by companies in training on digital and enabling technologies (a broad list of areas technological areas is provided) (Gazzetta Ufficiale, 2019). The tax credit amounts to a certain percentage of the incurred training expenses, with percentages varying according to the company's dimension: □ 50% of expenses for small businesses (up to an annual maximum of € 300,000); □ 40% of expenses for medium-sized enterprises (up to an annual maximum of € 250,000); □ 30% of expenses for large companies (up to an annual maximum of € 250,000). The rate increases to 60% of the eligible expenses, across firm sizes, if the training involves disadvantaged employees. All companies can apply (with few exceptions). The earned credit can only be appropriated in the form of discounts on the firm's tax liability or social contributions for the following years. The scope of eligible expenses is broad: the labour cost of workers in training, both as learners and as teachers, for the hours concerned by the training activity; (almost) all operating costs related to the training activity, including travel expenses, supplies directly related to the project, depreciation of tools and equipment used, or overheads (administrative costs, rents); the costs of consultancy services related to the training project, including those aimed at assessing the training needs and developing the training plan. The activities can target both the development of new skills, and the consolidation of existing ones. These features translate into very flexible and versatile training pathways, which can well adapt to the company's actual training needs. The possibility to pitch the costs of workers that are either teaching or learning provides a double advantage to those firms that organise and deliver the training activity internally. Importantly, as of 2020 costs related to the entrepreneurs' training are eligible as well. These features mild the concerns that training tax credits distort firms' decisions away from informal learning (which is

		likely preferred by SMEs) towards externally provided, formal training (Stone, 2012). On the downside, the measure requires firms to submit some documentation that SMEs may fail to assemble appropriately: a certification to workers, attesting their attendance to the activity; a document describing the way the activity was organised; proofs of the expenses incurred in the training activity, as certified by a professional accountant; a collective agreement governing the training activity, which may be more complicated to set up in firms where there are no unions' representatives. Lastly, little is currently known about the firms that are benefiting from the tax credit, nor about its effectiveness in terms of firms' outcomes, which calls for a renewed effort to monitor and evaluate the measure. The Ministry of Economic Development (MISE) further provides a tax credit for activities of R&D, innovation, or design by the firm, as long as these happen within technological domains that are connected to the fourth industrial revolution and the green transition. Recently amended in design, tax credit rates currently range from 6% to 12% of the volume invested, and are different for different activities (fundamental research, industrial research and experimental development; technological innovation; design) and different expenditure thresholds. The measure covers investments in both tangible and intangible assets. The measure is of relevance for this study because it provides an incentive to hire qualified R&D personnel, as the labour costs of these employees, as well as those of external collaborators, consultants and R&D groups, qualify for R&D tax relief. No special provision is made for SMEs. While SMEs are found to react more strongly (i.e. to produce more R&D for each Euro of tax credit) than large firms (Appelt et al., 2020[90]), they may be more sensitive, once again, to the cost of compliance with the policy requirements. These include a certificate showing that the assets possess certain technical characteristics, and this certificate must be issued by a sworn expert in case costs exceed EUR 300 000.
6	**Target groups:***	Entrepreneurs. Professionals and digital services' experts. Workers. Civil servants.
7	**Dissemination / implementation method:** *Note: If needed.*	The **implementation model** of the national initiative Industry 4.0, Enterprise 4.0 and Transition 4.0 allows to update the operational plan on a six-monthly basis, evaluating the general impact of the whole plan and the effectiveness of the actions and improving them where necessary, and considering the ever-changing context according to the Plan-Do-Check-Act (PDCA) continuous improvement model.
8	**Results / impact with a focus on:** **1. sector**	

	2. individuals, like students or employees *Note: If needed, if we have results we can write.*	
9	**Sustainability:** *Note: If needed, if we have results we can write.*	
10	**What were the obstacles?** *Note: If needed, if we have results we can write. What were the difficulties in introduction?*	Difficulties in investments on digitalization. Financial costs. Lacking digital culture at managerial level. Sustaining private investments in advanced digital technologies. Diffidence on innovative working processes supported by digital tools.
11	**What innovative skills (if any) the described above best practice might have developed to enhance students employability?** *Note: Please list skills only we mark the skills.*	Industry 4.0 practical applications Enterprise and digital transition Digital skills Innovative operational plans Stakeholders' involvement in digital reorganisation New digital jobs Linked workplaces and dematerialization
12	**References (pls insert a link to more data on the practice)**	https://www.oecd.org/els/emp/skills-and-work/adult-learning/Raising_skills_in_SMEs_Italy.pdf https://ati.ec.europa.eu/sites/default/files/2020-06/DTM_Industria4.0_IT%20v2wm.pdf https://oa.inapp.org/bitstream/handle/123456789/862/INAPP_Cirillo_Fanti_Mina_Ricci_Digital_technologies_and_firm_performance_Industry_4.0_in_the_Italian_economy_2021.pdf?sequence=2&isAllowed=y https://www.finanze.gov.it/export/sites/finanze/.galleries/Documenti/Varie/dfwp6-1_ultimo.pdf

3.4 BEST PRACTICES -POLAND

DigiWork. Best Practices of Digital Transformation

1. Best practice for digital transformation and implementation of the Industry 4 concept in Poland		
1	**Best practice name:***	Digitizing a pallet company
2	**Sector:***	production of special-purpose pallets
3	**Organization implementing/ disseminating the practice:***	PalettenWerk Kozik Spółka Jawna ul. Przemysłowa 219 34-240 Jordanów Poland https://palettenwerk.pl/en/
4	**The goal:* (up to 100 words)**	PalettenWerk is a manufacturer of wooden pallets. In this company the aim of implementation of modern solutions is first of all to optimize the pallet production process and company management.
5	**Description / Focus:***	Although the production of wooden pallets seems not connected with new technologies, PalettenWerk shows what manufacturer 4.0 should look like. First of all, the company has been managed thanks to the modern, fully integrated ERP system. ERP (*Enterprise Resources Planning)* is a comprehensive business management software. It provides centralized, dynamic planning of reserves, supply chain, production, and sales. It allows for identifying all materials and products, optimizes the process of production, and creates reports and summaries. PalettenWerk also invests in machines. In their second venue, they launched an automated pallet painting line. The output capacity of the line is 4,000 pallets per 8 hours of operation! Although the company hasn't informed the public about its previous capacity, it admitted that thanks to the new production line, it has significantly increased its production capacity for pallets that require painting. Moreover, using a new line reduces the environmental impact because of an efficient filtration system. In 2020, PalettenWerk has completed the installation of Europe's most modern production line of pallets. The production line has a capacity of 1000 pallets over 8 hours of operation. The machine guarantees the remarkable quality of the manufactured products and optimized process of work at the same time. The investment was completed with the support of EU funds from the Regional

		Operational Programme for Świętokrzyskie, 2014–2020, Priority Axis 2. Konkurencyjna gospodarka, Działanie 2.5 Support for the investment in the SME sector.
6	**Target groups:***	students of engineering schools engineering school teachers
7	**Dissemination / implementation method:** *Note: If needed.*	
8	**Results / impact with a focus on:** **1. sector** **2. individuals, like students or employees** *Note: If needed, if we have results we can write.*	
9	**Sustainability:** *Note: If needed, if we have results we can write.*	
10	**What were the obstacles?** *Note: If needed, if we have results we can write. What were the difficulties in introduction?*	Automated production lines are very expensive. PalettenWerk wrote in the announcements on its website that the purchase of the modern line was possible thanks to EU funds. So we can assume that the obstacle was the high price of the machine and the solution was EU funds.
11	**What innovative skills (if any) the described above best practice might have developed to enhance students employability?** *Note: Please list skills only we mark the skills.*	ERP implementation in a manufacturing company lean management with ERP system managing automated production data management analytical skills looking for alternative sources of financing for the purchase of new technologies

12	**References (pls insert a link to more data on the practice)**	https://palettenwerk.pl/en/erp-system-for-palettenwerk-group-completed/ https://palettenwerk.pl/en/automated-pallet-painting-line/ https://palettenwerk.pl/en/europes-most-modern-dhp-pallet-production-line/

2. Best practice for digital transformation and implementation of the Industry 4 concept in Poland

1	**Best practice name:***	Self-service hotel
2	**Sector:***	hotels & accommodation
3	**Organization implementing/ disseminating the practice:***	**Hotel Panorama** Bohaterów Warszawy 28, 78-400 Szczecinek Poland
4	**The goal:* (up to 100 words)**	The purpose of this best practice is to show how a modern hotel that: - is friendly for both tourists and business customers - has no time limits for check-in and check-out - there are no restrictions due to the lack of staff at the reception desk - respects guests' privacy and time using new technologies.
5	**Description / Focus:***	The Panorama Hotel is located in the center of the small town, Szczecinek, on the top floor of the Galeria Nova Shopping Mall. Szczecinek is neither an engaging tourist place nor an enormous business center. Nevertheless, the hotel owners decided to create a very modern and contactless place for guests to stay. Guests can make room reservations on many popular portals such as booking.com. Immediately after booking, guests are instructed how to enter the hotel. The instruction is necessary because the hotel does not have a traditional reception desk.

		Upon arrival, they do not have to stand in any queue, check-in, or ask for a key card. This is probably the last thing a tired tourist or businessman dreams of after a day of negotiations. So how do guests get to the room? That is possible through a digital access system to the facility and the room without the need for personal attendants. This system also allows guests to move around the facility on their own and check out efficiently. In case of any technical problems, the hotel staff is available at the virtual reception, which guests may access at the phone number provided. The advantage of this hotel is its availability at any time (a guest with an access code can check in and check out at any time of day or night), comfort, and privacy. Due to the prevailing COVID-19 pandemic, it is also important to note the increased security through reduced contact with staff and other guests.
6	**Target groups:***	hotels & accommodation schools — both teachers and students business schools — both teachers and students MSME
7	**Dissemination / implementation method:** *Note: If needed.*	
8	**Results / impact with a focus on:** **1. sector** **2. individuals, like students or employees** *Note: If needed, if we have results we can write.*	
9	**Sustainability:** *Note: If needed, if we have results we can write.*	

10	**What were the obstacles?** *Note: If needed, if we have results we can write. What were the difficulties in introduction?*	
11	**What innovative skills (if any) the described above best practice might have developed to enhance students employability?** *Note: Please list skills only we mark the skills.*	designing digital hotel ecosystems digital hotel key system monitoring digital payment system management OCR in accounting virtual reception and customer service user experience design
12	**References (pls insert a link to more data on the practice)**	https://hp-hotel.pl/hotel

3. Best practice for digital transformation and implementation of the Industry 4 concept in Poland

1	**Best practice name:***	Increasing academic accessibility
2	**Sector:***	university
3	**Organization implementing/disseminating the practice:***	Tischner European University/ Wyższa Szkoła Europejska im. ks. Józefa Tischnera al. Jana Pawła II 39a 21-864 Kraków Poland
4	**The goal:* (up to 100 words)**	The main goal of the project is to make the university more accessible (both structurally and in terms of education and communication) to people with disabilities. This good practice shows how to do this using new technologies.
5	**Description / Focus:***	Tischner European University (WSE) in Kraków has launched 1 the accessibility-related program in recent years:

- The program "Including Effectively in Access = EEU" aims at ensuring that the European University increases the accessibility of the university for people with disabilities by, among others: improving communication accessibility, improving IT tools (including the website), adapting teaching materials, procedures and organizational structure, and increasing the competence of the university staff in the field of the inclusive education in accordance with the 7 principles of educational support.

These 7 principles are the result of the Conference of Rectors of Academic Schools ("KRASP") and established therein the Resolution of the Presidium of KRASP dated June 2, 2016, on providing equal educational conditions for students with disabilities in access to education in higher education institutions. The following principles are:

1. "Individualization - adapting the study process of a person with a disability to his/her individual educational needs, resulting from the specifics of his/her condition and the specifics of the classes, including the conditions in which they are held. (...)
2. Subjectivity - taking into account the autonomy of a person with disabilities and their right to self-determination. (...)
3. Development of potential of a person with disabilities in relation to the educational process - selecting reasonable adaptations that would allow the student to acquire knowledge and develop practical skills (...)
4. Rationality of adaptations - proposing adaptations that are economically rational, provide a satisfactory level of equal opportunities for the disabled person and guarantee that academic standards are maintained. (...)
5. Maintenance of the academic standard - preparing adaptations while maintaining academic standards applicable to all students. (...)
6. Adaptations that are closest to the standard course of classes — i.e. those that do not have the character of a privilege for a disabled person, but that would reasonably equal their chances in terms of the possibility of realization of the educational process considered optimal in given classes (...)
7. Equal rights and obligations - taking care not only to realize equal rights for persons with disabilities but also to enforce (by ensuring these rights) the fulfillment of student obligations at the same level as for students without disabilities."

Source:
https://kssn.pl/kssn_czasopismo_archiwum/017_KSSN/pdf/KSSN_17_DODATEK_PDF.pdf

The University' s main objectives under this program are:

		• activities in the area of the organizational and procedural structure of the university to increase its accessibility, including, among others, adjusting the WSE website to WCAG standards, providing loan equipment to facilitate education for people with various disabilities, ensuring greater accessibility of library collections, organizing on-call specialists in individual support for people with disabilities.
		• activities in the area of architectural and equipment accessibility
		  ○ reduction of architectural and equipment barriers in order to increase the accessibility of the university
		• activities in the area of adaptation of didactic materials, equipment, and software to the needs of persons with disabilities in order to increase the accessibility of the educational process
		  ○ adjustment of e-learning courses, purchase of equipment enabling the realization of classes in 3D technology
		• activities in the area of staff training
		  ○ improving the competencies of the university staff in terms of educational support for persons with disabilities and improving the accessibility of the university for them

6	**Target groups:***	universities
7	**Dissemination / implementation method:** *Note: If needed.*	WCAG (Web Content Accessibility Guidelines) is a set of documents published by the WAI (Web Accessibility Initiative) containing recommendations for creating accessible websites. The WCAG standard consists of 4 main principles: Perceivable - information presented on a site must be provided in such a way that it can be perceived by users with various limitations (e.g., adding alternative text to images for blind users). Operable - buttons and other interface components must be accessible to users with various limitations (e.g., users with mobility impairments should be able to use the keyboard instead of the mouse). Understandable - information on the site and its architecture should be understandable to users (e.g., a screen reader should be able to read the content of the site correctly for blind or visually impaired users). Robust - the structure and operation of the website should meet standards

		appropriate for the technology used, which is supposed to enable long-term functioning of the website.
8	**Results / impact with a focus on:** **1. sector** **2. individuals, like students or employees** *Note: If needed, if we have results we can write.*	
9	**Sustainability:** *Note: If needed, if we have results we can write.*	
10	**What were the obstacles?** *Note: If needed, if we have results we can write. What were the difficulties in introduction.*	
11	**What innovative skills (if any) the described above best practice might have developed to enhance students employability?** *Note: Please list skills only we mark the skills.*	user experience design user interface design e-learning design web design WCAG implementation QA tests
12	**References (pls insert a link to more data on the practice)**	**https://wse.krakow.pl/projekty/wlaczamy-skutecznie-w-dostepie-wse/** https://kssn.pl/kssn_czasopismo_archiwum/017_KSSN/pdf/KSSN_17_DODATEK_PDF.pdf https://www.w3.org/Translations/WCAG21-pl/ https://www.w3.org/TR/WCAG20/

4. Best practice for digital transformation and implementation of the

Industry 4 concept in Poland		
1	**Best practice name:***	Creating databases in the cloud
2	**Sector:***	database, cloud, apps
3	**Organization implementing/disseminating the practice:***	Digitalseum Sp. z o.o. Jasionka 954E, 36-002 Jasionka Poland https://digitalseum.com
4	**The goal:* (up to 100 words)**	The purpose of creating such a unique platform was to enable museums and libraries to digitize their resources and make them more accessible.
5	**Description / Focus:***	**3.4.1.1** The pandemic exposed the problem of many Museums, which is the lack of an intuitive tool for the digitization of museum collections and their public presentation. That is why designers of the new app (now called Digitalseum) ask for funds for their new project. **3.4.1.2** Digitalseum is an innovative platform that allows maintaining order in digital collections of museums, libraries, archives, etc. This is a virtual place where cultural institutions may keep their records of items. Digilalseum offers various stages of digitization. Creators promise an intuitive tool that eases the cataloging of the items stored and designing a database for your museum or library. Depending on the need and possibilities of your institution, collections may be presented in the form of traditional pictures (2D), 3D scans, animations, films, or rotating images. It is like an enormous virtual archive. Ok, so you know how to store the data — what next? Each item that you add to your collection may get 1 of 3 indexes: barcodes, mini GPS carriers, or RFID (*Radio-frequency identification)* tags. Thanks to that you will always keep your collection in the right order.

		The platform is designed to support the process of digitization and data inventory of museum exhibits, documentation in the form of records, and collections management, among others. The creators offer not only the application itself (web and mobile) but also the hardware infrastructure. By ensuring integration between the platform, applications, cloud computing, and the aforementioned, the process of digitization and data inventory is faster, more efficient, and organized.
6	**Target groups:***	universities university libraries museums
7	**Dissemination / implementation method:** *Note: If needed.*	
8	**Results / impact with a focus on:** **1. sector** **2. individuals, like students or employees** *Note: If needed, if we have results we can write.*	
9	**Sustainability:** *Note: If needed, if we have results we can write.*	
10	**What were the obstacles?**	

	Note: If needed, if we have results we can write. What were the difficulties in introduction.	
11	**What innovative skills (if any) the described above best practice might have developed to enhance students employability?** *Note: Please list skills only we mark the skills.*	2D and 3D scanning photographing 360 degree photography cloud computing database creating/ managing cybersecurity in cloud copyrights
12	**References (pls insert a link to more data on the practice)**	https://digitalseum.com/#scrollToServices https://www.parp.gov.pl/component/grants/practice/cyfryzacja-zasobow-muzealnych-w-zakresie-udostepniania-elektronicznych-zasobow-muzealnych-bibliotecznych-zabytkowych-oraz-archiwalnych

3.5 BEST PRACTICES - SLOVAKIA

DigiWork. Best Practices of Digital Transformation

1. Best practice for digital transformation and implementation of the Industry 4 concept in Slovakia		
1	**Best practice name:***	**Digital marketing**
2	**Sector:***	**Professional education**students, marketers and entrepreneurs in the field of online marketing.

3	**Organization implementing/disseminating the practice:***	Digital University, Bratislava
4	**The goal:* (up to 100 words)**	The course is suitable for anyone who wants to learn online marketing practically.
5	**Description / Focus:***	The Digital University is an innovative educational project of the Digital Marketing Club, which for 10 years has specialized in the professional education of students, marketers and entrepreneurs in the field of online marketing. The digital university helps graduates start their careers and find a better job, but also helps many entrepreneurs to start their business better. The main areas of education are: Digital marketing • The real power and potential of online marketing for a brand • Digital tools and their effective use • How about a marketing strategy • Campaign planning and budgets • Samples of the most successful advertising campaigns • Key current trends in online marketing **Brand building** What can a strong brand influence? Heuristics, mental shortcuts and possibilities of their application How can a brand influence a customer's purchasing behavior? Tips for building a successful brand Examples of successful ads and brand strategies How to effectively measure the success of brand campaigns Creating a marketing strategy for existing vs. new brand **Web and e-shop creation** • How to start creating a website - plan and processes • Web and e-shop creation without programming • Getting to know WordPress • How to secure and protect your website • Useful plugins and add-ons to improve your website • Rules and tips for a successful website • Important activities after the launch and during the operation of the website **Social networks I. Facebook and Instagram** • Facebook and Instagram as inseparable parts of the marketing strategy • What kind of content will attract attention on Facebook and Instagram • Types of ads and different forms of content • How to properly set up communication on social networks

		• Different types of posts and hot news on social networks • Principles of successful Community management • Which stats have value and should be tracked • What should it contain and what should the content plan look like **Youtube marketing** • What potential and power YouTube has for a brand • What you should know before you start on YouTube • How to make money with YouTube videos • How to set up a YouTube channel professionally • How to create great content and build your community • How to create videos efficiently and quickly • A strategy that can improve performance by 70x **Facebook ads and Business Manager** • Facebook Business Manager and its benefits • Advertising account setup and structure • How to manage a Facebook page • How to schedule posts • Basic principles of advertising and how to proceed with its targeting • What viral ad formats can you use? • Evaluation and optimization of Facebook ads **Consumer behavior** • How to get to know your customer and find out how they make decisions • Important elements and information in advertising that influence the customer • Examples of consumer behavior surveys • Find out what's going on in your customers' minds • Tools to understand, predict and influence human decisions • What and how to say to make it work • What are the reasons for perceived demandingness, uncertainty and how to eliminate them **Softskills in marketing** • Discovering and developing strengths • Communication and presentation skills • Negotiation principles • How not to burn out thanks to work-life balance • How to save and strengthen your vitality • How to manage stress • Effective Time-management **Psychology in marketing** • Paradigm shift - how the human mind works and prejudices • Positive and negative verbal anchoring • Techniques that can be used to influence the customer's decision • Triggers and biases in behavior • Mistakes that cost us a customer • How to arouse interest? - emotions vs reason

		• Practical examples of influencing people
6	**Target groups:***	intended for beginners who want to start their career faster, but also for senior marketers who have specialized so far and want to understand the issue more comprehensively or move to better positions. Also for graduates of various schools who have not found a suitable job and would like to use the potential of online business or find a job in this field.
7	**Dissemination / implementation method:** ***Note: If needed.***	
8	**Results / impact with a focus on:** **1. sector** **2. individuals, like students or employees** *Note: If needed, if we have results we can write.*	
9	**Sustainability:** *Note: If needed, if we have results we can write.*	
10	**What were the obstacles?** *Note: If needed, if we have results we can write. What were the difficulties in the introduction.*	

11	**What innovative skills (if any) the described above best practice might have developeddoes it enhance student employability?** *Note: Please list skills only we mark the skills.*	
12	**References (pls insert a link to more data on the practice)**	https://digitalnauniverzita.sk/predmety/ https://digitalnauniverzita.sk/o-nas/ https://hashtag.zoznam.sk/kariera-v-marketingu-digitalna-univerzita/

2. Best practice for digital transformation and implementation of the Industry 4 concept in Slovakia

1	**Best practice name:***	Certified interdisciplinary courses
2	**Sector:***	Healthcare
3	**Organization implementing/disseminating the practice:***	Pavel Jozef Šafárik University in Košice, Faculty of Public Administration UPJS KE
4	**The goal:* (up to 100 words)**	The main goal of the courses is to increase students' skills and prepare them for the digital society and the challenges of Industry 4.0. The courses solve the problem of the lack of qualified employees and the insufficient level of students' skills for practice in the field of soft communication skills as one of the most important and at the same time least developed competencies of recent graduates entering the labor market. After completing the courses, students can communicate assertively, resolve conflicts arising in the workplace, effectively receive and provide feedback, as well as master the basics of working in accounting systems or programming languages. New knowledge from the field of data analysis and data manipulation will improve the application of graduates on the labor market in computationally supported decision-making.

5	**Description / Focus:***	A unique offer of certified interdisciplinary courses: • Skills for success - from university to practice, • Use, administration and development in the SAP system, • IT for practice, • Solving conflict and crisis situations in school practice, • Project management, • International ECo-C certificate, • International ECDL certificate, Each course contains several modules. The decisive topics of the modules and subjects in relation to the acquisition of new knowledge and skills for greater application in the public and private sector include: • Development of professional competences: Soft vs. hard skills, Personality typology, Emotional intelligence, Motivation, Leadership, Decision making, Team work, Conflicts, Assertiveness, Stress management, Time management, Intercultural competence • **E-government**: main characteristics, definitions, goals, strategies and legislation, E-government of territorial self-government, Smart city, Open Data, • **Digital technologies for public administration I., II:**Creating documents, Working with data tables, Using the Internet, Working with databases, Creating presentations, Information security. • **Web and user interface design:**HTML - markup language for describing the structure and content of HTML documents, CSS - language for describing the way (X)HTML documents are displayed, Page layout, Website accessibility. • **Management of information systems:**Introduction to information systems. Organizational strategy and the role of information systems in gaining competitive advantage. Managing data and knowledge. Business Intelligence. Ethics and privacy protection. Information security. Social Computing. E-shop. Wireless and Mobile Computing. The role of information systems within the organization and public administration. CRM systems. Management of supply-customer chains. Information retrieval systems. • International ECo-C certificate (European Communication Certificate)is a standardized certificate in the field of personal development and communication skills in the countries of the European Union. International ECDL certificate (European Computer Driving

		Licence) is the world's most widespread system for verification (certification) of knowledge and skills in the field of working with computer technology intended for ordinary personal computer users.they increase the chance for graduates to find employment on the labor market and their attractiveness among employers. Certificates are bilingual - in Slovak and English - and have unlimited validity.
6	**Target groups:***	active certified interdisciplinary courses are intended for all students of bachelor's, master's, doctoral, doctoral full-time and part-time studies at all faculties of the university. e there is a high demand from public institutions and companies for graduates of non-informatics fields with basic knowledge in the fields of ICT, the courses are nded also for students of non-informatics fields of study. New knowledge from the field of data analysis and data manipulation will improve the application of the graduate on the labor market in computationally supported decision-making.
7	**Dissemination / implementation method:** ***Note: If needed.***	
8	**Results / impact with a focus on:** **1. sector** **2. individuals, like students or employees** *Note: If needed, if we have results we can write.*	

9	**Sustainability:** *Note: If needed, if we have results we can write.*	
10	**What were the obstacles?** *Note: If needed, if we have results we can write. What were the difficulties in the introduction.*	
11	**What innovative skills (if any) the described above best practice might have developeddoes it enhance student employability?** *Note: Please list skills only we mark the skills.*	
12	**References (pls insert a link to more data on the practice)**	**Register of UPJŠ study programs (upjs.sk), https://studijne-programy.upjs.sk/program/ISVSb** Certified interdisciplinary courses | UPJŠ (upjs.sk) https://www.upjs.sk/studenti/certifikovane-indisciplinarne-kurzy/ SFS - Skills for success - from university to practice | UPJŠ (upjs.sk) https://www.upjs.sk/pracoviska/ccvapp/medzinarodne-certifikaty/ecdl/studenti/

3. Best practice for digital transformation and implementation of the Industry 4 concept in Slovakia

1	**Best practice name:***	Simulator and virtual medicine
2	**Sector:***	Interactive teaching of medical and non-medical fields
3	**Organization implementing/disseminating the practice:***	Pavel Jozef Šafárik University in Košice, Faculty of Medicine UPJS KE - Center for simulator and virtual medicine
4	**The goal:* (up to 100 words)**	The center helps in the teaching of several subjects within all grades in various study programs, while improving the quality and attractiveness of the teaching of pre-clinical and clinical subjects with the help of "hi-tech". The use of high-quality simulators and models represents the most modern trends in the teaching of medicine and other medical fields and allows students to acquire a lot of knowledge and practical habits in an extremely attractive way. Thus, students have the opportunity to learn how to behave even in life-threatening conditions of patients.
5	**Description / Focus:***	The Center for Simulator and Virtual Medicine represents a new era of interactive teaching of medical and non-medical fields and brings a completely new perspective on modern solutions in the teaching process. At the same time, it provides opportunities for students to supplement their theoretical knowledge with practical training on the most realistic simulators. The center currently has 34 interactive teaching aids and models for practicing nursing techniques. These are, for example, an ultrasound examination simulator, an anatomical simulator, a virtual laparoscope or an operating room with an advanced patient simulator. The student training on the LAP Mentor simulator wears a virtual headset and is fully immersed in the operating room environment, where there are also other team members, the patient, equipment and realistic sound dispersion. This environment ensures a very realistic experience and teaches students how to cope with the stressful and often busy operating room environment. The tactile resistance of the tissue when using the surgical instruments ensures the feeling of performing a real laparoscopic surgery There is also a multimedia table with software, containing virtual patients for training and solving scenarios from a hospital or ambulatory environment, an advanced nursing

		model of an adult, enabling the practice of basic physical examinations and nursing procedures, a set of equipment for simulating the injured, containing bleeding and simulating injuries. Other VR models include: Body Interact 1 and 2 The realistic virtual environment of Body Interact contains a number of its own physiological algorithms and artificial intelligence programs, thanks to which work with each virtual patient is almost the same as with a real patient. Sectra 1 and 2 SECTRA is an interactive teaching aid using real anatomy and clinical cases to develop thinking in critical situations. It allows users to easily reveal and explore a virtual representation of real body parts down to the smallest detail. 3D images are quickly and easily generated from data taken during CT or MR. The Sectra Table also perfectly complements the incisions made in traditional anatomy teaching. Teachers can repeat a cut from a previous case for review or demonstration to other students. Students can dissect the same body, discover and learn about anatomical variations and different parts of the body.
6	**Target groups:***	Students of medical and healthcare fields, ning of practical exercises of specific activities
7	**Dissemination / implementation method:** ***Note: If needed.***	
8	**Results / impact with a focus on:** **1. sector** **2. individuals, like students or employees** *Note: If needed, if we have results we can write.*	
9	**Sustainability:** *Note: If needed, if we have results we can write.*	

10	**What were the obstacles?** *Note: If needed, if we have results we can write. What were the difficulties in the introduction.*	
11	**What innovative skills (if any) the described above best practice might have developeddoes it enhance student employability?** *Note: Please list skills only we mark the skills.*	
12	**References (pls insert a link to more data on the practice)**	Center of simulator and virtual medicine | UPJŠ (upjs.sk) https://mediweb.hnonline.sk/zdn/spravy/8749207-medici-v-kosiciach-mozu-trenovat-v-unikatnom-centre-simulatorováj-a-virtualnej-mediciny https://www.youtube.com/watch?v=vHFw9mXC_z4

4. Best practice for digital transformation and implementation of the Industry 4 concept in Slovakia

1	**Best practice name:***	Industry 4 technologies in advanced robotic cells
2	**Sector:***	Engineering industry - Intelligent robotic cells

3	**Organization implementing/disseminating the practice:***	Manex Kosice
4	**The goal:* (up to 100 words)**	The Manex company belongs to an SME that implements Industry 4 technologies as much as possible in its solutions. The project and production profile of the company is automated production and transport lines based on robots. The goal of the design and implementation of such workplaces is to achieve the widest possible use of handling and technological devices with intelligent cyber-physical elements enabling interconnection within IoT, M2M and H2M, visualization of processes and parameters. In the process of designing production lines, its goal is to obtain as much as possible the basic characteristics of the "real process" from the simulation of the digital twin.
5	**Description / Focus:***	The current approach of the Manex company is based on the philosophy of developing human potential in the form of various trainings, participating in exhibitions and conferences, acquiring the latest knowledge and trends of Industry 4, as well as acquiring new talents for project management functions. In his projects, he uses: - modern control systems that have built-in software systems and have an Internet address to connect and be addressed via IoT (Internet of Things). In this way, products and means of production are connected and can "communicate", enabling new ways of production, value creation and optimization in real time, - one of the most important technologies of production digitization is the digital twin technology. A digital twin is a virtual model of a product or production line, which simulates and tests various changes before putting them into real operation, which guarantees their reliable implementation. - advanced robotics with the ability to perceive the working and operating environment from internal and external sensors used to control the functions of the target program, - unique conveyor systems, the conveyor system can be the only automated part within the entire production, but in most cases it is only a subsystem of the entire automated line or robotic system. Even if the overall transport system is made up of standard and "special" conveyor modules, due to the large number different types of transported products and specific performance and layout requirements, each transport system as a whole is a unique project. The result is automated handling systems designed and custom-made for a specific customer. Technical solutions and used equipment are always dimensioned to meet all specified quality and performance parameters of the user. It also implements the most modern "pick and place" robots,

		which are used for quick handling of small and light objects.
6	**Target groups:***	narily the food, beverage, chemical, wood and automotive industries. Due to their high variability and good performance parameters, industrial robots have also found application in various other applications, such as robotic handling or robotic palletizing.
7	**Dissemination / implementation method:** ***Note: If needed.***	
8	**Results / impact with a focus on:** **1. sector** **2. individuals, like students or employees** *Note: If needed, if we have results we can write.*	
9	**Sustainability:** *Note: If needed, if we have results we can write.*	

10	**What were the obstacles?** *Note: If needed, if we have results we can write. What were the difficulties in the introduction.*	
12	**References (pls insert a link to more data on the practice)**	http://www.manex.sk/web/index_sk.html http://www.manex.sk/web/offer_01_sk.html

3.6 BEST PRACTICES - SPAIN

DigiWork. Best Practices of Digital Transformation

1. Best practice for digital transformation and implementation of the Industry 4 concept in Spain		
1	**Best practice name:***	Spain Digital Enterprise („España Empresa Digital_“)
2	**Sector:***	All sectos
3	**Organization implementing/disseminating the practice:***	The chamber of commerce of Spain („Cámara de Comercio de España“)
4	**The goal:* (up to 100 words)**	The main objective of the Industry 4.0 Program is to contribute to the improvement of the competitiveness of SMEs, micro-SMEs and self-employed in the industrial sector, through the adoption of a culture, use and permanent use of ICTs in their business strategies, to achieve sustained economic growth, as well as to minimize the impact of the COVID-19 crisis. They provide entrepreneurs with personalized advice and assistance for the digital transformation of your company.

5	**Description / Focus:***	The main objective of the program is the identification of solutions and actions adapted to the needs of the SME, with three basic lines of action: • Intra-company / inter-company management applications: business solutions, intelligence solutions (Big Data and Analytics) and control, collaborative platforms. • Communications and data processing: Computing and cloud, connectivity and mobility • Hybridization physical and digital world: Additive manufacturing (3D scanning and printing), advanced robotics, sensors and embedded systems (IoT, VR/AR, simulation).
6	**Target groups:***	Self-employed, businessmen/woman and entrepreneurs with an industrial SME registered in the IAE census.
7	**Dissemination / implementation method:** *Note: If needed.*	• Awareness-raising seminars held in regional and national chambers. • Specific workshops and seminars • Forums to improve training and confidence in the digital environment. • Digital maturity model (self-diagnosis test).
8	**Results / impact with a focus on:** 1. **sector** 2. **individuals, like students or employees** *Note: If needed, if we have results we can write.*	There are a multitude of success stories (Gaviplas SL, Grupo Alcamin SL, Alvaro Avant, Go British, Conciencia Nutricional, etc.), which are shown in the following web address: https://empresadigital.camara.es/casos-de-exito
9	**Sustainability:** *Note: If needed, if we have results we can write.*	
10	**What were the obstacles?**	

	Note: If needed, if we have results we can write. What were the difficulties in introduction.	
11	**What innovative skills (if any) the described above best practice might have developed to enhance students employability?** *Note: Please list skills only we mark the skills.*	Spain Digital Company currently has three aid programs, co-financed by the European Regional Development Fund, aimed at SMEs and the self-employed affected by the COVID-19 crisis. This three aid programs are: • TICCAMARAS • CIBERSECURITY • INDUSTRY 4.0 All of them allow companies to assess the degree of digitalization of each company and how the each specific program can help them in the current context of the crisis derived from COVID-19, in the incorporation of new solutions that allow them to improve their business, increasing the productivity and maximizing their opportunities.
12	**References (pls insert a link to more data on the practice)**	https://empresadigital.camara.es/programas/industria-4-0

2. Best practice for digital transformation and implementation of the Industry 4 concept in Spain		
1	**Best practice name:***	National Plan for Digital Skills
2	**Sector:***	Digital skills (in general)
3	**Organization implementing/disseminating the practice:***	Ministry for Economic Affairs and Digital Transformation Ministry of Education and Vocational Training Spain
4	**The goal:* (up to 100 words)**	The aim of the National Plan for Digital Skills is to provide a roadmap, in order to identify the measures needed (on a national, regional and local level) to ensure that all citizens have access to relevant resources so they can acquire and develop digital

		skills. The National Plan for Digital Skills of Spain was launched by the President of the Government of Spain, Pedro Sánchez in 2021 together with 2 other National Digitalisation plans: the Digitalisation of SMEs Plan 2021-2025 and the Digitalisation of the Public Authorities Plan. The different digitalisation strategic plans are launched within the context of the Digital Spain Agenda 2025.
5	**Description / Focus:***	The National Plan for Digital Skills - Spain addresses a variety of challenges related to digital inclusion, access to technology, and lifelong learning for all. It aims to address these by: • Ensuring no Spanish citizen is left behind and promoting inclusion in the digital world. • Bridging the gender digital divide, through actions aimed at increasing the number of women studying, graduating and working in the information and communication technology (ICT) field. • Supporting the acquisition of adequate digital skills for education, among teachers and students, and at all levels of the education system. • Fostering the development of more advanced digital skills amongst the working population. Ensuring that Spanish companies in general, and specifically small and medium sized enterprises (SMEs), have sufficient digital skills and access to a skilled talent pool of qualified workforce, in order to manage the impact of the digital transformation. The Plan sets out seven lines of action and sixteen measures, aimed at improving digital skills in seven different areas. The focus areas operate within the framework of the 4 pillars set forward by the Digital Skills and Jobs Coalition: digital skills for all citizens, digital skills in education, digital skills for the labour force, and digital skills for ICT professionals and other digital experts.
6	**Target groups:***	• Digital skills for the labour force. • Digital skills for ICT professionals and other digital experts. • Digital skills in education. • Digital skills for all
7	**Dissemination / implementation method:** *Note: If needed.*	The Ministries responsible for different digital skills thematic segmentations and various target groups will supervise the implementation of the projects and measures put forward in the Plan. Each responsible Ministry operates within the framework of its sectoral arrangements with the Autonomous Communities - via

		agreements and other instruments of public-private collaboration.
8	**Results / impact with a focus on:** **1. sector** **2. individuals, like students or employees** *Note: If needed, if we have results we can write.*	No results yet
9	**Sustainability:** *Note: If needed, if we have results we can write.*	The total budget for the Spanish Digital Skills Plan is €3,75 billion, including €3,59 billion from the Spanish Reconstruction, Transformation and Resilience Plan.
10	**What were the obstacles?** *Note: If needed, if we have results we can write. What were the difficulties in introduction.*	Risk of increasing the digital divide by segmenting by socioeconomic level. Non-formal education increases its offer faster than formal education, offering more opportunities to students from higher income families. Risk that the digital training of Spanish students may be deficient compared to other European countries, which may hinder their integration into the labor market and the competitiveness and modernization of the Spanish market.
11	**What innovative skills (if any) the described above best practice might have developed to enhance students employability?** *Note: Please list skills only we mark the skills.*	Specialized digital competences are defined in Article 2(f) of the Regulation of the European Parliament and of the Council establishing the Digital Europe program for the period 2021-2027 as "the competences and skills needed to design, develop, manage, deploy and maintain the technologies funded under this regulation. • "advanced digital skills" means the professional skills and competencies that require the knowledge and experience to understand, design, develop, develop, manage, test, deploy, use and maintain the experience necessary to understand, design, develop, manage, manage, test, deploy, use and maintain the technologies, products and services supported by the technologies, products and services supported by the Program referred to in Article 7; https://www.boe.es/doue/2021/166/L00001-00034.pdf
12	**References (pls insert a link to**	https://digital-skills-jobs.europa.eu/en/actions/national-

	more data on the practice)	initiatives/national-strategies/spain-national-plan-digital-skills

3. Best practice for digital transformation and implementation of the Industry 4 concept in Spain		
1	**Best practice name:***	Boost 4.0
2	**Sector:***	Industrial Sector
3	**Organization implementing/disseminating the practice:***	Innovalia Association as leader (+ 52 partners from 16 countries)
4	**The goal:* (up to 100 words)**	The program aims to "democratize access to Big Data for small and medium-sized companies". Boost 4.0, starting 1st January 2018 and with a duration of 3 years, is the biggest European initiative in Big Data for Industry 4.0. With a 20M€ budget and leveraging 100M€ of private investment, Boost 4.0 will lead the construction of the European Industrial Data Space to improve the competitiveness of Industry 4.0 and will guide the European manufacturing industry in the introduction of Big Data in the factory, providing the industrial sector with the necessary tools to obtain the maximum benefit of Big Data.
5	**Description / Focus:***	**3.6.1.1 Global Standards:** Contribution to the international standardization of European Industrial Data Space data models and open interfaces aligned with the European Reference Architectural Model Industry 4.0 (RAMI 4.0) **3.6.1.2 Secure Digital Infrastructures:** Adaptation and extension of cloud and edge digital infrastructures to ensure high performance operation of the

		European Industrial Data Space; i,e, support of high-speed processing and analysis of huge and very heterogeneous industrial data sources. **3.6.1.3 Trusted Big Data Middleware:** Integration of the four main open source European initiatives (Industrial Data Space, FIWARE, Hyperledger, Big Data Europe) to support the development of open connectors and big data middleware with native blockchain support in the European Industrial Data Space. **3.6.1.3.1.1 Digital Manufacturing Platforms:** Open interfaces for the development of big data pipelines for advanced analysis services and data visualization supported by the main digital engineering, simulation, operations and industrial quality control platforms. **3.6.1.3.1.2 Certification:** European certification program of equipment, infrastructures, platforms and big data services for their operation in the European Industrial Data Space.
6	**Target groups:***	The target group of Boost 4.0 are the factories from Automotive, Machine Tool, White Goods and Applications.
7	**Dissemination / implementation method:** *Note: If needed.*	The European Industrial Data Space and Big Data Services: • Deployed and assessed in the factories of the 10 main European manufacturing leaders. • Evaluated in 3 strategic economic sectors (automotive, manufacturing equipment and household appliances). • Adopted by 3 factories in traditional and highly regulated manufacturing sectors (textile, ceramics, aero).
8	**Results / impact with a focus on:** **1. sector** **2. individuals, like students or employees** *Note: If needed, if we have results we can write.*	The project was developed with **11 pilot factories**, where 10 were lighthouse Factories (Volvo, Philips, +GF+, Volkswagen, Whirpool, etc.) It implies **6 digital Infrastructures**: Connectivity, fog/edge, data-center, HPC and cloud.

		There are **9 digital Manufacturing platforms** involved: Engineering, planning, operations, quality control, analytics, maintenance and cybersecurity. And there are **4 open initiatives**: Open Big Data Pipelines, Data Sovereignty, Context Information Brokering, Distributed Data Traceability.
9	**Sustainability:** *Note: If needed, if we have results we can write.*	Private investment: 100 M€ Funding: 20 M€
10	**What were the obstacles?** *Note: If needed, if we have results we can write. What were the difficulties in introduction.*	
11	**What innovative skills (if any) the described above best practice might have developed to enhance students employability?** *Note: Please list skills only we mark the skills.*	Only in the final conference, • Attendees learnt how digital technologies in general but big data in particular can be adopted and integrated by industry. • Moreover, factories learnt how platforms and ecosystems will be shaped by digital industries to determine future individual business opportunities, collaboration patterns across industry and the resilience of manufacturing value chains. • Manufacturing industry learnt how next digital datadriven factory innovation will be unfolding. This conference was centered in three pillars: 1. Public Policies for Industry 4.0 data-driven Digital Transformation 2. Data-driven Industrial Big Data Large Scale Piloting 3. Replication, Scale-up & Ecosystem development
12	**References (pls insert a link to more data on the practice)**	https://boost40.eu/

4 CONCLUSION AND RECOMMENDATIONS

Knowledge from previous revolutions is that companies that failed to advance in established trends and that failed to hire and retrain employees for emerging technologies began to fall behind the competition and many ended their activities. This is much more true for Industry 4.

Success in Industry 4.0 starts at university, where students must learn to be prepared for the ever-changing technological challenges they will face after graduation.

With the ever-changing environment of Industry 4.0, students will need to see learning as a lifelong endeavor that does not end at school. In order to be active participants in Industry 4.0, students will have to constantly update their skills and knowledge and develop and improve themselves. This is the mindset that every university should instill in its students, preparing them to take more responsibility for their own education.

Values such as diligence, discipline and humility combine to shape individuals who will actively seek to improve themselves in pursuit of knowledge. This is crucial because many roles in Industry 4.0 are still unfamiliar and require adaptable individuals.

Educational institutions must adapt to the rapidly evolving work environment and ensure that students have the theoretical and practical knowledge to meet the demands of a demanding workforce. Schools need to do more than just recognize that times are changing fast: their role is to educate the future workforce so they have the technical skills to adapt and succeed.

The key factors of Industry 4.0 are innovation, critical thinking, creative problem solving, observation of meaningful associations and a unique vision. Thoughts with big ideas and the will to implement them will be the most valuable asset.

The digital skills acquired in school and in real-world projects must become the key to landing your dream job. When students leave their universities, a good knowledge of Industry 4.0 technologies and the ability to work in the digital world will lead them to greater job prospects and the ability to get ahead.

Recognizing students' lack of technical skills, companies are working with colleges and universities to help prepare the next generation of workers for Industry 4.0. Technology is developing at lightning speed and universities must keep up. To succeed in this environment, students must learn more than just theory and classroom tools: they must learn how to apply technology to solve problems.

New industries and sectors need theoretical and practical-minded graduates who are well-versed in sensor connectivity, machine and production process data, data and applications of new solutions.

The new industrial revolution has an impact on the labor market. Employees are required to have higher qualifications, especially in engineering and information technology. A personality profiling curriculum must be interdisciplinary and teach students how to develop the skills necessary to become capable and competent employees in their respective professional positions.

Many job positions are changing or disappearing and many new job positions are being created, and this calls for changes in almost all educational programs. In general, every student must already be prepared to work with digital technologies, and vocational school students must already acquire knowledge of the basic technological pillars of Industry 4. With higher requirements for qualifications, the demands for the so-called soft skills. These soft skills are becoming increasingly important, as new employees will already be forced to solve new production problems and independently decide on next steps.

"Worker 4" is the new term for an employee who will have these new required skills. Based on this, the table below shows the required skills of employees for Smart Factory. These skills should be taken into account when developing new study programs.

Hard skills	Soft Skills
Language knowledge	Communication skills
Degrees, apprenticeships, certificates with technical or information focus	Flexibility
Machine operation	Self-discipline
Programming language	People Management
Software knowledge	Time Management
Cybersecurity knowledge	Emotional Intelligence
Knowledge of Data Analysis	Critical Thinking
Cloud Computing	Creativity
Knowledge of Artificial Intelligence	Coordination with others
Knowledge of Processes	Complex Problem Solving

The following jobs with required soft and hard skills will be needed for the intelligent factory, (A.Benesova, M. Hirman, F. Steiner, J. Tupa: Requirements for Education 4.0 and Study Programs within Industry 4.0, Industrial Engineering and Operations Management, 2019):

1. For information technology professions

Informatics Specialist

Hard skills: Language skills - English, German, etc.; Analytical/Logic thinking; Advanced knowledge of large domain and network management; Basic knowledge of working with databases, virtualization and cloud services

Soft skills: Autonomy; Responsibilities; Creativity; Flexibility, Communication skills; Reliability People Management; Time Management; Problem solving.

Robot Programmer

Hard skills: Language skills - English, German, etc.; Analytical/Logic thinking; Knowledge of the simulated process; Knowledge of off-line and on-line robot programming; Experience with basic robot parameterization and calibration

Soft skills: Responsibility; Flexibility; Creativity; Communicativeness Reliability; Problem solving; Cooperation with others

Software Engineer

Hard skills: Language skills - English, German etc. ; "Knowledge of C/C++ programming; Knowledge of C # / .NET"; Basic knowledge of working with databases (SQL)

Soft skills: Autonomy; Creativity; Flexibility; Problem solving; Cooperation with others

Data Analyst

Hard skills: Language skills - English, German, etc.; Analytical/Logic thinking; Knowledge of working with a spreadsheet (Excel); Basic knowledge statistically; PL / SQL – advanced; UML - advanced Soft skills: Autonomy; Creativity; Flexibility; Problem solving; Cooperation with others; Time Management;

Cybersecurity

Hard skills: Language skills – English, German etc; Analytical/Logic thinking; Knowledge of security standards and communication standards; Knowledge of servers (level - administrator)

Soft skills: Autonomy; Responsibilities; Creativity; Cooperation with others; Ability and willingness to learn new things; People Management;

2. For manufacturing professions

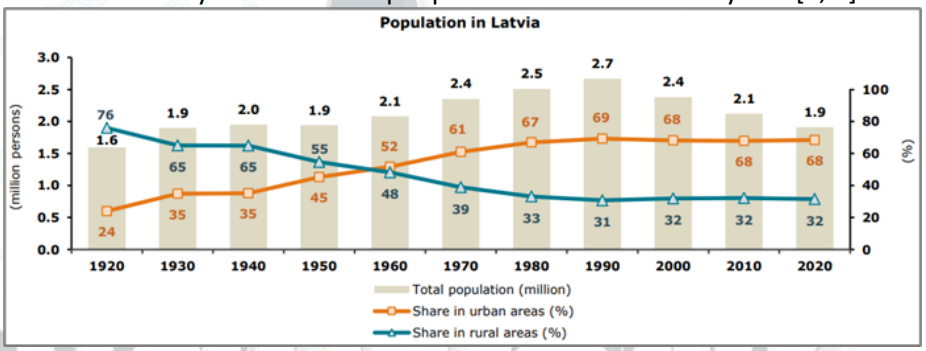
Electronics Technician:
Hard skills: Knowledge of maintenance of new machines; Knowledge of service of the pressure cylinders; Knowledge of performing service inspections; Analytical/ Logical thinking;
Soft skills: Manual skills; Flexibility; Autonomy; Responsibilities; Creativity; Complex Problem Solving;
Automation Technician:
Hard skills: Knowledge of safety standards, Language skills - English, German, etc.; Analytical/ Logical thinking;
Soft skills: Manual skills; Flexibility; Autonomy; Responsibilities; Creativity; Complex Problem Solving;
Production Engineer:
Hard skills: Language skills - English, German, etc.; Analytical/ Logical thinking;
Soft skills: Flexibility; Creativity; Complex Problem Solving; Creativity; Autonomy; Responsibilities; People Management; Time Management; Cooperation with others; Ability and willingness to learn new things;
Manufacturing Engineer:
Hardware skills: Technical skills; Language skills - English, German etc. Knowledge of technical documentation; Analytical/ Logical thinking;
Soft skills: Flexibility; Complex Problem Solving; Autonomy; Responsibilities; Creativity; Cooperation with others; Communication skills; People Management; Time Management;

5 APPENDICES

5.1 Appendix 1: Statistics and economic indicators on digitalisation and digital skills

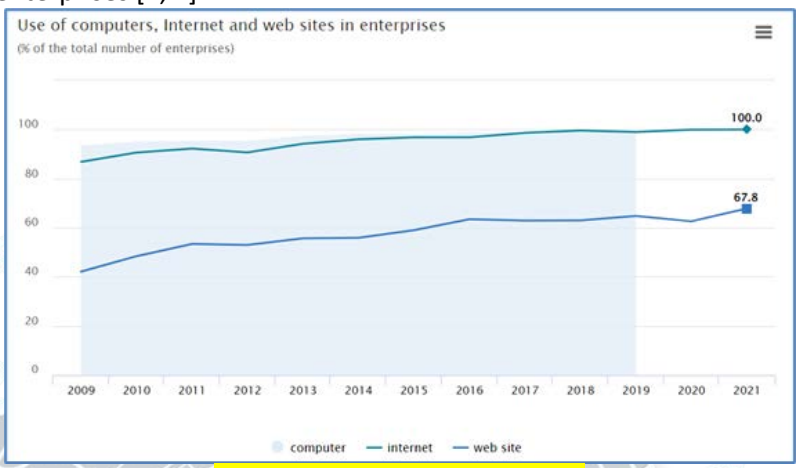
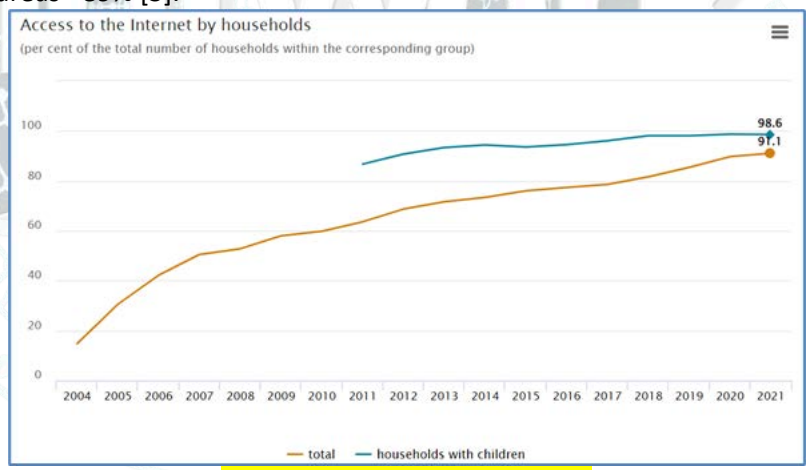
Geography and population

Title of the indicator:	**Geographical characteristics of Latvia and population**

Value:	The territory of Latvia comprises 64.6 thousand km^2, of which 62.2 thousand km^2 or 96 % is the territory of land, but 2.4 thousand km^2 or 4 % is the territory of inland waters. Protected natural areas take up 7.8 thousand km^2 or 12.1 % of the territory. Latvia has a land border with Estonia (343 km), Russia (2784 km), Belarus (173 km) and Lithuania (587 km) with a total length of 1387 km and a maritime border with a total length of 513 km [1]. Latvia is the fifth smallest country in the European Union. At the beginning of 2021, there were 1 million 894 thousand residents in Latvia, which is 13.9 thousand less than in the previous year. The majority (68%) of the Latvian population live in cities, almost half of this in Riga, while the rest (32%) are rural residents. The population of Latvia has been decreasing; since 1990, it has decreased by 760 thousand people or 29% in the last 30 years [1, 2].  (the figure is adopted from [1])
References:	1. https://admin.stat.gov.lv/system/files/publication/2021-05/Nr_03_Latvia_Statsitcs_in_Briefi_2021_%2821_00%29_EN.pdf 2. https://stat.gov.lv/en/statistics-themes/population/population-number/247-population-number-its-changes-and-density?themeCode=IR

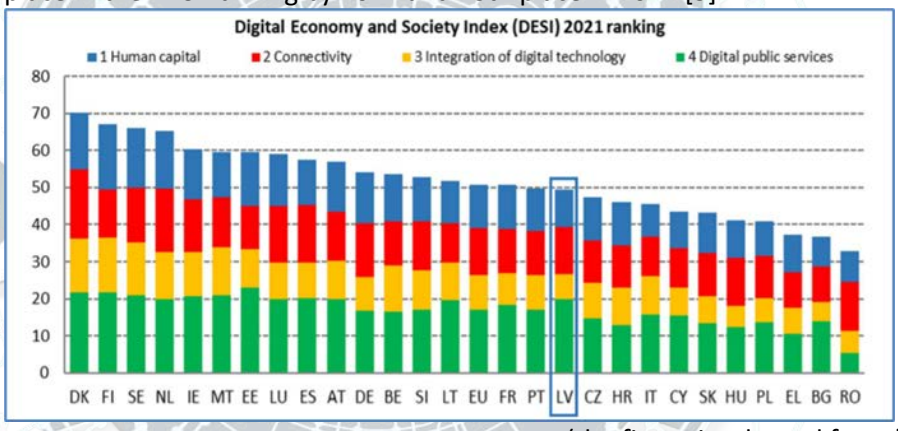
Internet access

Title of the indicator:	**Access to the Internet in enterprises and households in Latvia**

Value:	In 2021, 100% of enterprises had access to the Internet. The access has increased by 1% compared to the situation before the Covid-19 pandemic. At the beginning of 2021, 67.8 % of enterprises had their websites, of which 95.5% were large enterprises, 87.3% were medium-sized enterprises and 63.5% - small enterprises [1, 2].  (the figure is adopted from [1]) In 2021, 91.1% of households had access to the Internet (an increase of 5.6% since 2019). At least 98.6% of households with children had access to the Internet [1, 2]. In the urban regions, access to the Internet is up to 92%, but in rural areas - 89% [3].  (the figure is adopted from [1]) The digital divide is still present despite investments in middle-mile connections in rural regions. The rural regions still have the unused potential for broadband optical internet access, providing a reliable and fast digital infrastructure for businesses and remote working opportunities [4, 5].

References:	1. https://admin.stat.gov.lv/system/files/publication/2021-05/Nr_03_Latvia_Statsitcs_in_Briefi_2021_%2821_00%29_EN.pdf 2. https://stat.gov.lv/en/statistics-themes/information-technologies/computers-and-internet 3. https://www.itu.int/en/ITU-D/Statistics/Documents/DDD/ddd_LVA.pdf 4. https://ec.europa.eu/newsroom/dae/redirection/document/80482 5. https://www.em.gov.lv/lv/media/12820/download

Digitalisation

Title of the indicator:	**Digitalisation level in Latvia**
Value:	Regarding digitalisation, the Digital Economy and Society Index (DESI) report ranks Latvia in 17th place with a score of 49.5 across all EU member states in 2021. This score is below the EU average – 50.7 [1, 2]. According to the National Development Plan of Latvia for 2021-2027, the goal is to reach 15th place in the DESI ranking by 2024 and 13th place in 2027 [3].  (the figure is adopted from [1]) Currently, progress has been made in terms of connectivity (relatively high coverage and deployment of high-speed broadband networks) and digital public services (launch of the Latvian Open Data Portal, as well as a life-cycle approach to public service delivery) [4]. Latvia performs well in the provision of digital public services. The number of e-government users continues to increase, and the provision of online public services has further improved [2]. Latvia is a front-runner in broadband coverage and take-up and is well prepared for the introduction of 5G. The country's main strengths are the highly advanced coverage of fast broadband (93% against the EU average of 87%) and the fact that 39% of households subscribe to at least 100 Mbps broadband, compared to the EU average of 34% [2]. More and more people also use internet banking and e-government services, but half of them do not have digital skills, or their level is low [4]. While many indicators show a positive tendency, like job applicants' growing rates of using the Internet for job search or the growing share of enterprises making sales online, other indicators show a grimmer picture as the share of hired ICT specialists has decreased significantly in the past years [5]. Several reasons can be identified.

	Industry stakeholders have recognised that the key obstacle and challenge related to the take-up of digital technologies is a severe lack of qualified personnel [5]. Latvia's competitiveness is also significantly weakened by institutional shortcomings (regulatory shortcomings, inefficient bureaucracy, and others), insufficient quality of infrastructure, low innovation performance, and insufficient business development and quality [6]. Competitiveness is still largely based on relatively low labour costs, to a lesser extent on technological innovations [6]. Promoting innovation can help Latvian enterprises to improve their productivity, which is currently at a low level. This aspect could foster growth despite a shrinking population and increase salaries, which can help retain employees. In particular, digital innovations can overcome distance problems and help Latvia increase its exports [7]. The government, together with enterprises and the public, must take targeted measures to implement digital transformation measures, ensuring access to digital infrastructure that will strengthen the development of digital solutions in all sectors of the economy [6]. The government might be able to increase digitisation by making some digital aspects mandatory to guide the industry towards more significant investment in digitisation and personnel education [5].
References:	1. European Commission, "Questions and Answers: Digital Economy and Society Index (DESI) 2021," Nov. 12, 2021. [Online]. Available: https://ec.europa.eu/commission/presscorner/detail/en/QANDA_21_5483 [Accessed: Mar. 5, 2022]. 2. https://ec.europa.eu/newsroom/dae/redirection/document/80482 3. https://komitejas.esfondi.lv/anm_rrf/Plnoanas%20dokumenti%20ANMRRF/Tematisk%C4%81s%20diskusijas/2021_gads/08.03.2021_tematiskas_diskusijas_(ANM_DP21-27_1_Digitalizacija)/3_EM_Digitalizacija_08032021.pdf 4. https://www.em.gov.lv/lv/media/12820/download 5. https://ec.europa.eu/information_society/newsroom/image/document/2019-32/country_report_-_latvia_-_final_2019_0D30BE44-054B-C822-C8DEFA25536D65B0_61211.pdf 6. Ministru kabinets, "Par Nacionālās industriālās politikas pamatnostādnēm 2021.–2027. gadam," Feb. 16, 2021. [Online]. Available: https://likumi.lv/ta/id/321037 [Accessed: Mar. 7, 2022]. 7. https://www.oecd-ilibrary.org/science-and-technology/digitalizacija-latvija_a58d1c1a-lv

Digital skills

Title of the indicator:	**Digital skills in Latvia**
Value:	According to DESI 2021, Latvia ranks 20th among the 27 EU countries for *Human capital*, below the EU average. Human capital is the DESI dimension characterised by the level of Internet user skills and advanced digital skills, as well as by the number of ICT specialists [1]. In Latvia, basic

digital and advanced digital skills levels were much lower than the EU average: only 43% of the Latvian population had basic digital skills compared to 56% in the EU. One of the causes might have been the ageing population. However, even young people aged 16 to 24 lacked digital skills compared to the EU [1]. Moreover, the gap between Latvia and other EU countries is even more comprehensive regarding advanced or "above basic" digital skills. In Latvia, only 24% of the population possess above basic digital skills compared to the EU average level (31%) [1]. Latvia is also among those four countries, together with Romania, Greece, and Croatia, that suffer from a loss of talents with skills in advanced technologies since they primarily emigrate to the United Kingdom and Germany [2].

	Latvia			EU
	DESI 2019	DESI 2020	DESI 2021	DESI 2021
1a1 At least basic digital skills % individuals	48% 2017	43% 2019	43% 2019	56% 2019
1a2 Above basic digital skills % individuals	27% 2017	24% 2019	24% 2019	31% 2019
1a3 At least basic software skills % individuals	49% 2017	44% 2019	44% 2019	58% 2019
1b1 ICT specialists % individuals in employment aged 15-74	2.6% 2018	3.1% 2019	3.7% 2020	4.3% 2020
1b2 Female ICT specialists % ICT specialists	19% 2018	24% 2019	23% 2020	19% 2020
1b3 Enterprises providing ICT training % enterprises	11% 2018	18% 2019	17% 2020	20% 2020
1b4 ICT graduates % graduates	5.0% 2017	4.7% 2018	4.4% 2019	3.9% 2019

(the figure is adopted from [1])

Latvia's performance is above average regarding ICT graduates (4.7% against 3.8%) and female ICT specialists (23%, against 19% at the EU level). Latvia is also reducing the gap for ICT specialists, representing 3.7% of total employment versus the EU average of 4.3% [1]. However, the shortage of digital skills is a crucial obstacle to the more widespread use of digital solutions by the private sector; almost half of the Latvian companies (56%) that tried to fill vacancies for digital specialists encountered difficulties [1].

Improving the population's digital skills is a precondition for creating and ensuring an environment conducive to digitalisation, improving business productivity and promoting Latvia's progress and investment in new digital technologies [3, 4].

It is necessary to strengthen the cooperation between universities and industry to improve the content of study programs and align it with the development needs of the industry, especially by promoting the acquisition of competencies necessary for industry 4.0 [5]. With the digitalisation of different sectors and the emergence of new technologies and knowledge, the higher education sector should be more flexible in transferring this new knowledge and skills to the population, i.e., those in the labour market or entrepreneurs who already have one or more higher education but do not possess knowledge on the latest trends [5].

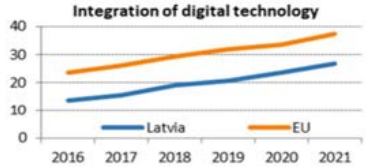
Currently, the Latvian government has identified the development of digital skills at all levels as a national priority [1]. In general, the rise of digital skills for various society groups (by age and education levels) has

	been included in several national development plans, e.g., National Development Plan 2021–2027 [6], Guidelines for Digital Transformation 2021–2027 [7] and National Industrial Policy Guidelines 2021–2027 [8]. In addition, other sectoral policies address the development of digital skills, such as the Implementation Plan on an Adult Education Governance Model, which is in force until 2023 and has also created the Adult Education Governance Board. Furthermore, since 2020, the Training Commission of the Ministry of Welfare has outlined broader 'Digital skills' among the priority fields for the courses organised by the State Employment Agency [1].
References:	1. https://ec.europa.eu/newsroom/dae/redirection/document/80482 2. https://ati.ec.europa.eu/reports/policy-briefs/meeting-sectoral-skills-challenge-advanced-technologies 3. https://www.em.gov.lv/lv/media/12820/download 4. OECD, Going Digital in Latvia. OECD Publishing, Paris, 2021. 5. https://www.izm.gov.lv/sites/izm/files/iap2027_projekta_versija_apspriesana_160720201_2.pdf 6. Saeima, "National Development Plan of Latvia for 2021-2027," Jul. 2, 2020. [Online]. Available: https://www.pkc.gov.lv/sites/default/files/inline-files/NAP2027_ENG.pdf [Accessed: Mar. 8, 2022]. 7. Ministru kabinets, "Par Digitālās transformācijas pamatnostādnēm 2021.–2027. gadam," Jul. 7, 2021. [Online]. Available: https://likumi.lv/ta/id/324715 [Accessed: Mar. 8, 2022]. 8. Ministru kabinets, "Par Nacionālās industriālās politikas pamatnostādnēm 2021.–2027. gadam," Feb. 16, 2021. [Online]. Available: https://likumi.lv/ta/id/321037 [Accessed: Mar. 8, 2022].

Advanced technologies in enterprises

Title of the indicator:	**Advanced technologies used in Latvian enterprises**
Value:	Latvian businesses can take more significant advantage of the opportunities offered by digital technologies. According to the DESI 2021, the country ranks 23rd for *integrating digital technology* by business, which is still well below the EU average in almost all categories. Integration of digital technology is the DESI dimension characterised by companies' ability to use digital technologies such as cloud services, big data, artificial intelligence and the spread of e-commerce [1].

3 Integration of digital technology	Latvia		EU
	rank	score	score
DESI 2021	23	26.8	37.6



(the figure is adopted from [1])

Latvian companies are adopting different technologies to enhance productivity in digital transformation, such as sharing internal information electronically or using RFID, e-Invoicing, social media and cloud technologies

[2]. The share of SMEs with at least a basic level of digital intensity is 42%, while the EU average is 60%. Even though Latvian companies have increased their use of cloud services, the use of big data is progressing slowly. The share of companies using cloud services is 18%, a notable increase from 11% last year. However, only 9% of enterprises use big data, and only 19% have activities on social media, which is below the EU average. Regarding e-commerce, only 11% of SMEs sell online, and only 7% of SMEs' turnover is from e-commerce [1]. According to data by the Central Statistical Bureau of Latvia, in 2020, 24.3% of all enterprises used the Internet of Things (IoT). IoT was used by every second by 52.6% of large enterprises, 38.1% of medium-sized and 20.7% of small enterprises. IoT was mostly used in electricity, gas, steam and air conditioning supply, water supply, sewerage, waste management and remediation activities (for 47.3% of enterprises) [3].

	Latvia			EU
	DESI 2019	DESI 2020	DESI 2021	DESI 2021
3a1 SMEs with at least a basic level of digital intensity % SMEs	NA	NA	42% 2020	60% 2020
3b1 Electronic information sharing % enterprises	25% 2017	32% 2019	32% 2019	36% 2019
3b2 Social media % enterprises	13% 2017	19% 2019	19% 2019	23% 2019
3b3 Big data % enterprises	8% 2018	8% 2018	9% 2020	14% 2020
3b4 Cloud % enterprises	11% 2018	11% 2018	18% 2020	26% 2020
3b5 AI % enterprises	NA	NA	21% 2020	25% 2020
3b6 ICT for environmental sustainability % enterprises having medium/high intensity of green action through ICT	NA	NA	65% 2021	66% 2021
3b7 e-Invoices % enterprises	7% 2018	7% 2018	15% 2020	32% 2020
3c1 SMEs selling online % SMEs	10% 2018	11% 2019	11% 2020	17% 2020
3c2 e-Commerce turnover % SME turnover	5% 2018	5% 2019	7% 2020	12% 2020
3c3 Selling online cross-border % SMEs	5% 2017	7% 2019	7% 2019	8% 2019

(the figure is adopted from [1])

According to the National Industrial Policy Guidelines 2021-2027, it is planned to reach 21st place by 2023 and 20th place by 2027 in the DESI dimension for integrating digital technology by business [4].

The Covid-19 crisis has accelerated the digitalisation of the economy and the automation of companies, so the new jobs and skills may be different from what it was before the crisis; however, it is also an opportunity to create and find new solutions for business development, creating innovative products. Latvia has improved in some categories but still performs below the EU average in all of them [4, 6]. In general, digital technologies are used more by large companies. The use of digital technologies has a direct relationship with the amount of added value. Employee productivity and salaries are also higher in more digitalised companies [5]. Considering the EC and Europe-wide guidelines, Latvia pays special attention to integrating new technological solutions into Latvian manufacturing companies. Latvia intensifies its focus on updating digitisation activities by providing manufacturing companies with the

	opportunity to work with smart technology developers, mainly companies in the ICT industry, to collaborate on implementing new technologies and improving existing ones awarding the latest available technology and data processing capabilities [7]. In general, the integration of digital technologies is mainly hampered by a lack of investment in R&D, a lack of digitally skilled employees and insufficient connectivity in rural areas [4, 8]. Latvia also has a high level of non-compliance with formalities, which can hinder the introduction of digital technologies. Failure to comply with formalities may hamper digitalisation because, unofficially, companies may want to stay small to avoid disclosure, but declaring reduced income may discourage banks from lending money. [6]. Almost half of the Latvian companies indicate that funding is a barrier to investment that can be a barrier to innovation [6]. There is a lack of targeted funding in ICT and other sectors to develop innovative ICT solutions based on the needs of companies. Also, cross-sectoral cooperation is too weak to generate ICT innovation throughout the product value chain. Adequate funding for innovative ICT solutions (big data processing, digitisation, 3D printing, artificial intelligence, visualisation, sensors, cloud computing, future plants, robotics, and others) is essential in this regard [9]. In order to promote digital transformation, Latvia should develop a strategy for the digitisation of SMEs, focusing on creating the conditions for SMEs to adopt digital technologies and invest in additional knowledge-based assets and digital security [6].
References:	1. https://ec.europa.eu/newsroom/dae/redirection/document/80482 2. https://ati.ec.europa.eu/reports/policy-briefs/latvia-national-industrial-policy-guidelines-2014-2020 3. https://admin.stat.gov.lv/system/files/publication/2021-05/Nr_03_Latvia_Statsitcs_in_Briefi_2021_%2821_00%29_EN.pdf 4. Ministru kabinets, "Par Nacionālās industriālās politikas pamatnostādnēm 2021.–2027. gadam," Feb. 16, 2021. [Online]. Available: https://likumi.lv/ta/id/321037 [Accessed: Mar. 8, 2022]. 5. https://likumi.lv/ta/id/321834-par-finansu-sektora-attistibas-planu-20212023-gadam 6. OECD, Going Digital in Latvia. OECD Publishing, Paris, 2021. 7. https://ec.europa.eu/information_society/newsroom/image/document/2019-32/country_report_-_latvia_-_final_2019_0D30BE44-054B-C822-C8DEFA25536D65B0_61211.pdf 8. https://www.em.gov.lv/lv/media/12820/download 9. https://likumi.lv/ta/id/322858-par-latvijas-atveselosanas-un-noturibas-mehanisma-planu

5.2 Appendix 2: National strategic planning and regulatory documents

Policy documents for the planning period 2021-2027

National Development Plan of Latvia for 2021-2027

Program name:	National Development Plan of Latvia for 2021-2027
Designed for the sector:	Society as a whole (including citizens and entrepreneurs)
Period:	2021-2027
Aid amount:	Funding differs for each priority and direction. For example, the priority "Business Competitiveness and Material Well-being" has 3,53 billion euros.
Focus on:	NDP2027 contributes to implementing a human-centred, long-term concept approved by the Saeima (Parliament) - "Growth model for Latvia: People first". It outlines sectoral policies and key reforms, public investments from the state budget, local government budget, European Union (EU) funds and other financial sources (including foreign and national funds and programmes). This plan is realistic because ambitious goals are feasible and in line with available resources [1].
Short description: (100-200 words)	The National Development Plan for 2021-2027 (NDP2027) is Latvia's highest national-level medium-term planning document that defines the strategic aims planned to be achieved in Latvia by 2027 [1]. One of the priorities of NDP2027 is "Business Competitiveness and Material Well-being", which includes direction "Productivity, innovation and export" related to Industry 4.0 [1]. The goal of this direction is the growth and competitiveness of companies based on their ability to create and sell high-tech, knowledge-intensive goods and services and to integrate into ever higher value-added global chains. Smart specialisation, innovation, technological development and modernisation, and targeted investment in human capital are the basis for productivity growth [1]. Indicative funding for this direction is 797.78 million EUR. In addition, one of the tasks of this direction is promoting digital transformation (digitisation, automation, robotisation, artificial intelligence, and others) in business [1].
References:	1. Saeima, "National Development Plan of Latvia for 2021-2027," Jul. 2, 2020. [Online]. Available: https://www.pkc.gov.lv/sites/default/files/inline-files/NAP2027__ENG.pdf [Accessed: Mar. 8, 2022].

National Industrial Policy Guidelines 2021-2027

Program name:	National Industrial Policy Guidelines 2021-2027

Designed for the sector:	Public (administrative institutions), private (companies) and academic (HEIs) sectors
Period:	2021-2027
Aid amount:	The financing of the activities set up in the National Industrial Policy Guidelines (NIP) is ensured by both the public and private sectors despite initial hesitation from the private sector to invest [1]. For the digitalisation priority, 179 million euros are allocated [2].
Other indicators:	The NIP guidelines aim to increase exports to € 22 billion in 2023 and € 27 billion in 2027. In addition, the sub-objective of the NIP is to increase spending on R&D activities to EUR 300 million in 2023 and EUR 600 million in 2027 [1].
Focus on:	The NIP guidelines are a medium-term policy planning document that covers all sectors of the economy and sets out goals and directions for growth for the next seven years, both locally and internationally [1]. These guidelines offer a clear vision for reallocating public resources in favour of more productive growth of future sectors, industries and ideas [3].
Short description: (100-200 words)	NIP guidelines highlight the national approach to the transformation of the economy into an innovative and knowledge-based economic model, using the development of Smart specialisation strategy (RIS3) value chain ecosystems. It will be based on structured dialogue and coordinated action between all stakeholders (a network of private, public and academic cooperation partners), thereby promoting the development of new products and services, knowledge transfer in the national economy and increasing private investment in research and development [3]. Promoting digital transformation (digitisation, automation, robotisation, artificial intelligence, and others) in business, including the manufacturing industry, is also one of the main challenges in the NIP guidelines [1]. In terms of Industry 4.0, one of the directions of this plan is "Infrastructure", which includes several tasks, e.g., Support for the introduction of digital solutions, automation, modernisation, new decarbonisation technologies, investment programs for the automation of production processes. Another direction, "Innovations", focuses on new products, technologies, and digital transformation. This direction includes tasks related to the financial support and promotion of digital transformation and deploying technology-intensive solutions, including artificial intelligence solutions, in the private and public sectors. This direction also involves closer cooperation between research and industry to develop infrastructure and ensure accessibility [1].
References:	1. Ministru kabinets, "Par Nacionālās industriālās politikas pamatnostādnēm 2021.–2027. gadam," Feb. 16, 2021. [Online]. Available: https://likumi.lv/ta/id/321037 [Accessed: Mar. 7, 2022]. 2. https://lddk.lv/wp-

	content/uploads/2021/04/Ropazi21042021_compressed.pdf [Accessed: Apr. 11, 2022]. 3. https://www.em.gov.lv/en/media/4499/download

Digital Transformation Guidelines for 2021-2027

Program name:	Digital Transformation Guidelines for 2021-2027
Designed for the sector:	The guidelines set out a common policy for the digital development of public administration, the economy and society [1].
Period:	2021-2027
Aid amount:	The implementation of the guidelines will take place mainly by attracting EU funds and private financing, as well as financing from the state budget. The overall funding is 951 million euros [1].
Focus on:	The Guidelines are a medium-term policy planning document that sets out Latvia's digital transformation (information society development) policy, covering the period from 2021 to 2027 [1]. The Digital Transformation Guidelines aim to develop unified digital solutions and introduce new efficient, publicly available services and infrastructures in line with the goals of the global information society and the evolution of the EU's digital single market [2].
Short description: (100-200 words)	The guidelines expand the digital transformation policy's goals, directions and tasks approved in the National Development Plan 2021–2027 [3]. The digital transformation strategy for the country's digital transformation defined in the Latvian Digital Transformation Guidelines 2021-2027 covers ICT education and skills, internet access, modern and efficient public administration, e-services and digital content for society [4]. The guidelines define the development of digital skills for society, from basic skills to day-to-day communication to the skills needed for deploying digital technologies in manufacturing, services, innovation and commercialisation [5]. Overall, the guidelines provide for action in five directions and cover all key aspects of the digital societal breakthrough [6]: ● Digital skills and education ● Digital security and credibility ● Access to telecommunications services ● Digital transformation of the economy (incl., "public administration") ● Information communication technology (ICT) innovation development, and commercialisation, industry and science.
References:	1. Ministru kabinets, "Par Digitālās transformācijas pamatnostādnēm 2021.–2027. gadam," Jul. 7, 2021. [Online]. Available: https://likumi.lv/ta/id/324715 [Accessed: Mar. 8, 2022]. 2. Ministru kabinets, "Par Nacionālās industriālās politikas pamatnostādnēm

	2021.–2027. gadam," Feb. 16, 2021. [Online]. Available: https://likumi.lv/ta/id/321037 [Accessed: Mar. 7, 2022]. 3. https://lvportals.lv/norises/321428-cela-karte-latvijas-digitalajai-transformacijai-2020 4. https://ec.europa.eu/newsroom/dae/redirection/document/80482 5. https://www.varam.gov.lv/en/article/latvian-digital-transformation-guidelines-2021-2027-accellation-digital-capacities-future-society-and-economy 6. https://unctad.org/system/files/information-document/CSTD2021-2022_Issues01_Industry4.0_en.pdf

Guidelines for Science, Technology Development and Innovation 2021-2027

Program name:	Guidelines for Science, Technology Development and Innovation 2021-2027
Designed for the sector:	HEIs, scientific institutions, enterprises, state and local governments
Period:	2021-2027
Aid amount:	Total financial support - 1.14 billion euros [1]
Other indicators:	Main results to be achieved by 2027 [2]: ● Investment in research has increased to 1.5 % of gross domestic product (currently 0.64 %). ● At least 1% of employment in Latvia is in science (currently 0.67%). ● Latvia's position on the European Innovation Scoreboard has risen from 24th to 22nd. ● The contribution of companies to state scientific institutions has reached 10% (currently 6%).
Focus on:	Guidelines emphasise the need to invest fully in the human capital of research, scientific excellence, international cooperation, and technology transfer, contributing to developing a smart, technologically advanced, and innovative society in Latvia [2].
Short description: (100-200 words)	The guidelines set out the main principles, objectives, priorities, action directions, and tasks to be carried out according to the Latvian National Development Plan 2021-2027 supporting the priority "Knowledge and skills for personal and national growth" [1, 2]. The guidelines are based on a detailed analysis of the current situation, global trends, and opportunities for developing the research and development system. Their content is based on two monitoring reports of the Smart Specialisation Strategy of Latvia and two studies of the Policy Support Facility of the European Commission, as well as other national and international studies [1, 2]. Guidelines determine the strategic goals to be

	achieved in Latvia by 2027, outline the directions of action and main reforms of the science and technology development policy, as well as the directions of public investment from the state budget, EU funds and other financial sources for investment in the development of the R&D system [1].
References:	1. https://likumi.lv/ta/id/322468-par-zinatnes-tehnologijas-attistibas-un-inovacijas-pamatnostadnem-2021-2027-gadam 2. https://labsoflatvia.com/en/news/directions-for-science-technology-and-innovation-development-and-support-established-for-following-years

Research and Innovation strategy for Smart specialisation of Latvia

Program name:	Research and Innovation strategy for Smart specialisation of Latvia
Designed for the sector:	Private, public and academic sectors
Period:	2021-2027
Focus on:	Latvia's Smart Specialization Strategy (RIS3) is a strategy of economic transformation towards higher added value, productivity and more efficient use of resources. The strategy of economic transformation ensures changes and growth in the structure of production and exports of traditional industries, as well as promotes the development and growth of existing and new high-value-added products and services sectors [1].
Short description: (100-200 words)	The smart specialisation strategy (RIS3) for Latvia was developed in 2014 to concentrate public R&D investment in programs that create future domestic capability and interregional comparative advantage [1]. This conceptually new and complex strategy provides a balanced and complementary support tool kit to strengthen the innovation capacity of the Latvian economy [2]. Furthermore, the strategy aims to restructure export by inducing change and growth in [2]: ● Production and export structure in traditional sectors of the economy. ● Future growth of sectors in which exist or may be products and services with high added value. ● Sectors with significant horizontal impact and contribution to the transformation of the national economy. The priorities of the Strategy, among others, include facilitation of the production of higher-value-added products, development of new products and industries with high development potential, development of a modern ICT system, development of a modern and future-focused education system, and developed science base [3]. In addition, the strategy has outlined seven investment priorities to induce change and growth and defined five specialisation areas. The investment priorities are [2]: 1. High added value products; 2. Productive Innovation System;

	3. Energy Efficiency; 4. Modern ICT; 5. Modern education; 6. The knowledge base; 7. Polycentric development. The knowledge specialisation areas are Knowledge-intensive bio-economics; Biomedicine, medical technologies; Bio-pharmacy and biotechnologies; Smart materials, technologies and engineering systems; and Information and communication technologies (ICT) [2].
References:	1. Ministru kabinets, "Par Nacionālās industriālās politikas pamatnostādnēm 2021.–2027. gadam," Feb. 16, 2021. [Online]. Available: https://likumi.lv/ta/id/321037 [Accessed: Mar. 7, 2022]. 2. https://www.izm.gov.lv/en/smart-specialisation-strategy 3. https://sciendo.com/pdf/10.2478/eb-2018-0013

Implementation strategy of Platform "Industry 4.0."

Program name:	Implementation strategy of Platform "Industry 4.0."
Designed for the sector:	The platform envisages interaction between the scientific sector, the state and industry.
Period:	From 2019
Aid amount:	According to the government, the Industry 4.0 platform will be formally launched through the Digital Europe Program (2021-2027), which proposes to make available 9.2 billion euros in areas such as supercomputing, artificial intelligence and the creation of a European network of digital innovation centres and strengthening [1].
Focus on:	To promote similar projects and expand them to other sectors, the government, together with several centres of excellence and the AHK-German-Baltic Chamber, has signed a memorandum of cooperation on developing and implementing the Industry 4.0 platform [1, 2].
Short description: (100-200 words)	Platform Industry 4.0 aims, in particular, to strengthen cooperation and coordination between stakeholders by advising Latvian companies on new technologies in the manufacturing sector and developing policies to promote digital technologies [1]. In order to promote digital transformation in Latvian companies, a guide for the development of industrial digitisation in Latvia and a strategy for implementing the Industry 4.0 platform are being developed [3]. The government aims to use Digital Innovation Hubs as a physical platform to implement Industry 4.0. Such centres would act as a single point of contact for companies, in particular SMEs, as well as public sector organisations to access services related to testing, attracting investors, skills and training,

	networking and the innovation ecosystem [1].
References:	1. OECD, Going Digital in Latvia. OECD Publishing, Paris, 2021. 2. https://ec.europa.eu/information_society/newsroom/image/document/2019-32/country_report_-_latvia_-_final_2019_0D30BE44-054B-C822-C8DEFA25536D65B0_61211.pdf 3. https://www.zemeunvalsts.lv/documents/view/35051070e572e47d2c26c241ab88307f/Latvijas%20ekonomisk%C4%81s%20att%C4%ABst%C4%ABbas%20p%C4%81rskats%202019.pdf

Cyber Security Strategy

Program name:	Cyber Security Strategy
Designed for the sector:	Government, including national and municipal administrations, the private sector and individuals
Period:	2019-2022
Aid amount:	The total financing required for the implementation of the strategy is 29.8 million euros [2]
Focus on:	The main digital security policy initiative in Latvia is the Cyber Security Strategy of Latvia (2019-2022), which replaces the Cyber Security Strategy of Latvia (2014-2018). Prepared by the Ministry of Defence in cooperation with other ministries and the National Information Technology Security Council, this document sets out the national priorities for digital security policy in Latvia and identifies upcoming challenges [1].
Short description: (100-200 words)	The first Cyber Security Strategy of Latvia (2014-2018) took stock of the digital transformation and marked a shift towards a more strategic and whole-of-government approach to digital security. The second Cyber Security Strategy of Latvia (2019-2022) continues this trajectory, with a greater emphasis on risk management, resilience, public awareness, and the need to balance digital security with openness, prosperity and human rights [1]. The goal of the cyber security policy for the period 2019 to 2022 is to strengthen and improve digital security capabilities by increasing resilience to cyber attacks and enhancing public awareness of threats in cyberspace [1, 2]. Cyber Security Strategy relies on a "vision of cyber security policy as a secure, open, free and reliable cyberspace that guarantees the safe, reliable and continuous receipt and delivery of services essential to the state and society, and respects the individual's human rights in a physical and virtual environment". The strategy also acknowledges that "Latvia needs to take advantage of the digital environment to ensure economic and social welfare,

	while at the same time reducing the overall level of cybersecurity risk without unnecessarily limiting the flow of technology, communications and data" [1]. The new strategy also recognises the development of cyber-physical systems and the need to move beyond the virtual-physical dichotomy [1].
References:	1. OECD, Going Digital in Latvia. OECD Publishing, Paris, 2021. 2. https://www.mod.gov.lv/sites/mod/files/document/kiberstrategija.pdf

Guidelines for the Development of Education for 2021-2027. Future Skills for the Future Society

Program name:	Guidelines for the Development of Education for 2021-2027. Future Skills for the Future Society
Designed for the sector:	Educational institutions, society
Period:	2021-2027
Aid amount:	The overall aid amount for all goals and action directions is 4.49 billion euros [1].
Focus on:	The overarching goal of guidelines is to provide quality educational opportunities for all Latvians to promote the development and realisation of their potential throughout their lives and to build their ability to change and responsibly manage constant change in society and the economy [1].
Short description: (100-200 words)	The guidelines set the current goals and directions for education development for the next seven years. Given that the educational process affects everyone, the guidelines cover all types and levels of education [2]. By implementing the goals of education development, it will be possible to achieve the following results of the education policy for 2021-2027 [1]: 1) qualitative and quantitative generation of teachers and academic staff, 2) quality and modern education, 3) everyone has access to support for their growth, 4) sustainable and efficient management of the education system and resources. Major horizontal changes also cover digitalisation [1]: ● priority development of digital skills as a cross-cutting competence in society; ● increase of the e-learning offer in vocational, higher and adult education, including education of interests; ● development and integration of digital learning management platforms, digital learning resources and support materials into the learning process, thus creating high-performance digital education ecosystems. The guidelines also set out key changes in adult learning, such as increasing participation in adult learning, improving the quality of adult education, and

	developing a sustainable and socially responsible funding system for adult education [1].
References:	1. https://likumi.lv/ta/id/324332-par-izglitibas-attistibas-pamatnostadnem-20212027-gadam 2. https://www.izm.gov.lv/sites/izm/files/iap2027_projekta_versija_apspriesana_160720201_2.pdf

Support programmes and initiatives

Latvia's Recovery and Resilience Plan

Program name:	Recovery and Resilience Plan
Designed for the sector:	Companies, government and local municipalities
Period:	2021-2026
Aid amount:	1,82 billion EUR in total (Digital transformation: 365 million EUR) [1]
Focus on:	Within the Recovery and Resilience Plan framework, the faster recovery of the Latvian economy after the Covid-19 pandemic includes four directions of action - reduction of regional inequalities, digitisation of enterprises, climate change, economic transformation and productivity [2].
Short description: (100-200 words)	The Recovery and Resilience Plan is a new budget program managed centrally by the EC, in addition to the EU's multiannual budget for the 2021-2027 programming period [3]. Latvia's Recovery and Resilience Plan is a response to the economic and social situation and strengthens Latvia's growth potential by tackling the main digital challenges [4]: ● Lack of digital skills by training public officials, students, teachers, professionals and ICT specialists. ● Investments and reforms in the Digital Infrastructure Transformation to address the insufficient rural connectivity with investments in last-mile connectivity and physical infrastructure in 5G corridors. ● Targeted measures in the Digital transformation and innovation of businesses to enhance digitalisation capacities through a broad spectrum of actions. ● Measures in the Digital transformation of public administration, including municipalities, to maintain and improve Latvia's performance. Measures to promote digitisation include investment in training to improve digital skills and the use of digital opportunities, tools and e-services. At the same time, it is planned to increase the efficiency of the

	state and local governments and introduce unified ICT solutions for communication with the public. In total, 20% of the total funding will be invested in digitisation activities, including support measures for the provision of 5G infrastructure and the development of citizens' basic digital skills, development of public platforms and national IT systems, as well as 140 million euros for the digital transformation of business and digital skills. improvement [1, 3]. It is planned to provide support for developing digital skills of enterprises for training at least 3,000 small and medium-sized enterprises, providing 20 million euro funding for this purpose [3].
References:	1. https://www.esfondi.lv/upload/anm/atjaunos_meh_finmin_800x600-ppt-eng_short.pdf 2. https://www.em.gov.lv/lv/atveselosanas-fonds 3. https://www.em.gov.lv/lv/jaunums/uznemumu-digitalizacijai-un-digitalo-prasmju-uzlabosanai-paredzets-ieguldit-140-milj-eiro-no-eiropas-atveselosanas-fonda 4. https://ec.europa.eu/newsroom/dae/redirection/document/80482

Norwegian Financial Mechanism

Program name:	Norwegian Financial Mechanism's 2014-2021 Programme "Business Development, Innovation and SMEs" grant for "Application of green industry innovation and ICT products and technologies"
Designed for the sector:	Entrepreneurs registered in Latvia who comply with the status of a small (micro), small or medium-sized enterprise will be able to receive support. Entrepreneurs can also attract project partners, who can be any public or private legal entity registered in Norway or Latvia and with the appropriate competence to help introduce new products into production [1].
Period:	The project shall be implemented within two years from the date of commencement of the eligibility of the project expenditure specified in the project contract, but not later than 30th April 2024 [2].
Aid amount:	The total amount of funding available for the call is EUR 8 495 389, of which EUR 5 847 694,50 is available for green industry innovation projects, while the available funding for the ICT projects is EUR 2 647 694,50. Support for a single project is between EUR 200 000 and EUR 600 000 [1, 2].
Other indicators:	The maximum aid intensity for small-sized enterprises shall be 55% of the project's total eligible costs and 45% for medium-sized companies [1].
Focus on:	The support is given to project promoters for [2]: ● application of new products and technologies with reduced environmental impact in the area of green industry innovation; ● application of ICT products in the production process ensuring digitalisation or automation of the manufacturing processes in the area of ICT.

Short description: (100-200 words)	The objective of the grant is to increase competitiveness for Latvian enterprises within the focus areas of green industry innovation and ICT [3]. These areas include creating more environmentally friendly and energy-efficient materials and products, intelligent mobility, clean transport, water management, automation, robotics and sensor solutions, next-generation mobile technologies, artificial intelligence solutions and other high-value-added products and technologies [1]. Grant supports the purchase of new equipment, software, licenses and patents, as well as activities related to introducing a new product and technology into production [2]. This funding will support the creation or modernisation of at least 15 new plants, making production processes more automated and environmentally friendly while creating at least 50 new jobs and boosting the turnover and exports of the supported companies [1].
References:	1. https://www.em.gov.lv/lv/mazajiem-un-videjiem-uznemumiem-pieejams-atbalsts-jaunu-produktu-un-tehnologiju-ieviesanai-razosana 2. https://eeagrants.lv/en/2021/04/14/the-open-call-application-of-green-industry-innovation-and-ict-products-and-technologies/ 3. https://www.em.gov.lv/en/media/4499/download

Innovation Motivation Programme

Program name:	Innovation Motivation Programme
Designed for the sector:	The programme's target group is potential business start-ups, self-employed persons, natural persons (authors of business ideas), associations and foundations, pupils and students of educational institutions, entrepreneurs, universities, scientific institutions, municipal institutions, and society in general [1].
Period:	2018-2023
Aid amount:	The total eligible funding for implementing the Innovation Motivation Program is 5,3 million euros, including the European Regional Development Fund (ERDF) funding - 4,5 million euros and the state budget resources - 795 590 euros [1].
Other indicators:	The maximum eligible amount of ERDF funding does not exceed 85% of the total eligible funding of the project [1].
Focus on:	Within the framework of the programme, well-known activities will be implemented, such as the competition of innovative business ideas "CUP OF IDEAS", events within the program "Student Learning Companies", and new - a multi-day event with foreign experts and master classes to promote technological interests and creativity, management innovation training course for entrepreneurs and others. Also, in cooperation with other organisations, a series of events will be organised for different target groups - networking seminars, discussions, master classes, new product creation workshops (hackathons), and others [1].
Short description:	The Innovation Motivation Program aims to inform and encourage the

(100-200 words)	public to start an innovative business, using awards as a promotion mechanism. It is also planned to inform the public about the developments related to innovations and their potential, thus encouraging the public and entrepreneurs to focus on the development and use of innovative solutions, as well as increase the share of innovative entrepreneurs in the economy and motivate start-ups in the specialisation priorities or areas [1].
References:	1. https://www.liaa.gov.lv/lv/programmas/inovaciju-motivacijas-programma

Business Incubators

Program name:	Business Incubators
Designed for the sector:	Support for business start-ups and development for individuals and new businesses [1].
Period:	2016-2023
Aid amount:	The planned financing of the project is 30.8 million euros, which consists of the European Regional Development Fund financing of 26 198 233 euros and the state budget financing of 4 623 217 euros [1].
Focus on:	Support programs include [1]: ● *Pre-incubation* suitable for idea authors - individuals and companies who want to develop a business model and test the viability of a business idea. ● *Incubation* suitable for start-ups that need support for faster growth. (A company may not be registered in the Commercial Register of the Republic of Latvia for more than three years at the time of joining).
Short description: (100-200 words)	The project aims to support the establishment and development of new viable and competitive businesses in the regions of Latvia by providing small (micro), small and medium-sized businesses (SMEs) with the necessary consultations, training and events on entrepreneurship, general business issues, mentor support, environment (premises) and grant co-financing for the operating costs of businesses [1]. There are 11 regional business incubators, nine support units throughout Latvia, and a Creative Industries Incubator in Riga, which specialises in providing support to creative industries companies [1].
References:	1. https://www.liaa.gov.lv/lv/programmas/biznesa-inkubatori

Start-up support programmes

Program name:	Start-up support programmes
Designed for the sector:	Start-up Companies
Period:	2017-2023
Aid amount:	The aid is achieved under de minimis conditions, i.e. up to EUR 200000 over three years

Other indicators:	The implementation period of support programs is up to 12 or 24 months.
Focus on:	Start-up support programmes include [2]: ● Aid Programme for Attracting Highly Qualified Employees ● Tax Relief Related to Aid Programmes ● Aid Programme for Fixed Payments
Short description: (100-200 words)	The goal of the support is to promote the establishment of new companies in Latvia to promote research and the use of innovative ideas, products or processes in economic activities [1]. The expected result is to create Latvia's success stories - innovative, globally competitive products. It is planned that as a result of the operation of the support programs, at least 30 start-ups will emerge in Latvia each year, attracting approximately 160 highly qualified employees [3].
References:	1. https://www.liaa.gov.lv/lv/programmas/jaunuznemumu-atbalsta-programmas 2. https://likumi.lv/ta/en/en/id/287272-law-on-aid-for-the-activities-of-start-up-companies 3. https://www.facebook.com/atbalstsuznemejiem/photos/infografika-ko-nosaka-jaunuz%C5%86%C4%93mumu-darb%C4%ABbas-atbalsta-likums/1818584285022963/?__rdr

Innovation vouchers and support for the attraction of highly-qualified specialists

Program name:	Innovation vouchers and support for the attraction of highly-qualified specialists
Designed for the sector:	Company registered in the Commercial Register of the Enterprise Register of the Republic of Latvia [1].
Period:	The innovation Voucher is valid for 12 months starting when a support contract with LIAA is signed. The service contract must be signed within two months after a support contract, but no later than 30 June 2022 [3].
Aid amount:	The program offers three types of vouchers that are worth between EUR 5,000 and EUR 25,000, depending on the type of voucher [2]. Voucher support is granted following the De minimis Regulation (max support EUR 200,000 over the last three years) or EU Regulation No 651/2014 conditions [3].
Other indicators:	Eligibility criteria [1, 3]: 1. The company can prove that innovation contributes to the company's competitiveness and productivity. 2. The company has a business plan for a new product/technology that considers the development process up to introduction and production.
Focus on:	Innovation Voucher is a government financial support tool offered by the Investment and Development Agency of Latvia to drive collaboration between industry and the research community. It is available to all-size companies (including start-ups) registered in Latvia which seek to innovate their existing product/technology or develop a new one [2].

Short description: (100-200 words)	The support aims to promote innovation activity in enterprises with technology transfer and highly qualified employees by supporting the development of new or significantly improved products or technologies that contribute to the achievement of the goals of the Latvian Smart Specialization Strategy [1]. The same company can apply for several Innovation Vouchers within different business idea development. However, one project at a time is possible [3]. Products created during the Innovation Voucher support program shall be owned exclusively by the companies. Business development of a new product/ technology should be reasonable and well thought through [3].
References:	1. https://www.liaa.gov.lv/lv/programmas/inovaciju-vauceri/apraksts 2. https://startuplatvia.eu/innovation-voucher 3. https://startuplatvia.eu/files/resources/editor/a4-innovation-vouchers-programme.pdf

Support for science results commercialisation

Program name:	Support for science results commercialisation
Designed for the sector:	Public research organisations - higher education institutions and scientific institutes
Period:	2017-2023
Aid amount:	The total funding available is 15,9 million euros, made up of funding from the European Regional Development Fund and the national budget. The maximum funding for one technology transfer project is € 300,000, and the aid intensity is up to 90% [1].
Focus on:	The purpose of the support is to contribute to achieving the goals of the Latvian Smart Specialisation Strategy by supporting the commercialisation of research results owned by research organisations both in Latvia and abroad to increase research organisations' income from commercialisation [1].
Short description: (100-200 words)	Technology transfer projects aim to bring the technology to a practical demonstration or prototyping stage as a result of industrial research and experimental development and to carry out further commercialisation activities, the resulting benefits of which are transferred to a third party in the form of a registered patent or license, incl. establishing a new, technology-oriented company in a research organisation [1]. Eligible actions include carrying out feasibility studies, preparation of commercialisation strategy, industrial research, experimental developments, participation in various activities for commercialisation of developed technologies and intellectual property, strengthening industrial property rights, preparing a commercialisation offer, and others. [1].
References:	1. https://www.liaa.gov.lv/lv/programmas/atbalsts-petniecibas-rezultatu-komercializacijai 2. https://startuplatvia.eu/science-commercialization

International competitiveness development

Program name:	Promotion of International Competitiveness (business)
Designed for the sector:	merchants, cooperative societies in which at least three companies are associated, farms or fish farms, individual enterprises, associations of at least five merchants or cooperative societies, foundations, where the founders and members include at least five merchants or cooperative societies, local governments, port authorities [1].
Period:	2016-2023
Aid amount:	The total amount of aid is € 60.6 million [2]. Financial support is awarded following de minimis terms and conditions, support for a group of related companies for three fiscal years – EUR 200 000; support for beneficiaries who are involved in the primary production of agricultural products – EUR 25 000; support for beneficiaries in fishing and aquaculture industry – EUR 30 000. In a calendar year, financial support for associations and foundations, local governments, planning regions and port authorities shall not exceed EUR 66 666 [1].
Focus on:	The support program aims to promote the competitiveness of industries by supporting entrepreneurship and entering foreign markets, ensuring the operation of Latvia's foreign economic representations [2].
Short description: (100-200 words)	Support is granted to the following activities: participation in national stands at international exhibitions or in trade missions abroad, export support activities, including developing websites, online stores, digital applications and virtual communication platforms for the export market [1].
References:	1. https://www.liaa.gov.lv/lv/media/6255/download 2. https://business.gov.lv/atbalsta-programmas/starptautiskas-konkuretspejas-veicinasana-uznemejdarbiba

Support for staff training

Program name:	Event "Support for staff training"
Designed for the sector:	Merchants
Period:	2016-2023
Aid amount:	The total funding available for the event is 7,9 million euros. The maximum amount of support per merchant is 200 000 euros. At least one non-unique person is trained for every 8 000 euros in support [1].
Focus on:	Focus on companies that develop products, technologies or services in one of the areas specified in the smart specialisation strategy or a new competitive niche identified by the industry [1]. The project provides support for small and micro ICT skills development and implementation in the fields of digital technology, digitalisation of internal processes and digital tools for manufacturing and development of services [2].

Short description: (100-200 words)	The aim is to promote the productivity, export capacity and work efficiency of micro, small, medium and large enterprises by increasing the qualifications and skills of employees [1]. Through this project, people can update their skills to handle new technologies [2]. The aim is to facilitate the transformation of enterprises in line with global trends, ensure maximum export capacity and increase the production of high-value-added products to attract investors [1]. By the end of 2019, more than 1,200 companies had been involved in the project, and more than 3,900 training events had been organised [3].
References:	1. https://www.liaa.gov.lv/lv/programmas/atbalsts-darbinieku-apmacibam/apraksts 2. https://ec.europa.eu/newsroom/dae/redirection/document/80482 3. https://www.em.gov.lv/en/media/4499/download

Acceleration funds

Program name:	Acceleration funds offered by Development Financial Institution "Altum"
Designed for the sector:	Start-ups
Period:	2018-2023
Aid amount:	In total, 15 million euros [1]
Focus on:	Creation and development of innovative start-ups [2].
Short description: (100-200 words)	Latvia has three accelerators - Buildit, Commercialization Reactor and Overkill Ventures. Overkill Ventures focuses on start-ups offering software for business-to-business, while BuildIT focuses on hardware and the Internet of Things [3]. Altum has provided € 5 million of European Regional Development Fund funding for each of them out of € 15 million [1, 3]. Funding is initially available for business model research and initial concept development - costs for patent registration, market research, compensation of employees, and others. Additional funding is available for the product and prototype development. [2]. Includes [1]: ● An Acceleration Programme focusing on IoT and hardware start-ups from all over the world. ● An Acceleration Programme focusing on deep-tech start-ups. ● An Acceleration Programme focusing on work environment efficiency and automation start-ups from Central and Eastern Europe that will work in the fields of environment efficiency and automation for B2B companies. ● An Acceleration Programme focusing on B2B SaaS, CyberNorth and Fintech start-ups.
References:	1. https://startuplatvia.eu/acceleration-funds 2. https://www.em.gov.lv/lv/atbalsts

	3. https://www.oecd-ilibrary.org/science-and-technology/digitalizacija-latvija_a58d1c1a-lv

5.3 Appendix 3:

Educational events related to Industry 4.0

Short or one-time events

Title of the event:	Conference Industrie 4.0 in Riga and beyond "Getting Ready for INDUSTRIE 4.0: Transformations Needed"
Date:	December 1, 2017
Place:	Kipsala International Exhibition Centre BT 1
Organiser:	German-Baltic Chamber of Commerce and the Association of Mechanical Engineering and Metalworking Industries of Latvia (MASOC) in cooperation with the Ministry of Economics of Latvia and the Riga City Council
Target audience:	Representatives of manufacturing, electronics, IT and mechanical engineering
Short overview:	The conference was devoted to the opportunities and requirements that Industry 4.0 brought about
Information on the event is taken from:	https://www.masoc.lv/data/pielikumi17/Industry%204.0%20in%20Riga%20and%20Beyond_provizorisk%C4%81%20programma.pdf

Title of the event:	II European-Latvian Forum "Industrial revolution 4.0: Digital Economics, Data protection and Compliance Best-Practice"
Date:	September 7-8, 2018
Place:	Latvian Academy of Sciences
Organiser:	Institute of Economics of the Latvian Academy of Science and LMT enterprise
Target audience:	Entrepreneurs and potential investors, scientists, politicians, representatives of local governments and ministries, representatives of embassies, journalists
Short overview:	The main aims of the forum were: ● Great attention must be paid in all areas of the economy to future information and communication technologies (ICT), to European resources in the age of digitalisation and globalisation to promote and establish Latvia's leading position as a 'smart country'. ● The scientific potential and the transfer from research and teaching to business to determine new profiles and achievements for the development of entrepreneurial activities, to observe and stimulate trends of globalisation and digitisation in the economy of the 21st century. ● With the practice established in the I Economic Forum, we want to continue and use the Forum as a platform for the exchange of experience and cooperation of scientists, entrepreneurs and politicians and to promote and accompany innovation and investment of foreign and national investors in Latvia's innovative national economy as a 'smart country'.

Information on the event is taken from:	• https://2018.economicforum.lv/ • https://2018.economicforum.lv/wp-content/uploads/2019/10/conference_program_en.pdf

Title of the event:	The international conference "Digital Transformation of the Engineering Industries in the Baltic Sea region" in the framework of Techn Industry 2018
Date:	November 30, 2018
Place:	Kipsala International Exhibition Centre BT 1
Organiser:	Latvian Information and communication technology association (LIKTA), Association of Mechanical Engineering and Metalworking Industries of Latvia (MASOC) with financial support by "#R050 DIGINNO of Interreg Baltic Sea Region" (DIGINNO) project, Ministry of Economics of Latvia and Riga City Council
Target audience:	Not specified
Short overview:	The conference discussed the current status and trends of the digitalisation in the engineering industry sector in the Baltic Sea Region as well as introduced the latest technologies for industry digitalisation, automation, and optimisation
Information on the event is taken from:	https://likta.lv/en/digital-transformation/

Title of the event:	Seminar "3D printing - work environment aspects: risks and solutions"
Date:	December 3, 2018
Place:	Rīga Stradiņš University Medical Technology Education Center
Organiser:	Rīga Stradiņš University, Institute of Occupational Safety and Environmental Health
Target audience:	Senior occupational safety specialists, competent occupational safety specialists, entrepreneurs, doctors of occupational diseases and health care, and others interested in the topic
Short overview:	The seminar provided information on 3D printing technologies and materials used, their potential risks and impact on the work environment, health and safety
Information on the event is taken from:	https://www.rsu.lv/seminars-3d-druka-darba-vides-aspekti-riski-un-risinajumi

Title of the event:	Section "Industry 4.0: Opportunities and Challenges" of the 78th International Scientific Conference of the University of Latvia
Date:	February 7, 2019
Place:	Faculty of Business, Management and Economics of the University of Latvia
Organiser:	Faculty of Business, Management and Economics of the University of Latvia
Target audience:	Students, lecturers and researchers from all Latvian universities and scientific institutions, representatives of companies and

	organisations, as well as foreign guests
Short overview:	University conference with the presentations addressing Industry 4.0
Information on the event is taken from:	https://www.bvef.lu.lv/index.php?id=69384

Title of the event:	Digitalisation and Innovation Forum DIG-IN
Date:	February 15, 2019
Place:	RISEBA Architecture and Media Center H2O
Organiser:	Ministry of Economics (Latvia)
Target audience:	Representatives of the various manufacturing sectors
Short overview:	The forum highlighted and analysed the smart specialisation sectors of the Latvian economy. It addressed the promotion of digitalisation potential within Industry 4.0, its opportunities and benefits for the introduction of new technological solutions in companies
Information on the event is taken from:	https://www.em.gov.lv/lv/about https://lvportals.lv/dienaskartiba/302011-digitalizacija-uznemejdarbibas-inovacijas-produktivitates-un-konkuretspejas-pamats-2019

Title of the event:	Business delegation trip "Industry 4.0 - Insider T(r)ip to East Westphalia-Lippe"
Date:	March 14-15, 2019
Place:	Trip from Latvia to Germany
Organiser:	German-Baltic Chamber of Commerce in Estonia, Latvia, Lithuania
Target audience:	Not specified
Short overview:	The trip included visits to the world's leading German companies and production facilities, providing an understanding of Big Data use in the manufacturing sector, machine intelligence, digital platforms and future jobs, smart systems in the agricultural sector and Industry 4.0 in steel processing
Information on the event is taken from:	https://mediafra.admiralcloud.com/customer_609/a413be51-e72d-4a26-9df3-ce618eddd9d4?response-content-disposition=inline%3B%20filename%3D%22PDF_Programmentwurf_Industrie_4.0_Stand_14.01.19_Flug_Paderborn.pdf.pdf%22&Expires=1649251319&Key-Pair-Id=APKAI2N3YMVS7R4AXMPQ&Signature=sQ7aDN~kILCzQ~bPWNVikddUnStg1GWfSrMDNsa67NDxu11S6zbuFx8K3jjnern-gjy9R--MlCCrOGSrifLe0ce6YIySfRlazGrmN-Vgk0PeIlA8lQ0-APXx5bteDkWjbnt37DStZrkX-VTKnoTTPoZMXIpThE-pJIS~hT3P51IYceD3RipabA37SYrgEgdxvxVB5tPgugENeDilJxV~lEZLdG7macuKxNVwSp9jR2cFtn1SNiv2Zd6hfkzBeUqg-9pD7W511s10iZCrBXvgJzvgej~93UKtYn1a-8qY8m19cwLkhlT2PVJ2e0TOKLWrkgi7CsgK7P1Q6blXf~G-ug__

Title of the event:	Seminar "Innovative technologies in animal husbandry"
Date:	April 12, 2019
Place:	Exhibition complex "Rāmava"
Organiser:	Farmers' Association
Target audience:	Livestock farmers and others who are interested
Short overview:	The seminar focused on the Implementation of innovative solutions on farms to improve production efficiency and economic performance
Information on the event is taken from:	https://zemniekusaeima.lv/calendar/zsa-seminars-inovativas-tehnologijas-lopkopiba/

Title of the event:	Professional Competence Development Courses "Industry 4.0 Challenges in the Work of a Vocational Education Teacher in the Metalworking Industry"
Date:	June 6-7,2019
Place:	Not specified
Organiser:	ERASMUS + program project "Training of metalworking workers to work with smart technologies according to the needs of Industry 4.0" (Project No. 575813-EPP-1-2016-1-LT-EPPKA2-SSA)
Target audience:	Vocational teachers in the field of mechanical engineering
Short overview:	During the course, the participants were introduced to the teaching and methodological tools developed in the Erasmus + project "Preparing employees in the metalworking industry to work with smart technologies according to the needs of Industry 4.0" and their practical application in the learning process. Teachers had the opportunity to work in the interactive learning environment developed in the project, take knowledge tests and test the environment's functionality. Teachers were introduced to the development of the mechanical engineering and metalworking industry, the possibilities of "Industry 4.0" and implementation trends in Latvia, as well as learned about the possibilities of robot operation and the use of 3D printers in metalworking industry.
Information on the event is taken from:	https://zrkac.lv/event.php?id=5763

Title of the event:	3rd Mechanical Engineering and Metalworking Business Forum
Date:	November 25-26, 2020
Place:	Virtual
Organiser:	Association of mechanical engineering and metalworking industries of Latvia, together with the Investment and Development Agency of Latvia
Target audience:	Foreign and local enterprises in the industry
Short overview:	The forum included presentations of industry experts about the future of mechanical engineering, Industry 4.0, robotics and supply chains in Latvia

Information on the event is taken from:	https://zemniekusaeima.lv/calendar/zsa-seminars-inovativas-tehnologijas-lopkopiba/

Title of the event:	Online meeting "DIH as a facilitator of digital transformation of SMEs"
Date:	April 15, 2021
Place:	Online
Organiser:	Institute of Electronics and Computer Science
Target audience:	Any entrepreneur of SMEs
Short overview:	The event addressed the development, impact and importance of Industry 4.0 in today's business, as well as support mechanisms of the Digital Innovation Center - funding, experience stories, competitiveness and other topics
Information on the event is taken from:	https://kraslava.lv/zinas/pilns-raksts/tiessaistes-pasakums-uznemumiem https://talsunovads.lv/zinas/uznemejdarbiba/notiks-seminars-uznemumiem-par-digitalajam-inovacijam/

Title of the event:	Training seminar "Development of technologies, their application in the study process and business environment"
Date:	August 26, 2021
Place:	Online
Organiser:	Rīga Stradiņš University and BA School of Business and Finance
Target audience:	Researchers, academic staff
Short overview:	There were several presentations related to modern technologies. One was "Industry 4.0 - Production Automation", which highlighted current issues in machine learning, applications of artificial intelligence algorithms and researchers' experience in production automation and international European projects (VIZTA, AI4DI).
Information on the event is taken from:	https://www.edi.lv/edi-petnieki-un-eksperte-uzstajas-tehnologiju-seminara/

Title of the event:	Educational campaign "Smart Latvia"
Date:	Started in 2019
Place:	No specific place
Organiser:	Latvian Information and Communication Technology Association, together with ICT companies Edisoft, Microsoft Latvia, Lursoft, VISMA and ELVA
Target audience:	SMEs
Short overview:	The "Smart Latvia" campaign is organised to educate the managers of Latvian medium and small companies about the latest IT solutions, encouraging them to implement them in their companies and providing them with the necessary information support.
Information on the event is taken from:	https://www.gudralatvija.lv/par

Recurring events

Title of the event:	Business Technology Exhibition and Conference RIGA COMM
Date:	Annually in October
Place:	International Exhibition Center in Kipsala
Organiser:	International Exhibition Company BT1
Target audience:	Anyone interested in the topics of the conference
Short overview:	The conference typically includes sub-conferences related to machine learning, the Internet of Things, smart HR systems, use of artificial intelligence in different fields
Information on the event is taken from:	https://rigacomm.com/en

Title of the event:	International Exhibition "Tech Industry"
Date:	Annually
Place:	International Exhibition Center in Kipsala
Organiser:	International Exhibition Company BT1
Target audience:	Anyone interested in the topics of the conference
Short overview:	The exhibition demonstrates achievements in the fields of Mechanical Engineering, Metalworking, Automation, Electronics and Electrical Engineering
Information on the event is taken from:	http://www.techindustry.lv/

Long-term training

Title of the event:	Training of ICT professionals for promotion of innovation and development of the industry
Date:	June 1, 2016 – March 31, 2019
Place:	N/D
Organiser:	The Latvian Information and Communications Technology Association (LIKTA), using ERAF funding
Target audience:	Working ICT professionals
Short overview:	The project aimed to increase the qualification of working ICT professionals through training and, in this way, to promote technical innovations and increase productivity, which will increase the number of innovative businesses, the export share of ICT, and the overall growth of the ICT field [1]. The project supported entrepreneurs in training and rising qualification of ICT professionals in the following fields, among others, innovative applications of ICT for specific fields, big data and knowledge infrastructure, information security and cybersecurity. The source [2] reports that 1630 persons used the training opportunities offered by this project.
Information on the event is taken from:	1. https://likta.lv/ikt-profesionalu-apmacibas/ 2. https://likta.lv/wp-content/uploads/2020/05/Apmacibu-izmaksas-07.2016-03.2020.pdf

Title of the event:	Training of small and micro-entrepreneurs for the development of innovations and digital technologies in Latvia
Date:	December 2016 - December 2023
Place:	N/D
Organiser:	The Latvian Information and Communications Technology Association (LIKTA), using ERAF funding
Target audience:	Employees of small and micro enterprises as well as the self-employed persons
Short overview:	The project aims to promote entrepreneurs' understanding of innovations and raise the qualification of self-employed persons and employees of small and microenterprises, promoting the adoption of technological innovations and raising efficiency and productivity [1]. It is planned to train more than 6200 managers and employees of small and microenterprises and self-employed persons through this project[1]. Furthermore, training offers trainees an opportunity to try out new ICT tools and technologies [1]. According to [2] project offers training in several thematic blocks: 1. Digital technologies; 2. Digitalisation of enterprise's internal processes; 3. Digital tools for the development of manufacturing and services. A list of the courses offered is published in [2], and it includes training in cloud services and security. According to [3], before January 13, 2020, 3931 persons had already been trained from more than 1200 enterprises. The most demanded courses are "Data analysis and preparation of reports" and "Data gathering and processing".
Information on the event is taken from:	1. https://likta.lv/mmu-kursi/ 2. https://www.mmu.lv/Lapas/Apmacibas.aspx 3. https://likta.lv/mmu-kurusu-rezultati/

Title of the event:	Training for ICT professionals
Date:	April 27, 2020– December 31, 2023
Place:	N/D
Organiser:	The Latvian Information and Communications Technology Association (LIKTA), using ERAF funding
Target audience:	Working ICT professionals

Short overview:	The aim of the project, as stated in [1], is "to increase the qualification of working ICT professionals through training and in this way to promote technical innovations and increase of productivity, which in turn will increase the number of innovative businesses, export share of ICT, and the overall growth of the ICT field. Planned results are reported in [1]. They include training at least 1400 ICT professionals from at least 51 enterprises in several training programmes, including computer systems, data analysis, IT security, engineering science and technologies.
Information on the event is taken from:	1. https://likta.lv/projekts-ikt-profesionalu-apmacibas/

Title of the event:	Improvement of professional competence of employed persons
Date:	January 1, 2017 - December 31, 2023
Place:	N/D
Organiser:	State Education Development Agency, together with municipalities, educational institutions and National Employment Agency (ESF project)
Target audience:	Working and self-employed persons, including those at social risk
Short overview:	The project aims to improve the professional competence of employed persons to timely eliminate the mismatch of the labour force's qualification with the labour market's demand, promote the competitiveness of employees and increase labour productivity [1]. The project offers several courses in business analytics, data analysis, digital transformation, IT and cybersecurity, the Internet of Things, cloud computing, artificial intelligence, and others.
Information on the event is taken from:	1. https://www.macibaspieaugusajiem.lv/par-projektu?tab=collapse-82

5.4 Appendix 4:

International and local projects on Industry 4.0

Title:	**Data Driven Dairy Decision For Farmers**
Acronym (if any):	**4D4F**
Website:	https://4d4f.eu/
Period:	01.03.2016 – 28.02.2019
Source of funding:	H2020-EU.3.2.
Partners: (Latvian partners in bold)	• Innovation for Agriculture (United Kingdom)- coordinator • Flanders research institute for agriculture, fisheries and food (ILVO) (Belgium) • The Estonian University of Life Sciences (Estonia) • **Latvian Academy of Sciences (Latvia)** • The University of Agronomic Sciences and Veterinary Medicine of Bucharest (Romania) • The Royal Swedish Academy of Agriculture and Forestry (KSLA) (Sweden) • The Zuidelijke Land- en Tuinbouworganisatie (ZLTO) (Netherlands) • Wim Govaerts & Co (Belgium) • Knowledge Information Market (KIM) (Spain) • Paragon Europe (Malta, Belgium) • Van Hall Larenstein University of Applied Sciences (Netherlands) • Institute for Food and Agricultural Research and Technology (IRTA) (Spain) • Liba (Beligium) • DeLaval International AB (Sweden) • Porphyrio NV (Belgium) • KU Leuven (Belgium)
Short overview:	From [1]: "The Data Driven Dairy Decisions for Farmers (4D4F) thematic network will focus on the role which dairy animal and environmental sensors can play in collecting real time information to help make more informed decisions in dairy farming. The network will develop a Community of Practice (COP) comprised of farmers, farm advisors, technology suppliers, veterinarians and researchers who work together to debate, collect and facilitate the co-creation of best practice on data and sensor technology."
Main results in regard to Industry 4.0:	From [2]: "The EU-supported 4D4F network was established to help dairy farmers base management decisions on data, such as that gathered by **sensing equipment**, leading to best practices for more sustainable dairy farming. [..] virtual resource known as the Warehouse of Technology, (comprising an overview of, and comparisons between, all of the current technology)" Series of Standard Operating Procedures [3] have been developed to "help to make a decision on what to do when a certain alarm shows up when using sensors on cattle".
References:	1. https://4d4f.eu/content/about 2. https://cordis.europa.eu/article/id/241023-sharing-data-and-experience-to-benefit-sustainable-dairy-farming 3. https://4d4f.eu/content/standard-operating-procedures

Title:	**Latvijas valsts un sabiedrības izaicinājumi un to risinājumi starptautiskā**

	kontekstā **(Challenges and solutions of the Latvian state society in an international context)**
Acronym (if any):	**INTERFRAME-LV**
Website:	https://www.lza.lv/aktualitates/projekti/content/82-projekti
Period:	Planned: 01.12.2018–30.11.2021, Extended till: 30.06.2022
Source of funding:	VPP (Administration of Studies and Research of the Republic of Latvia)
Partners: (Latvian partners in bold)	• **Latvian Academy of Sciences- coordinator** • **Latvia University of Life Sciences and Technologies;** • **Riga Stradiņš University;** • **Institute of Agricultural Resources and Economics;** • **University of Latvia.**
Short overview:	Project objectives as stated in [1]: • Assess the relevance of the economic and societal model in the context of global and European processes. • To formulate the characteristics of the desired economic and public model, which deals with Latvia's internal and external security, guaranteeing the sustainability of its existence. [..] • To provide guidelines for further sustainable development of Latvia in the perspective, highlighting the main patterns of action in global changing processes, the impact of which cannot be avoided by the country."
Main results in regard to Industry 4.0:	Results of the project are reported in Yearbooks 2020 and 2021 of Latvian Academy of Sciences: • Analysis of structural changes in the economy [3] • Analysis of digitalisation of the national economy • and society [3] • Sociological surveys to identify public opinions on changes (including digitalisation) in the public life[3]. • 5 regional forums for exchanging of views between scientists and practitioners [4] • Monograph "Latvian Sustainability Perspectives: Challenges and Opportunities" summarises both the conclusions of the research and provide further guidelines for the balanced development of the country from the perspective of scientists (to be published) [4]. • 68 reports on the INTERFRAME-LV project presented at international conferences.
References:	1. https://socialsciences.llu.lv/en/projects/challenges-and-solutions-latvian-state-society-international-context 2. https://www.lza.lv/aktualitates/projekti/content/82-projekti 3. https://www.lza.lv/images/Annual_reports/Yearbook_2020.pdf 4. https://www.lza.lv/images/Annual_reports/YearBook_2021_articles/pages_13_19.pdf

Title:	**Industry 4.0 CHAlleNGE: Empowering Metalworkers For Smart Factories Of The Future**
Acronym (if any):	**4CHANGE**
Website:	http://www.change4industry.eu/
Period:	01.12.2016–29.02.2020
Source of funding:	Erasmus +

Partners: (Latvian partners in bold)	• Vilnius Jerusalem Labour Market Training Centre, VJDRMC (LITHUANIA)- coordinator • Engineering Industries Association of Lithuania, LINPRA (LITHUANIA) • Education Network for the Northern German Metal and Electrical Industries, NORDBILDUNG (GERMANY) • **Association of Mechanical Engineering and Metalworking Industries of Latvia, MASOC (LATVIA)** • Federation of Estonian Engineering Industry, EML (ESTONIA) • North Technical Academy, TAN (GERMANY) • **Zemgale Region Human Resource and Competences Development Centre, ZRKAC (LATVIA)** • Tallinn Lasnamae School of Mechanics, TLMK (ESTONIA) • Qualifications and Vocational Education and Training Development Centre, KPMPC (LITHUANIA) • **National Centre for Education, VISC (LATVIA)** • Baltec CNC Technologies JSC, BCT (LITHUANIA) • MTS Mathematical Technical Software Development JSC, MTS (GERMANY)
Short overview:	The overall goal of the project is to tackle skills gaps of metalworkers by addressing the following objectives: to design and deliver a new targeted VET programme based on the current and future skills demand in the metalworking sector, and to develop a self-adaptive work-based learning system in combination with coaching [1].
Main results in regard to Industry 4.0:	As is said in [2], one of the results of this project is development of E-learning platform. "[That] will act as an on-line training tool for learners, trainers, VET institutions, manufacturing enterprises and individuals aiming at acquiring metalworkers profession. It is established as an Open Education Resource system with a focus on accessibility and easy sharing." Address of this platform: https://cnc4change.org/ Analysis of current and future skills demand in the metalworking sector described in [2] includes such skills: • Advanced technology and digital skills due to increased need for engineers instead of manual workers; • Robotics and CNC operation skills due to technology- driven innovation; • Social and entrepreneurial skills due to need for highly motivated work-force to stay competitive; • Green skills due to promotion of energy efficiency.
References:	1. http://www.change4industry.eu/en/pages/home.html 2. http://www.change4industry.eu/uploads/Presentation4change.pdf

Title:	**Digital Innovation Network**
Acronym (if any):	**DIGINNO**
Website:	https://www.diginnobsr.eu/
Period:	01.09.2017–31.12.2020
Source of funding:	Interreg Europe
Partners: (Latvian partners in bold)	• Ministry of Economic Affairs and Communications of Estonia (Estonia) • Estonian Association of Information Technology and Telecommunications (Estonia)

	• Foundation Tallinn Science Park Tehnopol (Estonia) • DIMECC Ltd. (Finland) • Polish Chamber of Commerce of Electronics and Telecommunications (Poland) • **Latvian Information and Communications Technology Association (Latvia)** • **Ministry of Environmental Protection and Regional Development of Latvia (Latvia)** • Engineering Industries Association of Lithuania LINPRA (Lithuania) • Association INFOBALT (Lithuania) • RISE AB (Sweden) • Aalborg University (Denmark) • WITHDRAWAL (31/10/2018):The Ministry of Transport and Communications of the Republic of Lithuania (Lithuania) • The Brønnøysund Register Centre (Norway) • Ministry of the Economy and Innovation of Republic of Lithuania (partner as of 1.04.2018) (Lithuania)
Short overview:	A unique network for innovative solutions in public-private co-operation to speed up the process towards the Baltic Sea Region digital single market [1]. From [2]: "With DIGINNO we are focusing on three challenges: ● promoting uptake of ICT in the business sector, ● developing innovative digital public services and ● facilitating DSM [Digital single market] related policy discussions on BSR [Baltic Sea Region] level."
Main results in regard to Industry 4.0:	Planned results of the project are described in [3]: "The DIGINNO project will also produce a number of workable results that are closely related to the MEPRD's ICT Policy: 1. Identified and analysed cross-border e-services to be developed, 4 concepts of pilot projects developed. 2. An instrument has been created for enterprises to identify their maturity in the use of ICT opportunities (Industry 4.0 maturity), developed national industry 4.0. communities, transnational cooperation. 3. A compendium of good practices and recommendations for policy makers on cross-border eservices and Industry 4.0. promotion. 4. Information campaign on the Baltic Sea Region, including Latvia's role as a forerunner in the implementation of cross-border e-cooperation. " Tool for evaluating company's digital maturity: https://www.diginnotool.eu/home
References:	1. https://www.diginnobsr.eu/ 2. https://www.diginnobsr.eu/about 3. https://ec.europa.eu/information_society/newsroom/image/document/2019-32/country_report_-_latvia_-_final_2019_0D30BE44-054B-C822-C8DEFA25536D65B0_61211.pdf

Title:	**Digital Innovation Capacity Building**
Acronym (if any):	**DINNOCAP**
Website:	https://www.dinnocapbsr.eu/
Period:	01.01.2021-31.12.2021

Source of funding:	Interreg Europe
Partners: (Latvian partners in bold)	• Ministry of Economic Affairs and Communications of Estonia (Estonia)-coordinator • Aalborg University (Denmark) • Association INFOBALT (Lithuania • Estonian Association of Information Technology and Telecommunications (Estonia) • The Brønnøysund Register Centre (Norway) • **Latvian Information and Communications Technology Association (Latvia)** • Polish Chamber of Commerce of Electronics and Telecommunications (Poland) • Engineering Industries Association of Lithuania LINPRA (Lithuania) • RISE Research Institute Sweden AB • Association of SMEs Support Centres in Kaliningrad Region
Short overview:	Source [2] sums up the aim of the project like this: "The project supports small and medium sized enterprises (SMEs) around the Baltic Sea to update digital solutions faster. In this way, the project facilitates the transition to a digital single market in the region. Based on tools developed in DIGINNO, the project DIGINNOCAP works on improving digitalisation methods and their practical use." in [1] it is stated that: "DINNOCAP is an extension project of DIGINNO which was a digital collaboration project for the BSR carried out 2017-2020: https://www.diginnobsr.eu/. DINNOCAP will support the implementation of innovative ICT tools, cross-border e-services solutions, and policy recommendations developed in DIGINNO. These are: 1. Business needs assessment of ICT in SMEs in BSR 2. SME Digital Maturity Recommender Tool 3. Digital Assessment Toolkit for SME's 4. Four show-case models of G2B cross-border e-service 5. DIGINNO Policy White Paper"
Main results in regard to Industry 4.0:	In [3] the long term impact of the project has been stated: "A considerable amount of SMEs in the BSR region will be familiar with the digitalization and digital awareness tools, enabling them to increase their digitalization capacity and uptake of ICT, a.o. inspired by approaches and practices in the neighboring countries. In the long term, this will improve the innovation capacities of SMEs and encourage SME digitalization based on transnational learning. This will enhance the competitiveness of SMEs and the BSR industry sectors. [..]" From [1]: "The overall output of DINNOCAP will be a set of innovative digital transformation instruments to support capacity enhancement among SMEs, industry associations, and policymakers."
References:	1. https://www.dinnocapbsr.eu/ 2. https://interreg-baltic.eu/project/dinnocap/ 3. https://www.dinnocapbsr.eu/outcomes

Title:	**Improving innovation delivery of policies within 4.0 industry in Europe.**
Acronym (if any):	**INNO INDUSTRY** **(INNO4.0 in** https://clustero.eu/inno4-0-inno-industry**/)**
Website:	https://projects2014-2020.interregeurope.eu/innoindustry/

Period:	01.08.2019 – 31.01.2023
Source of funding:	Interreg Europe
Partners: (Latvian partners in bold)	• Regional Development Agency Posavje (RDA Posavje) (Slovenia) • Ecoplus. The Business Agency of Lower Austria (Austria), • Innovative business association of furniture manufacturers and related in the Murcia Region – AMUEBLA (Spain), • **Ministry of Economics of the Republic of Latvia (Latvia),** • Business and innovation Centre of Beira Interior (Portugal), • Romanian Cluster Association – CLUSTERO (Romania), • RISE Research Institutes of Sweden AB (Sweden), • Slovak Business Agency (Slovakia), • Buckinghamshire Business First (United Kingdom)
Short overview:	INNO Industry project aims to increase rate of clusters that develop activities to support the transformation towards Industry 4.0 by 2022 through the improvement of regional and national policies [1].
Main results in regard to Industry 4.0:	Planned results are described in [1]: "INNO Industry proposes to establish a strategic work group with the aim to share best practices related with cluster activities and the promotion of Industry 4.0 to develop a European Blueprint as a policy guide towards clusters 4.0. The development of INNO Industry will achieve as key outputs a SWOT analysis in 10 EU regions, the identification of at least 30 best practices related with clustering and industry 4.0, one European Blueprint towards clusters 4.0 and 10 action plans to introduce improvements in addressed policy instruments."
References:	1. https://projects2014-2020.interregeurope.eu/innoindustry/

Title:	**Boosting a novel and innovative training approach of Key Enabling Technologies**
Acronym (if any):	**BRACKET**
Website:	https://bracket.erasmus.site/
Period:	01.11.2018 – 30.04.2021
Source of funding:	Erasmus+
Partners: (Latvian partners in bold)	• Institute for Development and International Relations (IRMO) (Croatia) • Danmar Computers LLC (Poland) • University of Thessaly (Greece) • ASOCIACION EMPRESARIAL DE INVESTIGACION CENTRO TECNOLOGICO DEL MUEBLEY LA MADERA DE LA REGION DE MURCIA (Spain) • **Biedrība Eurofortis (Latvia)** • Ljudska univerza Rogaška Slatina (Slovenia) • InnoRenew CoE (international research centre estblished with funding from the H2020 WIDESPREAD-2-TEAMING programme)
Short overview:	Objectives of the project are described in [1]: "[T]he main objective of this project was to transfer KETs [Key Enabling Technologies, here specifically nanotechnology, biotechnology and advanced materials] to Vocational Education and Training (VET) through the development of innovative and open learning content in terms of KETs. High capacities cannot be developed and implemented in the markets if students and workers do not have the necessary competences and/or skills, both technical related to chemistry, computer sciences, etc., and non-technical skills as entrepreneurship, innovation, etc.

	To this end, the BRACKET Consortium defined the following specific objectives (SO): SO1. To study and analyse the incoming trends regarding KETs and competences necessaries to foster its implementation and work in VET. SO2. To design and develop a Joint Curriculum (JCV) for developing and fostering new skills on VET students (initial or continued VET) with the participation of stakeholders, experts and Universities with experience in these enabling technologies as well as in non-technical skills. SO3. To deliver the JCV on e-learning OER platform and protect it under open licenses. SO4. To break boundaries among VET students, workers and experts in KETs, creating common procedures and defining skills. It will be developed during the execution of the four Intellectual Outputs. SO5. To equip VET users and other target users with the right skills and knowledge about KETs from today and tomorrow and to foster a sustainable and innovative development. SO6. To create new job opportunities for people with the necessary skills in the field of KETs."
Main results in regard to Industry 4.0:	Developed course book [2] includes a chapter on Industry 4.0 explaining basic concepts and their linkage to KETs. "Key Enabling Technologies represent advanced technologies, which are in fact Industry 4.0 technologies, offering opportunities for the European industry to grow in services and products for the future benefit. Therefore, I4.0 has its place in KETS, especially the Internet of Things (IoT) which is generally used to refer to the connection between consumer goods, but in this respect, it is a network that connects physical devices (appliances, smart solutions, vehicle systems etc.) so that they are able to share data."
References:	1. https://bracket.erasmus.site/more-about/ 2. https://ec.europa.eu/programmes/erasmus-plus/project-result-content/4d47557a-f780-4aa5-be4d-a384058cf472/BRACKET%20Coursebook%205%20units.pdf

Title:	**Vision, Identification, with Z-sensing Technologies and key Applications** (Z-uztveres tehnoloģija redzei un identifikācijai)
Acronym (if any):	**VIZTA**
Website:	https://www.vizta-ecsel.eu/
Period:	01.05.2019-31.10.2022
Source of funding:	Horizon 2020 (ECSEL Joint Undertaking (JU))
Partners: (Latvian partners in bold)	• STMicroelectronics Crolles (France)- coordinator • Alter Technology TÜV Nord (Spain) • Applied Materials (France) • Ayming (International) • Beamagine (Spain) • Beamagine (Spain) • CEA (French Alternative Energies and Atomic Energy Commission)(France) • DFKI (German Research Centre for Artificial Intelligence) (Germany) • **EDI (Institute of Electronics and Computer Science) (Latvia)** • Eurecat (Spain) • Idneo (Spain)

	• IBEO (Germany) • IDEMIA (France) • IEE (Luxembourgh) • III-V LAB (France) • ISD (Integrated Systems Development S.A.) (Greece) • QUANTEL TECHNOLOGIES & KEOPSYS INDUSTRIES (France) • Semilab (Hungary) • ST (STMicroelectronics) (France) • TRUMPF Photonic Components (Germany) • UPC (Universitat Politècnica de Catalunya) (Spain) • Veoneer (Sweden)
Short overview:	VIZTA aims at developing innovative technologies in the field of optical sensors and laser sources for short to long-range 3D-imaging and to demonstrate their value in several key applications including automotive, security, smart buildings, mobile robotics for smart cities, and industry4.0 [1].
Main results in regard to Industry 4.0:	From [2]: "Technology developments of sensors and emitters are carried out by leading semiconductor product suppliers (STMicroelectronics, Trumpf, III-V Lab) with the support of equipment suppliers (Amat, Semilab) and CEA Leti RTO. VIZTA project also includes the development of 6 demonstrators for key applications including automotive, security, smart buildings, mobile robotics for smart cities, and industry4.0 with a good mix of industrial and academic partners (Ibeo, Veoneer, Ficosa, Beamagine, IEE, DFKI, UPC, Idemia, CEA-List, ISD, BCB, IDE, Eurecat)." EDI (Latvia) is involved in developing WP3- development of short range 3D imaging systems which can be used for: "[..] Face recognition, Gesture control, Driver monitoring, Industrial control, [..] Smart buildings, Mobile robots, Drones, Security, [..] Security of transport with LIDARs (Light based radars with much higher resolution) [3]"
References:	1. https://www.vizta-ecsel.eu/ 2. https://www.vizta-ecsel.eu/in-a-nutshell/objectives/ 3. https://www.vizta-ecsel.eu/in-a-nutshell/general-questions-answers/

Title:	**Competence Centre of Electrical and Optical Equipment Production Sector of Latvia (Latvijas elektrisko un optisko iekārtu ražošanas nozares kompetences centrs)** **Project 1.2.1.1/18/A/006**
Acronym (if any):	N/A
Website:	https://www.leopc.lv/projekti/
Period:	2019-2022
Source of funding:	ERAF
Partners: (Latvian partners in bold)	• **Competence Centre of Electrical and Optical Equipment Production Sector of Latvia- coordinator** • **LEITC SIA (Latvia)** • **Hansamatrix Innovations SIA (Latvia)** • **Hansamatrix Ventspils SIA (Latvia)** • **Mondot SIA (Latvia)**

	• **EDI (Institute of Electronics and Computer Science) (Latvia)** • **Robotic Solutions SIA (Latvia)** • **Riga Technical University (Latvia)** • **Lightspace Technologies SIA (Latvia)** • **SAF Tehnika AS (Latvia)** • **RIMI Latvia SIA (Latvia)** • **Conelum SIA (Latvia)** • **Apply SIA (Latvia)**
Short overview:	"Competence Centre of Electrical and Optical Equipment Production Sector of Latvia unites companies and research institutes with the aim to increase their competitiveness and to advance cooperation between industrial and research sectors in order to develop innovative products and technologies. Research projects are implemented in the fields of electronics, electrical engineering and optics by implementing Smart Strategy (RIS3) of Information and Communication Technologies – Hardware Engineering (Electronics)." https://www.leopc.lv/projekti/ Most relevant sub-projects/research activities: 1. Pētījums Nr. 1.1 "Elektromagnētiskās savietojamības testēšanas sistēmas izpēte un izstrāde, frekvenču diapazonā 1MHz-6GHz lietu interneta (IoT) testēšanai" ("Research and development of testing system of electromagnetic compatibility for a IoT in the frequency range 1MHz-6GHz") https://www.leitc.lv/lv/about-us#zinatne 2. Pētījums Nr. 1.2 "Vadības elektronikas shēmas izstrādes pētījums multifokālās papildinātās realitātes galvas displejam" ("Development of electronics for multifocal augmented and virtual reality displays") http://www.hansamatrix.com/hmx-launches-multifocal-electronics-project.html 3. Pētījums Nr. 1.5 "Efektīvs modulis automātiskai cilvēku un transporta detektēšanai ar Video novērošanas kamerām" ("An effective module for automatical detecting of people and transport using video from surveilance cameras") https://www.mondot.lv/jaunumi/params/post/3757775/mondot-petniecibas-projekta-efektivs-modulis-automatiskai-cilveku-un-transp 4. Pētījums Nr. 1.9 "Iekštelpu navigācijas risinājums dažādu funkciju autonomiem robotiem" ("Indoor navigation solutions for autonomous robots with various functions") https://www.squad-robotics.com/eu-funds 5. Pētījums Nr. 1.16 "Integrēta elektronikas risinājuma izstrāde galvas displeja pozīcijas noteikšanai telpā un attālinātās palīdzības funkcionalitātes nodrošināšanai" ("Development of integrated electronics for head position tracking and remote assistance functionality") hansamatrix.com/hmx-launches-tracking-peripherals-development-project.html https://lightspace3d.com/development-of-integrated-electronics-for-head-position-tracking-and-remote-assistance-functionality/ 6. Pētījums Nr. 1.21 "Caurspīdīgas stikla taras un tās elementu analīze un detekcijas metožu izpēte universālai defektoloģijas analīzei"

	("Analysis of translucent glass packaging and it's elements and research of detection methods usable for universal analysis of defects") https://www.applyit.lv/en/competence-center-glasscon 7. Pētījums Nr. 1.22 "Galvas displeja pozīcijas precīza noteikšana industriālos pielietojumos" ("Precise positioning of the head-mounted display in industrial applications") https://wp.lightspace3d.com/precise-positioning-of-the-head-mounted-display-in-industrial-applications/ 8. Pētījums Nr. 2.1 "Elektronisko bezvadu sensoru mērījumu lielu datu apjoma (Big Data) apstrāde izmantojot mākoņa (Cloud) risinājumu, un tā pielietojums pārtikas mazumtirdzniecības uzņēmumiem" ("Processing of large volumes (Big Data) of readings from electronic wireless sensors using cloud solutions and it's application to food retail enterprises") 9. Pētījums Nr. 2.2 "Conelum EloVIEW" https://www.leopc.lv/projekts/petijums-nr-2-2-conelum-eloview/
Main results in regard to Industry 4.0:	1. According to [1] system for testing Internet of Things in 1MHz-6GHz frequency has been developed. 2. "Small-size light-weight electronics driver for multifocal augmented and virtual reality displays and headsets. [..] control algorithms, schematics capture, layout development in flexi-board technology, manufacturing of prototypes, validation of functionality of the developed board in actual multifocal augmented reality headset." [3] 3. As stated in [11] effective computer vision based methods for video analysis for detecting and counting of members of traffic have been developed. Experimental prototype uses original machine learning based method for detecting objects using Recurrent Neural Network-based virtual detection line. 4. According to [5] existing indoors positioning methods and their technical implementations were compared in a laboratory setting. As a result proposals for improving and combining several methods were developed. 5. "[..]small-size light-weight electronics board that implements absolute position tracking for the head mounted display within a room and also implements a remote assistance functionality. The actions of the proposed project include development of SLAM algorithms, integrateable devices, electroncis module development and sample production run."[6] 6. Current results according to [8]: research of algorithms for determining the position and orientation of empty glass packaging and identification of various zones (i.e. bottom, bottle-neck etc) of glass packaging using the power of AI computer vision. Planned results according to [8]: to make detection of deffects of translucent empty glass packaging more more affordable and easier to install. 7. Expected result: "[..] to create a solution for tracking position of the head-mounted display in 5 x 5 m large industrial-like room, thus enabling the industrial use cases with Lightspace AR[Augmented reality]] headsets." [9] 8. Source [10] reports that: temperature sensors have been deployed in 130 Rimi Latvia stores. Centralised system for monitoring temperature in glass-cases in all stores has been developed using cloud for storing

	and analysing data. Machine learning module for detecting temperature anomalies based on sensor data has been developed to detect potential defects preventively. 9. The aim of the subproject 2.2. in [12] is described as development of wide field of vision opto-electronic modular system EloVIEW that allows completely automatic analysis of microbiological pollution for any industry. This subproject has created innovative approach that allows significantly speed up the microbiological pollution analysis process and to count animate cells in less than hour (traditionally it takes 3-7 days).
References:	1. https://www.leopc.lv/projekti/ 2. https://www.leitc.lv/lv/about-us#zinatne 3. http://www.hansamatrix.com/hmx-launches-multifocal-electronics-project.html 4. https://www.mondot.lv/jaunumi/params/post/3757775/mondot-petniecibas-projekta-efektivs-modulis-automatiskai-cilveku-un-transp 5. https://www.leopc.lv/projekts/petijums-nr-1-9-iekstelpu-navigacijas-risinajums-dazadu-funkciju-autonomiem-robotiem/ 6. http://www.hansamatrix.com/hmx-launches-tracking-peripherals-development-project.html 7. https://lightspace3d.com/development-of-integrated-electronics-for-head-position-tracking-and-remote-assistance-functionality/ 8. https://www.applyit.lv/en/competence-center-glasscon 9. https://wp.lightspace3d.com/precise-positioning-of-the-head-mounted-display-in-industrial-applications/ 10. https://www.leopc.lv/projekts/petijums-nr-2-1-elektronisko-bezvadu-sensoru-merijumu-lielu-datu-apjoma-big-data-apstrade-izmantojot-makona-cloud-risinajumu-un-ta-pielietojums-partikas-mazumtirdzniecibas-uznemumiem/ 11. https://www.leopc.lv/projekts/petijums-nr-1-5-efektivs-modulis-automatiskai-cilveku-un-transporta-detektesanai-ar-video-noverosanas-kameram/ 12. https://www.leopc.lv/projekts/petijums-nr-2-2-conelum-eloview/

Title:	**Competence Centre of Electrical and Optical Equipment Production Sector of Latvia (Latvijas elektrisko un optisko iekārtu ražošanas nozares kompetences centrs)** **Projekts Nr. 1.2.1.1/16/A/002**
Acronym (if any):	**N/A**
Website:	https://www.leopc.lv/projekti/
Period:	2016-2018
Source of funding:	ERAF
Partners: (Latvian partners in bold)	• **Competence Centre of Electrical and Optical Equipment Production Sector of Latvia- coordinator** • **Robotic Solutions SIA (Latvia)** • **Rīgas Tehniskā universitāte (Latvia)** • **EDI (Institute of Electronics and Computer Science) (Latvia)**
Short overview:	"Competence Centre of Electrical and Optical Equipment Production Sector of Latvia unites companies and research institutes with the aim to increase their competitiveness and to advance cooperation between industrial and research sectors in order to develop innovative products

	and technologies. Research projects are implemented in the fields of electronics, electrical engineering and optics by implementing Smart Strategy (RIS3) of Information and Communication Technologies – Hardware Engineering (Electronics)." https://www.leopc.lv/projekti/ Most relevant sub-projects: 1) Pētījums Nr. 9 "Daudzu robotu sistēmas pielietojumiem lauksaimniecībā" ("Multi-robot systems for applications in agriculture") https://www.leopc.lv/projekts/petijums-nr-9-daudzu-robotu-sistemas-pielietojumiem-lauksaimnieciba/ 2) Pētījums Nr. 11 "Pētījums par datorredzes paņēmienu attīstību industrijas procesu norises automatizācijai" (DIPA) ("The research on the development of computer vision techniques for the automation of industrial processes") https://www.edi.lv/projects/petijums-par-datorredzes-panemienu-attistibu-industrijas-procesu-norises-automatizacijai-dipa/
Main results in regard to Industry 4.0:	1) Results of subproject "Multi-robot systems for applications in agriculture" are reported in [1] and they are: a) development of multiple robot cooperation software framework that allows getting out of dead ends and for robots to replace each other if necessary. b) Development of methods for merging maps, planning routes, fusing sensor data and other purposes. c) Development of a prototype of multiple feed-pushing robots system. 2) A set of methods for automation of various processes in industry have been developed using visual information (2D and 3D computer vision) and it's processing with machine learning methods (neural networks, deep learning, etc.), reports [2]. Source [3] describes created model of industrial process for data gathering and processing. It gathers data using Kinect V2 sensors, processes data to detect objects of interest in a chaotic pile, processes data to determine the orientation of the picked-up object. Architecture of a modular system has been created that includes sensors, cameras, stereo modules, robotic manipulators, etc. This architecture allows using components from various producers with only minor changes necessary. Modularity has been achieved trough the usage of ROS- Robot Operating System.
References:	1. https://www.leopc.lv/projekts/petijums-nr-9-daudzu-robotu-sistemas-pielietojumiem-lauksaimnieciba/ 2. https://www.edi.lv/projects/petijums-par-datorredzes-panemienu-attistibu-industrijas-procesu-norises-automatizacijai-dipa/ 3. https://www.edi.lv/wp-content/uploads/2019/07/2017.08.-Prezentacija-publicitatei.pdf

Title:	**Next Generation Enhanced Augmented Reality 3D Glasses for medical education, pre-procedural planning, intra-procedural visualization, and patient rehabilitation**
Acronym (if any):	**NGEAR 3D**
Website:	https://cordis.europa.eu/project/id/960828

	https://lightspace3d.com/ngear-3d/
Period:	01.07.2020–30.06.2022
Source of funding:	Horizon 2020
Partners: (Latvian partners in bold)	**SIA Lightspace Technologies (Latvia)**
Short overview:	"Augmented reality (AR) technology offers great possibilities for advanced tools to be used in medicine to improve diagnostics and efficiency in surgical planning and tasks, heralding a new level of modern healthcare. However, the highly anticipated VR/AR 3D display glasses are not yet not suitable for close work, due to the focal rivalry of the stereoscopic 3D image and the real world, which results in eye strain and pains. To solve this problem, the EU-funded NGEAR 3D project supports the development of the state-of-the-art multifocal-accommodating AR headset that eliminates all adverse effects of existing headsets and outputs holographic-look 3D images." [1]
Main results in regard to Industry 4.0:	"Augmented Reality Glasses that can visualize high-quality 3D images at stretched arm's distance (0.3m –2.0m)." [2] "Augmented Reality headset and glasses prototype validation with strategic partners:in healthcare – with market-leading medical AR application company, cardio surgeons from two hospitals; in digital manufacturing – with global leading car manufacturer[..]"[2]
References:	1. https://cordis.europa.eu/project/id/960828 2. https://lightspace3d.com/ngear-3d/

Title:	**Innovation Framework for Challenge Oriented Intelligent Manufacturing**
Acronym (if any):	**INforM**
Website:	https://interreg-baltic.eu/project/inform/
Period:	January 2019 – December 2021
Source of funding:	Interreg Europe
Partners: (Latvian partners in bold)	• Tallinn University of Technology (Estonia)- coordinator • Innovative Manufacturing Engineering Systems Competence Centre (Estonia) • Machine Technology Center Turku Ltd. (Finland) • Lappeenranta University of Technology (Finland) • Odense Robotics (Denmark) • **Vocational education and training center "Liepajas State Technical school" (Latvia)** • Lithuanian Innovation Centre (Lithuania) • Klaipeda Science and Technology Park (Lithuania) • Torun Technology Park (Poland)
Short overview:	"The INforM project provides support to small and medium sized mechatronics and mechanical engineering companies in the ongoing digital transformation process. The continuous digitalisation of value chains called Industry 4.0 brings with it great challenges for smaller companies. The project plans to enable companies to benefit from the trend towards smart factories, which operate mainly based on intelligent, IT and web-based processes."[1]
Main results in regard to Industry 4.0:	"The project INforM creates a cross-sectorial Innovation Support Digital Framework to support small and medium sized enterprises (SMEs) in the digital transformation process. The Framework develops and implements

	customised smart engineering and educational solutions responding to the actual needs of the enterprises around the Baltic Sea in order to ensure their competitiveness and productivity." [1]
References:	1. https://interreg-baltic.eu/project/inform/

Title:	**Developing Industrial 4.0 competence centres and network in Estonia, Latvia and Lithuania**
Acronym (if any):	**i4.0 Baltics**
Website:	https://si.se/en/projects-granted-funding/i4-0-baltics-developing-industrial-4-0-competence-centres-and-network-in-estonia-latvia-and-lithuania/
Period:	30.06.2016 – 31.03.2017
Source of funding:	Baltic Sea region seed funding
Partners: (Latvian partners in bold)	• Eesti Plastitööstuse Liit (Estonia) • **Latvian Chamber of Commerce and Industry (Latvia)** • Public Entity Intechcentras (Lithuania)
Short overview:	"The i4.0 Baltics project focuses on small and medium size companies in the Baltic Sea region and their preparedness for the fourth industrial revolution. According to the i4.0 Baltics project, many small and medium size companies in the Baltic Sea region are not prepared for the fourth industrial revolution, Industry 4.0 or i4.0, a development that implies full digitalization of industries. Many of these companies only operate locally. They lack the requisite specialist staff to prepare for the changes that Industry 4.0 will require, according to this project. Also, some of the companies have a sceptical attitude towards a technology strategy they are not familiar with. The project wants to integrate these small and medium size companies into global value networks. The idea of is to create a network among leading companies, small and medium size companies and organizations in the Baltic Sea region. The network will serve to enhance the understanding of the implications and challenges of the fourth industrial revolution. Also, it will discuss strategies and methods to take advantage of the development." [1]
Main results in regard to Industry 4.0:	"One activity is to find local i4.0 consultants in Estonia, Latvia and Lithuania. Moreover, the project will arrange factory visits in Sweden and hold a 2-day training in i4.0."[1]
References:	1. https://si.se/en/projects-granted-funding/i4-0-baltics-developing-industrial-4-0-competence-centres-and-network-in-estonia-latvia-and-lithuania/

Title:	**An interregional cooperation project for improving SME competitiveness policies**
Acronym (if any):	**SKILLS+**
Website:	https://projects2014-2020.interregeurope.eu/skillsplus/
Period:	01.04.2016 – 31.03.2021
Source of funding:	INTERREG Europe
Partners: (Latvian partners in bold)	• Ministry for Regional Development and Transport of SaxonyAnhalt (Germany) • Kainuun Etu Ltd. (Finland) • **Ministry of Environmental Protection and Regional Development of the Republic of Latvia (Latvia)** • University of Western Macedonia (Greece)

	• Malopolska Regional Development Agency (Poland) • Trondelag County Authority (Norway) • Zadar County Rural Development Agency (Croatia) • Bulgarian Chamber of commerce and Industry (Bulgaria) • Ministry of Culture and Tourism of Castilla y Leon Regional Government (Spain) • Pannon Novum WestTransdanubian Regional Innovation Nonprofit ltd. (Hungary) • **University of Latvia (Latvia)** • Technical University of Ostrava (Czech Republic)
Short overview:	"SKILLS+ aims at advancing public policies promoting information and communication technologies (ICT) skills among SMEs in rural areas helping them seize fully the opportunities offered by a digital single market and benefits of a digital economy." [1] "The project was aimed at raising productivity, innovations and increasing the long-term competitiveness of small and micro enterprises by teaching them how to effectively apply ICT technologies and e-skills. The planned activity will directly train on the opportunities provided by ICT, how to design and develop a future corporate strategy using ICT that further contributes to the OP's [Operational Program] goal." [2]
Main results in regard to Industry 4.0:	"Support is provided for small and micro-enterprises, self-employed persons in training thematic blocks: 1. Digital skill and ICT solutions for productivity; 2. The use of ICT tools for SME's competitiveness and development; 3. Use of ICT solutions for business efficiency and export development."[2] 11 action plans to promote SME digitalisation in rural areas [3]. More than 5000 businesses expected to benefit from implemented actions directly and many more from the spillover effect [3].
References:	1. https://projects2014-2020.interregeurope.eu/skillsplus/ 2. https://projects2014-2020.interregeurope.eu/fileadmin/user_upload/tx_tevprojects/library/file_1576241987.pdf 3. https://projects2014-2020.interregeurope.eu/fileadmin/user_upload/tx_tevprojects/library/file_1553072485.pdf

Title:	**Digital Business EcoSystem Transformation**
Acronym (if any):	**DigiBEST**
Website:	https://projects2014-2020.interregeurope.eu/digibest/
Period:	01.08.2019– 31.07.2023
Source of funding:	Interreg Europe
Partners: (Latvian partners in bold)	• **Ministry of Environmental Protection and Regional Development of the Republic of Latvia (Latvia)- coordinator** • Trøndelag fylkeskommune (Norway) • **University of Latvia (Latvia)** • Sviluppo Basilicata Spa (Italy) • Austria Wirtschaftsservice Gesellschaft mbH (Austria) • Comunidade Intermunicipal do Tâmega e Sousa (Portugal) • Diputación Provincial De Granada (Spain)

Short overview:	"The overall objective of the project is to support and promote SMEs competitiveness through digital transformation of SMEs in rural European territories by proposing solutions to enhance their capacity to use advanced technologies and new innovative business approaches for promoting smart, sustainable and inclusive growth in Europe and its regions." [1]
Main results in regard to Industry 4.0:	Planned outcomes of the project according to [3] are: ● SMEs digital transformation barrier and solution analysis for each partner country. ● Development of enterprise digitalisation self-assessment tool; ● Development of road-maps for promotion of enterprise digitalisation. ● Development of action plan based on roadmaps for promotion of enterprise digitalisation.
References:	1. https://projects2014-2020.interregeurope.eu/digibest/ 2. https://keep.eu/projects/21526/Digital-Business-EcoSystem--EN/ 3. https://www.lu.lv/cets/research/euproject/digibest/

Title:	**YOUNG-ICT WOMEN: Innovative Solutions to increase the numbers of EU vulnerable girls and young women into the digital agenda**
Acronym (if any):	**WOMEN4IT**
Website:	https://women4it.eu/
Period:	01.09.2018 – 31.01.2023
Source of funding:	Grant from Iceland, Liechtenstein and Norway through the EEA and Norway Grants Fund for Youth Employment
Partners: (Latvian partners in bold)	• **LIKTA – The Latvian Information and Communications Technology Association (Latvia)- coordinator** • BETI – Baltic Education Technology Institute (Lithuania) • Tech.mt – Tech.mt - Malta Leading Through Innovation (Malta) • CRETHIDEV – Creative Thinking and Development (Greece) • ICS Skills – Training and Certification Body of the Irish Computer Society (Ireland) • PLAN International – Advancing children's rights and equality for girls (Spain) • Fundatia EOS – Educating for an Open Society (Romania) • ECWT – The European Centre for Women and Technology (Norway) • DIGITALEUROPE – The voice of the digital technology industry in Europe (Belgium)
Short overview:	"In the context of the structural transformation towards a digital economy, there are significantly fewer women than men on the European market. Left unaddressed, this digital gap will lead to loosing-out on the female talent, innovation and entrepreneurship – and further widen the gender gap. The ambition of the project partners is to develop the digital competences of young women who are at risk of exclusion from the labour market, by improving their employability." [1]
Main results in regard to Industry 4.0:	Key outcome indicators of the project as stated in [4]: • 10,000 Number of youth reached by digital career awareness activities • 350 Number of employers introduced to innovative solutions • 1,000 Number of young girls and women assessed by the profiling tool

	• 700 Number of target group enrolled in education and training, including work. Project's webpage [2] offers to choose between 8 Job profiles, including Data analyst, Data protection officer. As is stated in [3] till 21.08.2020 200 young women had registered in the training platform and tested their skills and 102 had signed up for training.
References:	1. https://women4it.eu/about-us/ 2. https://digitaljobs.women4it.eu/ 3. https://likta.lv/sakusas-projekta-women4it-pilota-aktivitates-latvija/ 4. https://women4it.eu/our-impact/

Title:	**DIGITAL COMPETENCE DEVELOPMENT SYSTEM**
Acronym (if any):	**DCDS**
Website:	http://www.dcds-project.eu/about/
Period:	01.01.2018 – 31.12.2020
Source of funding:	Erasmus+
Partners: (Latvian partners in bold)	• ALL DIGITAL (Belgium)- coordinator • Hellenic Open University (HOU), DAISSy Research Group (Greece) • Centro Studi Foligno (CSF) (Italy) • Associazione Emiliano-Romagnola Centri Autonomi di Formazione (AECA) (Italy) • Fundación ESPLAI (Spain) • **LIKTA (Latvia)** • EOS Foundation (Romania) • European Association for the Education of Adults (EAEA) (Belgium)
Short overview:	"The DCDS project aims to establish a framework that will provide the low-skilled adult European population with the basic digital and transversal competences needed for employment, personal development, social inclusion and active citizenship. The project will develop an open, innovative multilingual Digital Competences Development System (DCDS) and use it to provide non-formal training to low-skilled adults in different European countries. DCDS is completely aligned to the European Digital Competence Framework for Citizens – DigComp and thus promotes its adoption in Europe." [1]
Main results in regard to Industry 4.0:	Outputs from [1]: • Digital Competences Development Methodology(DCDM): for the development of digital competences and related transversal skills of adults; • Digital Competences Development Environment(DCDE): Consisting of a self-assessment tool, online management tools, online learning application, multilingual digital open educational resources, validation & certification of digital competences; • Personalised blended non-formal training: composed by training modules which combine online learning with face-to-face support sessions by e-facilitators • Handbooks and course guides: for implementing the methodology to assist the trainers and the training providers in planning and delivering flexible and modular training offers • Policy Influence Toolkit: which includes policy recommendations on e-Inclusion, Adult Education and Digital Skills Agenda.

	Learning outcomes for basic digital competence in [2] have been defined in accordance with DigComp 2.1framework. List of skill covered in this project includes: 4.1 Protecting devices 4.2 Protecting personal data and privacy 5.3. Creatively using digital technology (Involves ability to simply explain what new tools and services are such as: online collaboration environments, augmented/virtual reality, robots, voice commands, intelligent assistants, drones, 3D printing, internet of things.)
References:	1. https://eaea.org/our-work/projects3/dcds/ 2. http://www.dcds-project.eu/wp-content/uploads/2019/02/D6_DCD-Methodology-_v1_revised.pdf

Title:	**ICT Security in VET**
Acronym (if any):	**ITSVET**
Website:	http://database.centralbaltic.eu/project/5
Period:	01.12.2015 – 31.03.2019
Source of funding:	Interreg (Central Baltic Programme)
Partners: (Latvian partners in bold)	• The Technology Education Support Foundation (Igaunija)- coordinator • BCS Koolitus AS (Igaunija) • Tallinn Polytechnic School (Igaunija) • **Riga Technical College (Latvija)** • Helsinki Business College (Somija) • **The Latvian Information and Communications Technology Association – LIKTA (Latvija)** • Foundation Innove (Igaunija)
Short overview:	"The project ITSVET aims at developing a model for providing ICT security skills on the vocational education level. Reports show that demand for ICT security professionals has grown faster over the past five years than demand for other ICT jobs. Thus, the objective of the project is to meet the needs of the region's employers through developing a VET model for the ICT security specialists to reduce the skill gap of the labour market in the Central Baltic region. The consortium brings together ICT employers, vocational education institutions and vocational education regulatory bodies." [1]
Main results in regard to Industry 4.0:	The results of this project [1]: 1) Competence Standard (based on the analysis of ICT Security skills needs on the labour market); 2) Curricula in four languages (english, estonian, finnish, latvian) 3) Learning resources (in estonian, latvian and finnish); 4) Skilled and competent VET institution teachers for teaching ICT security; 5) Curriculums teaching plan (teaching methods, relevant resources and methodologies.) 6) Piloted and evaluated curriculum (in all three partner schools)
References:	1. http://database.centralbaltic.eu/project/5

Title:	**Speeding up network internationalization of food, ICT Industry 4.0 clusters and their SMEs towards strategic third countries beyond Europe in field of emerging industries and Fast Moving Consumer Goods (FMCG**

	4.0)
Acronym (if any):	**AUMENTA**
Website:	https://www.itbaltic.com/single-post/aumenta
Period:	01.09.2020 – 01.03.2022
Source of funding:	European Union's small and medium-sized enterprises (SMEs) competitiveness program "COSME"
Partners: (Latvian partners in bold)	• **Latvian IT Cluster (Latvia)- coordinator** • Agrofood and Bioeconomy Cluster (Poland) • SMART food cluster (Lithuania) • **Food Products Quality Cluster (Latvia)** • Asociación Cluster Granada Plaza Tecnologica y Biotecnologica (Spain) • Morocco • Georgia • Uruguay
Short overview:	From [1]: "The Project's overall aim is to implement and test joint internationalization strategy aimed at supporting SMEs to identify growth opportunities worldwide, increase the internationalisation of SMEs, augment business and cooperation opportunities with strategic partners in third countries beyond Europe and facilitate their integration into global value chains. [..] The project interconnects of five relevant and complementary partners from four countries (ES, PL, LT, LV) uniting high technology clusters (ICT/ Industry 4.0) with traditional sectors (food) towards jointly and consciously selected third countries beyond Europe: Morocco - as a strategic gate to North African/ South-Mediterranean (MEDA) markets; Georgia - as a strategic gate to Caucasus & post-URSS markets; Uruguay - as a strategic gate to Latin American markets to lead international cluster cooperation in field of emerging industries: -Food 4.0. -Industry 4.0 applied to agrofood industry -Fast Moving Consumer Goods (FMCG 4.0) and development of international commerce and eCommerce."
Main results in regard to Industry 4.0:	Expected results published in [2] are: • Number of cluster organisations and business networks from different COSME participating countries having benefited from the supported actions – 5 • Number of cooperation agreements resulting from the supported actions – 15 • Number of business agreements resulting from the supported actions – 20 • Number of events (workshops/ matchmaking events/ working group meetings) organised – 12 • Number of cluster and business matchmaking meetings supported – 48 • Number of SMEs having directly or indirectly benefited from the supported actions, resulting in cooperation projects – 30 • Increase in the percentage of the turnover from international activities, and employment in Europe, of the SMEs having benefited directly and indirectly from the supported actions, as measured through a survey by the end of the action – 5% • Impact of the supported actions in terms of number of resulting

	cooperation projects between international cluster and business network partners – 3
References:	1. https://www.itbaltic.com/single-post/aumenta 2. https://clustercollaboration.eu/eu-cluster-partnerships/escp4i/speeding-network-internationalization-food-ict-industry-40-clusters-and-their#section-5

Title:	**Integrated Components for Complexity Control in affordable electrified cars**
Acronym (if any):	**3Ccar**
Website:	**https://cordis.europa.eu/project/id/662192**
Period:	01.06.2015 – 31.10.2018
Source of funding:	Horizon 2020
Partners: (Latvian partners in bold)	INFINEON TECHNOLOGIES AG (Germany)- coordinator **Institute of Electronics and computer science (EDI) (Latvia)** and 45 more partners from Austria, Belgium, Czech Republic, Finland, France, Germany, Italy, Lithuania, Netherlands, Romania, Spain, Taiwan, United Kingdom
Short overview:	"3Ccar's impact is maximizing pragmatic strategy: Use semiconductor technology innovations to manage functionality & complexity increase. This leads also to cheaper, efficient, robust, comfortable, reliable and usable automotive systems. This strengthens Europe as a whole (OEM, Tier1, Semiconductor) generating economic growth and new jobs in Europe. The impact of 3Ccar is driven vertically by innovations and horizontally enabling growth and deployment in the industry based on what we see as European Values. We recognized that European engineers develop for highest efficiency, convergence and manageable complexity. [..] The technologies developed in 3Ccar will be commercialized all over the world while giving advantages to Europe's OEMs willing to manufacture in Europe. 3Ccar will be involved in standardization needed to ensure that large vertical supply chains can be established." [1]
Main results in regard to Industry 4.0:	As a result, 32 systems and products are being introduced to the market and/or being prepared for market introduction in the years 2018- 2025 [2].
References:	1. https://cordis.europa.eu/project/id/662192/results 2. https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5be166d82&appId=PPGMS

Title:	**Internet of Things as a policy instrument for the city change**
Acronym (if any):	**IoTXchange**
Website:	https://urbact.eu/iotxchange
Period:	02.09.2019–13.05.2022
Source of funding:	URBACT
Partners: (Latvian partners in bold)	• Fundão (Portugal)- coordinator • Razlog (Bulgaria) • Dodoni (Greece) • Åbo Akademi University (Finland) • Nevers Agglomération (France) • **Jelgava Local Municipality (Latvia)** • Ånge (Sweden)

	• Kežmarok (Slovakia)
Short overview:	"Internet of Things as a policy instrument for the city change. It encourages the creation of a network of European partners committed to the **design of digitalization plans based on Internet of Things (IoT) solutions** to increase the quality of life in small and medium sized EU cities. URBACT methodology based on transnational cooperation between cities and engagement of local groups offer to our network of 9 cities the conditions to each develop an Integrated Action Plan that will guide us through a new age of digital transformation." [1]
Main results in regard to Industry 4.0:	Planned results of a project as can be found on [2]: "Develop an action plan for municipality how it can use the Internet of Things for creating a smart city. Action plan covers various areas like administration, safety, health, education, enterpreneurship etc. (As stated in [3]: the period for action plan is 2022-2032.)
References:	1. https://urbact.eu/iotxchange 2. http://www.jelgavasnovads.lv/lv/pasvaldiba/projekti/paslaik-istenosana/interreg-iii-urbact/15275/lietu-internets-ka-politikas-instruments-parmainam-pasvaldiba-iotxchange/ 3. https://www.facebook.com/IoTXchange.URBACT

Title:	**Innovative Open Education on IoT: improving higher education for European digital global competitiveness**
Acronym (if any):	**IOT-OPEN.EU**
Website:	https://erasmus-plus.ec.europa.eu/projects/eplus-project-details#project/2016-1-PL01-KA203-026471
Period:	01.09.2016 – 31.08.2019
Source of funding:	Erasmus+
Partners: (Latvian partners in bold)	• Politechnika Slaska (Poland) • Universita Degli Studi Di Messina (Italy) • Itt Group (Estonia) • Tallinna Tehnikaulikool (Estonia) • **Rigas Tehniska Universitate (Latvia)** • Saint Petersburg National Research University Of Information Technologies, Mechanics And Optics (Russia)
Short overview:	"IOT-OPEN.EU project is aimed at bridging the gap between what higher education offers and what the European labor market needs in the field of Internet of Things - one of the most fast growing and promising areas in the world of information and communication technologies. [..] The IOT-OPEN.EU project offers students and teachers an array of possibilities to discover how digitalisation of education can bring significant quality improvements and make learning outcomes more relevant to the labour market needs. The project introduces virtual remote laboratories and open e-learning materials within one innovative multidisciplinary teaching module on the Internet of Things. It will allow students from Bachelor's to Master's levels and adult learners to experience capabilities of the Internet of Things devices both in theory and in practice." [1]
Main results in regard to Industry 4.0:	"IOT-OPEN.EU delivers content for classical IOT courses held at the universities or companies, MOOC online courses available through the web and provides access to the physical devices so-called VREL distant/remote access IoT laboratories." [2]

	Open access course book on Internet of Things (available in Latvian here: https://ec.europa.eu/programmes/erasmus-plus/project-result-content/92252e46-43c8-4ccc-9935-590bdb8ba9fe/iot-open.eu-LV.pdf) On 17.04.2020 it was reported that: "we've already hit far over 10K students, studying IOT-OPEN.EU content from virtually all over the world at the moment."[3]
References:	1. https://robolabor.ee/et/content/13-iot-open 2. https://erasmus-plus.ec.europa.eu/projects/eplus-project-details#project/2016-1-PL01-KA203-026471 3. https://www.linkedin.com/pulse/project-iot-openeu-innovative-open-education-iot-higher-di-pietro

Title:	**Advancing fail-aware, fail-safe, and fail-operational electronic components, systems and architectures for fully automated driving to make future mobility safer, affordable and end-user acceptable**
Acronym (if any):	**AutoDrive**
Website:	https://autodrive-project.eu/
Period:	01.05.2017 - 30.06.2020
Source of funding:	Horizon2020 ESCEL
Partners: (Latvian partners in bold)	• INFINEON TECHNOLOGIES AG (Germany)- coordinator • **Institute of Electronics and Computer Science (EDI) (Latvia)** • In total 58 partners from 13 countries: Germany, Austria, Spain, Italy, Latvia, Norway, Belgium, Czech Republic, Netherlands, Taiwan, Sweden, Finland, Lithuania
Short overview:	"Automated driving is a disruptive technology which opens the door to future multi-billion markets providing business opportunities to value chains in automotive and semiconductor industry. The European industry has leading competitive strength in the development and manufacturing of highly reliable electro-mechanical systems. In order to preserve this capability Europe needs to setup European standards for high level control such as real-time computing or big data processing. In order to respond on the global challenge AutoDrive has gathered Europe's leading semiconductor companies, suppliers, OEMs, and research institutes committed to create a pan-European eco-system, which has the critical mass to initiate standards and provides the components and subsystems for automated driving. [..] AutoDrive aims for the design of (i) fail-aware (self-diagnostics), (ii) fail-safe, (iii) fail-operational (HW and SW redundancy) electronic components and systems architecture that enable the introduction of automated driving in all car categories. AutoDrive results will significantly contribute to safer and more efficient mobility. It will raise end-user acceptance and comfort by supporting drivers in highly challenging situations (active safety) as well as in regular driving situations."[1] " AutoDrive is a European project focusing on the development of connected, electric and highly automated vehicles with special focus on safety. [..] With diverse background of all the partners, AutoDrive aims to find synergies among different aspects of autonomous driving. From the

	development perspective, it covers the whole development lifecycle from requirement analysis to validation and Test. From the product perspective, it includes most of the automotive functional components for automated driving such as perception, communication, decision, control and the electrical powertrain. From the technical perspective, it considers software, hardware, system architecture and safety."[4] Source [5] summarises **main aims** of the project: ● Fully automated driving and flying systems targeting SAE level; ● Highly automated driving SAE Level 4; ● Cooperative active safety for automated driving; ● Fail-operational 800V automotive powertrain ● Safe, secure and low latency communication ● Acquisition, 360° sensing, perception, and environmental awareness; ● Embedded intelligence and systems for automated driving; ● Fail aware components and health prediction.
Main results in regard to Industry 4.0:	It was concluded that during project 102 described, standardization and commercial exploitation results with exploitation routes were established. Whereas 83 scientific publications were released! 63 events attended! 36 project videos produced [..][3] The main results of the project are mentioned in [6]: ● 2 free assembled product prototypes (Shuttle Pod and Aircraft); ● Automated bus; ● Improved road scanning; ● Developed new active safety features (Cooperative automated emergency brake assistant, Fault tolerant lateral controller); ● New automotive power chain (Fail-operational, 800V, Stochastic drift model, weakness monitor); ● New reliable v2x communication system; ● Certification and standardization of automated driving systems (2 draft regulations: cybersecurity engineering and Software-update OTA [Over The Air update]); ● Traffic simulation tool;
References:	1. https://cordis.europa.eu/project/id/737469 2. https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5cfda8446&appId=PPGMS 3. https://autodrive2.automotive.oth-aw.de/news/201-autodrive-s-super-final-review-accomplished 4. https://www.kth.se/mmk/mechatronics/current-projects/autodrive-1.779888 5. https://autodrive2.automotive.oth-aw.de/images/dissemination/AutoDrive_Poster_EFECS2018.pdf 6. https://autodrive2.automotive.oth-aw.de/videos

Title:	**DIGINNO-Proto e-CMR prototype**
Acronym (if any):	**DIGINNO-Proto**
Website:	https://www.diginnobsr.eu/diginno-proto
Period:	July 2019 - December 2020
Source of funding:	Nordic Council of Ministers
Partners:	● Ministry of Economic Affairs and Communications (Estonia)-

(Latvian partners in bold)	coordinator • Associative partners: • **Latvian Information and Communication Technology Association (LIKTA) (Latvia)** • Lithuanian Information and Communication Technology Association (INFOBALT) (Lithuania) • Polish Chamber of Commerce for Electronics and Telecommunications (KIGEIT) (Poland) • **LMT (Latvia)** Alongside LMT, the pilot project participants from Latvia were the Latvia State Radio and Television Centre, Latvian Information and Communications Technology Association, the Ministry of Transport of Latvia, State Revenue Service, Freeport of Riga, Road Transport Administration, logistics companies, and other representatives of both private and public sector [4].
Short overview:	"DIGINNO-Proto project is a sub-project supporting and extending the DIGINNO project activities. [..] DIGINNO-Proto project was initiated to demonstrate one of these show-cases (eCMR) through prototyping."[1] "The prototype objective was to create an eCMR indexing prototype for paperless international logistics. It aimed to allow the service providers to index their active eCMRs and the controlling institutions to check the availability of CMR transport documents of the foreign road carriers driving through their territory in a secure and trustful way. With the use of the indexing service and the indexing number of an eCMR, the appointed government institutions of the involved country would be able to see where the eCMR is stored and receive agreed available data."[2]
Main results in regard to Industry 4.0:	The project partners developed a common cross-border indexing scheme – from the principles to the working prototype which was tested with cross-border test cases and against live eCMR service providers [2]. The prototype will allow a regional shift from paper CMR to eCMR – an opportunity for both businesses and authorities to gain efficiency and transparency through digitalization [2]. The prototype will enable businesses to manage their supply chain more effectively and simplify communication with public authorities: once the eCMR document is created, it can be shared electronically with the necessary authorities or business partners [2]. Cross-border prototype testing was carried out across all participating countries – Estonia, Latvia, Lithuania, Poland - in August and September 2020 in cooperation with governmental institutions (Tax and Customs Board, Police, Road Administration, etc.) together with private sector eCMR service providers and road carriers [3].

References:	1. https://www.diginnobsr.eu/diginno-proto 2. https://www.diginnobsr.eu/ecmr 3. https://www.diginnobsr.eu/ecmr-testing-results 4. https://innovations.lmt.lv/projects/e-cmr-documentation-digitization/

Title:	**Real-time AI urban video analytics**
Acronym (if any):	N/A
Website:	https://innovations.lmt.lv/projects/real-time-ai-urban-video-analytics/
Period:	in development
Source of funding:	Unknown
Partners: (Latvian partners in bold)	• **LMT (Latvia)** • Fyma (Estonia)
Short overview:	Using AI to transform urban data into valuable information that ensures increased road safety and traffic optimization [1].
Main results in regard to Industry 4.0:	"LMT has partnered with Fyma, an Estonia-based company that offers a GDPR-compliant computer vision solution that turns any CCTV camera into an intelligent analytics tool. LMT plays a crucial role in delivering the real time AI video analytics solution to its potential users. We set up, configure, and provide maintenance for certified network cameras, and securely send the video stream via the 4G network to Fyma servers. There, the stream is analyzed using multiple neural networks to obtain actionable data. LMT can provide reliable analytics in locations that lack infrastructure, and without our input and support the real time AI video analytics wouldn't be so widely available. Only the necessary data points obtained from the video stream are saved (no video footage or photos are saved in any format), ensuring data privacy and full compliance with GDPR regulations."[1]
References:	1. https://innovations.lmt.lv/projects/real-time-ai-urban-video-analytics/

Title:	**Intelligent Motion Control Platform for Smart Mechatronic Systems**
Acronym (if any):	**I-MECH**
Website:	https://cordis.europa.eu/project/id/737453
Period:	01.07.2017 – 31.05.2020
Source of funding:	Horizon2020 EU.2.1.1.7.
Partners: (Latvian partners in bold)	• SIOUX TECHNOLOGIES BV (Netherlands)- coordinator • **Institute of Electronics and Computer Science (EDI) (Latvia)** • and 30 more from Chech Republic, Netherlands, Spain, Greece, Portugal, Belgium, Italy, France, Ireland
Short overview:	"The I-MECH target is to provide augmented intelligence for wide range of cyber-physical systems having actively controlled moving elements, hence support development of smarter mechatronic systems. They face increasing demands on size, motion speed, precision, adaptability, self-diagnostic, connectivity, new cognitive features, etc. Fulfilment of these requirements is essential for building smart, safe and reliable production complexes. This implies completely new demands also on bottom layers of employed motion control system which cannot be routinely handled by available commercial products. On the ground of this, the main mission of this project is to bring novel intelligence into Instrumentation and Control

	Layers mainly by bridging the gap between latest research results and industrial practice in related model based engineering fields. Next, I-MECH will deliver new interfaces and diagnostic data quality for System Behavior Layer. It strives to provide a cutting edge reference motion control platform for non-standard applications where the control speed, precision, optimal performance, easy reconfigurability and traceability are crucial. The high added value of I-MECH reference platform will be directly verified in high-speed/big CNC machining, additive manufacturing, semicon, high-speed packaging and healthcare robotics. In these sectors, the main project pilots will be validated. However, the platform will be applicable in many other generic motion control fields. The project outputs will impact on the entire value chain of the production automation market and, through envisioned I-MECH center, create sustainable proposition for future smart industry."[1]
Main results in regard to Industry 4.0:	"The EU-funded I-MECH project developed a framework to employ advanced control solutions in industrial settings. The chosen approach is known as model-based systems engineering. The project developed 11 building blocks that (among other functions) monitor or control industrial processes to find incremental improvements.[..] The team applied its building blocks to five pilot applications, which use machinery developed by project partners. The applications include a generic substrate carrier, which is the conveyor component of large-format inkjet printers, and a 12" wafer stage of semiconductor manufacture. The remainder cover a teabag machine, a computer numerical control (CNC milling machine) and a healthcare robot that moves an X-rays system around patients that lie on a table. In each case, the systems received upgrades identified by the building blocks. Eventually, all building blocks, and an entire toolchain, will be available for industrial customers, who will be able to select just the building blocks they need for their specific application." Хзъ As reported in [2] EDI (Latvia) in this project is developing smart wireless sensor networks and algorithms for real-time mechatronic systems.
References:	1. https://cordis.europa.eu/project/id/737453 2. https://www.edi.lv/projects/intelligent-motion-control-platform-for-smart-mechatronic-systems-i-mech/ 3. https://cordis.europa.eu/article/id/422568-embedded-algorithms-design-faster-and-more-accurate-industrial-and-health-care-equipment

Title:	**Programmable Systems for Intelligence in Automobiles**
Acronym (if any):	**PRYSTINE**
Website:	https://cordis.europa.eu/project/id/783190
Period:	01.05.2018 – 31.10.2021
Source of funding:	Horizon 2020 ECSEL Joint Undertaking
Partners: (Latvian partners in bold)	• INFINEON TECHNOLOGIES AG (Germany)-coordinator • **Institute of Electronics and Computer Science (EDI) (Latvia)** • And 59 other partners from: Italy, Israel, Netherlands, Austria, Spain, Turkey, Greece, Finland, Romania, Lithuania, Germany, Belgium, Sweden
Short overview:	"The ambition of PRYSTINE is to strengthen and to extend traditional core

	competencies of the European industry, research and universities in smart mobility and in particular the electronic component and systems and cyber-physical systems domains. PRYSTINE's target is to realize Fail-operational Urban Surround perceptION (FUSION) which is based on robust Radar and LiDAR sensor fusion and control functions in order to enable safe automated driving in urban and rural environments. Therefore, PRYSTINE's high-level goals are: 1. Enhanced reliability and performance, reduced cost and power of FUSION components 2. Dependable embedded control by co-integration of signal processing and AI approaches for FUSION 3. Optimized E/E architecture enabling FUSION-based automated vehicles 4. Fail-operational systems for urban and rural environments based on FUSION."[1]
Main results in regard to Industry 4.0:	The main results of PRYSTINE project are novel Radar sensors, innovative embedded control and E/E architectures, pioneering sensorfusion approaches and AI-controlled vehicle demonstrators.[2] As reported in [2] EDI (Latvia) in this project is developing and implementing progressive AI algorithms for CPU/SOC/GPU based system. These algorithms are aimed at fusing data from LiDAR, stereo-camera and radar, detection and classification of objects, prediction of motion and decision-making with an emphasis on precision, reliability, safety and cost efficiency.
References:	1. https://cordis.europa.eu/project/id/783190 2. https://www.academia.edu/57339103/Programmable_Systems_for_Intelligence_in_Automobiles_PRYSTINE_Final_results_after_Year_3

Title:	**Aggregate Farming in the Cloud**
Acronym (if any):	**AfarCloud**
Website:	https://cordis.europa.eu/project/id/783221
Period:	01.09.2018 – 30.11.2021
Source of funding:	H2020-ECSEL
Partners: (Latvian partners in bold)	• UNIVERSIDAD POLITECNICA DE MADRID (Spain)- coordinator • **LATVIJAS UNIVERSITATES MATEMATIKAS UN INFORMATIKAS INSTITUTS (Latvia)** • And 60 more partners from: Spain, Germany, Belgium, Austria, Portugal, Norway, Sweden, Finland, Czechia, Poland, Italy and Greece
Short overview:	"AFarCloud will provide a distributed platform for autonomous farming that will allow the integration and cooperation of agriculture Cyber Physical Systems in real-time in order to increase efficiency, productivity, animal health, food quality and reduce farm labour costs. This platform will be integrated with farm management software and will support monitoring and decision- making solutions based on big data and real time data mining techniques. The AFarCloud project also aims to make farming robots accessible to more users by enabling farming vehicles to work in a cooperative mesh, thus opening up new applications and ensuring re- usability, as heterogeneous standard vehicles can combine their capabilities in order to lift farmer revenue and reduce labour costs. The achievements from AFarCloud will be demonstrated in 3 holistic

	demonstrators (Finland, Spain and Italy), including cropping and livestock management scenarios and 8 local demonstrators (Latvia, Sweden, Spain and Czech Republic) in order to test specific functionalities and validate project results in relevant environments located in different European regions."[1] "[..] AFarCloud project assumes the urgent need of a holistic and systematic approach, through smart sustainable and digital automated production. According to this view precision farming needs to consider orchestration of different application capabilities like data collection and cloud computing, a sensing-on-the-move approach, cyber physical systems (CPS) management, IoT sensing and actuation, decision support systems, autonomous vehicles (UAVs/UGVs) for most aspects of agricultural processes."[2]
Main results in regard to Industry 4.0:	Planned impact of the project as reported in [2]: ● Enhance the applications of Cyber-Physical Systems in the farming domain ● Improve the autonomy and cooperation of farming CPS solutions ● Increase the interoperability, cooperation, and reuse of CPS and autonomous vehicles achieving a better level of reduction of human labor ● Enable reliable, high-performance, real-time and secure data exchange for CPS. Guaranteeing the exchange of data in real-time is a critical safety requirement for systems that operate with autonomous vehicles. In addition, obtaining measurements in real-time is essential both in the monitoring of crops, in order to detect as quickly as possible harmful conditions for crops, such as ice or frost, as well as in the monitoring of livestock, to react quickly to any change in the health of animals, such as diseases or a calving ● Generate a direct impact and innovation in the EU farming and mechatronics industry, by providing new standards in the UAV [Unmanned Aerial Vehicles] and UGV [Unmanned Ground Vehicles] industry, in order to demonstrate and apply a structured and cost-effective approach to the development of new farming solutions.
References:	1. https://cordis.europa.eu/project/id/783221 2. https://www.sciencedirect.com/science/article/pii/S0141933120303793

Title:	**Full title: Digital Technologies, Advanced Robotics and increased Cyber-security for Agile Production in Future European Manufacturing Ecosystems**
Acronym (if any):	**TRINITY**
Website:	https://cordis.europa.eu/project/id/825196
Period:	01.01.2019 – 30.06.2023
Source of funding:	Horizon2020 - EU.2.1.1.
Partners: (Latvian partners in bold)	• Tampereen Korkeakoulusaatio SR (Finland)- coordinator • Centria Ammattikorkeakoulu OY (Finland) • Universitetet I Tromsoe - Norges Arktiske Universitet (Norway) • Institut Jozef Stefan (Slovenia) • Panepistimio Patron (Greece) • Budapesti Muszaki Es Gazdasagtudomanyi Egyetem (Hungary)

	• Fraunhofer Gesellschaft Zur Forderung Der Angewandten Forschung Ev (Germany) • Flanders Make (Belgium) • **Elektronikas Un Datorzinatnu Instituts (Latvia)** • Leuven Security Excellence Consortium L-Sec Vzw (Belgium) • Fastems Oy Ab (Finland) • Lp-Montagetechnik Gmbh (Germany) • F6s Network Limited (United Kingdom) • Uab Civitta (Lithuania) • Comite Europeen De Cooperation Des Industries De La Machine-Outil Cecimo Aisbl (Belgium) • Toppindustrisenteret As (Norway)
Short overview:	"The main objective of TRINITY is to create a network of multidisciplinary and synergistic local digital innovation hubs (DIHs) composed of research centers, companies, and university groups that cover a wide range of topics that can contribute to agile production: advanced robotics as the driving force and digital tools, data privacy and cyber security technologies to support the introduction of advanced robotic systems in the production processes. The result will be a one-stop shop for methods and tools to achieve highly intelligent, agile and reconfigurable production, which will ensure Europe's welfare in the future. The network will start its operation by developing demonstrators in the areas of robotics we identified as the most promising to advance agile production, e.g. collaborative robotics including sensory systems to ensure safety, effective user interfaces based on augmented reality and speech, reconfigurable robot workcells and peripheral equipment (fixtures, jigs, grippers, …), programming by demonstration, IoT, secure wireless networks, etc. These demonstrators will serve as reference implementation for two rounds of open calls for application experiments, where companies with agile production needs and sound business plans will be supported by TRINITY DIHs to advance their manufacturing processes. Besides technology-centered services, primarily laboratories with advanced robot technologies and know-how to develop innovative application experiments, TRINITY network of DIHS will also offer training and consulting services, including support for business planning and access to financing."[1]
Main results in regard to Industry 4.0:	This is an ongoing project, planned results are stated in the description given above. The role of EDI is described in [2]: "The main role of the EDI(Latvia) is to carry out experiments in co-operation with companies and collaborate to build on new calls as well as to strongly support dissemination and communication/networking activities. Also, EDI will take part in Business planning and TRINITY education & training knowledge transfer. Besides that, EDI will provide access to EDI IoT/WSN 100 node heterogeneous sensor network and wireless sensor network testbed (distributed around 7 floor building (inside & outside)) for validation and research in sensor network & wireless network protocols (additionally, 50 mobile nodes are available on site and can be moved to actual factory, to perform the tests in real production/manufacturing environment). EDI will provide best practices for rapid development of WSN/IoT systems.

	Created Impact: Decreased development and testing time/costs of WSN/IoT systems; Decreased time to market for large scale WSN/IoT networks in production environment; Smarter and more efficient production and manufacturing in factories. Also, EDI will provide access to ANN [Artificial Neural Network] algorithms and methods for object detection, recognition, classification, control, etc., which can be used for thousands of vision-based systems applications to automate/optimize different industrial processes. EDI will provide best practices for custom ANN development and use. Created Impact: Lower development costs; Rapid development; Smarter, optimized and more efficient production and manufacturing in factories."
References:	1. https://cordis.europa.eu/project/id/825196 2. https://www.edi.lv/en/projects/digital-technologies-advanced-robotics-and-increased-cyber-security-for-agile-production-in-future-european-manufacturing-ecosystems-trinity-2/

Title:	**Framework of key enabling technologies for safe and autonomous drones' applications**
Acronym (if any):	**COMP4DRONES**
Website:	https://www.comp4drones.eu/
Period:	01.10.2019 – 30.09.2022
Source of funding:	ECSEL JU
Partners: (Latvian partners in bold)	• Indra Sistemas Sa (Spain)- Coordinator • **Elektronikas Un Datorzinatnu Instituts (Latvia)** • **Latvijas Universitates Matematikas Un Informatikas Institutes (Latvia)** • **Latvijas Mobilais Telefons SIA (Latvia)** • and 57 more partners from Spain, Austria, Belgium, Czechia, France, Italy, Netherlands and Belgium
Short overview:	"The COMP4DRONES project complements SESAR JU efforts with a particular focus on safe software and hardware drone architectures. COMP4DRONES will bear a holistically designed ecosystem ranging from application to electronic components, realized as a tightly integrated multi-vendor and compositional drone embedded architecture solution and a tool chain complementing the compositional architecture principles. The ecosystem aims at supporting efficient customization and incremental assurance of drone embedded platforms, safe autonomous decision making concerning individual or cooperative missions, trustworthy drone-to-drone and drone-to-ground communications even in presence of malicious attackers and under the intrinsic platform constraints, and agile and cost-effective compositional design and assurance of drone modules and systems. COMP4DRONES will also build an open sustainable ecosystem around public, royalty-free and goal-driven software platform standards that will ease the development of new drone functionalities for multiple application domains. Lead applications driving ecosystem development and benchmarking on the fields of transport, infrastructure inspection, urban logistic, precision agriculture, parcel delivery, among others, will be produced."[1] "The project will mainly focus on the following objectives:

	– Ease the integration and customization of embedded drone systems. – Enable drones to take safe autonomous decisions. – Ensure the deployment of trusted communications. – Minimize the design and verification effort for complex drone applications."[2]
Main results in regard to Industry 4.0:	Results mentioned in [5] that have been created with this project include (some of them not yet finished as the project hasn't concluded yet): ● Drones regulations compliance handbook [3]; ● Specification of Integrated and Modular Architecture for Drones[4]; ● Safe and reconfigurable UAV [Unmanned Aerial Vehicle] software components that support autonomous decision making; ● Robust and efficient UAV communication infrastructure that ensures trustworthy drone-to-drone and drone-to-ground communications. As stated in [2]: EDI will develop a modular, highly adaptable and power efficient embedded platform for sensor data acquisition, fusion and processing in drones.
References:	1. https://www.comp4drones.eu/project-info/overview/ 2. https://www.edi.lv/en/projects/framework-of-key-enabling-technologies-for-safe-and-autonomous-drones-applications-comp4drones-2/ 3. https://www.comp4drones.eu/wp-content/uploads/2022/03/C4D_D2.5_D2.5-%E2%80%93-Drones-regulations-compliance-handbook_v3.1.pdf 4. https://www.comp4drones.eu/wp-content/uploads/2021/02/C4D_D3.1_Specification-of-Integrated-and-Modular-Architecture-for-Drones_v1.5.pdf 5. https://aeneas-office.org/funding/ecsel-ju/ecsel-projects-overview/comp4drones-3/

Title:	**Strategic programs for advanced research and technology in Europe**
Acronym (if any):	**SPARTA**
Website:	https://www.sparta.eu/
Period:	01.02.2019 – 31.01.2022
Source of funding:	H2020-EU.2.1.1.
Partners: (Latvian partners in bold)	• Commissariat A L Energie Atomique Et Aux Energies Alternatives (France)- coordinator • **Latvijas Mobilais Telefons SIA (Latvia)** • And 45 others from Austria, Belgium, Czechia, Germany, Estonia, Greece, Spain, France, Italy, Lithuania, Luxembourgh, Poland and Portugal
Short overview:	"The digital era has brought with it many advantages for mankind, but the issue of secure data exchange remains among the most significant concerns. The EU-funded SPARTA project is bringing together a unique set of actors at the crossroads of scientific excellence, technological innovation and social sciences to address the issue of cybersecurity. The project aims to set up unique collaborations, build transformative capabilities and form world-leading expertise centres. Through innovative governance, ambitious demonstration cases and active community engagement, SPARTA intends to re-think the way cybersecurity research is performed in Europe across various domains and fields of expertise."[1]

	SPARTA will create a long-lasting community capable of collaboration to define, develop, share, and evolve solutions that will help practitioners prevent cybercrime and enhance cybersecurity [3].
Main results in regard to Industry 4.0:	In [2] these results are listed among others: ● International and national cybersecurity certification initiatives ● Cybersecurity skills framework ● AI systems threat analysis mechanisms and tools ● Security-by-design framework for the intelligent infrastructure
References:	1. https://cordis.europa.eu/project/id/830892 2. https://cordis.europa.eu/project/id/830892/results 3. https://www.sparta.eu/#Structure

Title:	**Development of a robotic weed management equipment**
Acronym (if any):	**RONIN**
Website:	https://www.zm.gov.lv/lauku-attistiba/statiskas-lapas/projekts-robotizetas-nezalu-ierobezosanas-iekartas-izveide-?id=19468#jump
Period:	01.01.2019 - 31.12.2020
Source of funding:	European Agricultural Fund for Rural Development, Rural development 2014-2020 for Operational Groups
Partners: (Latvian partners in bold)	• **Latvia University of Life Sciences and Technologies (Latvia)- coordinator** • **Institute of Electronics and Computer Science (EDI) (Latvia)** • **Lejasvagaļu dārzs SIA (Latvia)** • **J. Lipska saimniecība "Absolūts Ēd" (Latvia)** • **Atvases ZS (Latvia)**
Short overview:	Source [1] sumarizes the goal of the project: "Within the project it is planned to develop a weed management equipment that would be able to autonomously move on a field and identify weeds and crops, as well as a high-power laser or precisely positioned mechanical tool is going to be used, to destroy the weed or considerably hinder its further growth."
Main results in regard to Industry 4.0:	Outcomes of this project as reported in [2] are: ● A functioning prototype of a weed management robot that can autonomously move to the field, move along the row of crops, detect and destroy weeds using laser or a mechanical tool. ● An algorithm for detecting weeds (based on deep learning with convolutional neural networks). ● An algorithm for detecting a row of crops.
References:	1. https://www.edi.lv/en/projects/development-of-a-robotic-weed-management-equipment-ronin/ 2. https://www.zm.gov.lv/public/ck/files/Nosleguma_parskats_RONIN_V2.pdf

Title:	**Automotive Intelligence for/at Connected Shared Mobility**
Acronym (if any):	**AI4CSM**
Website:	https://ai4csm.automotive.oth-aw.de/
Period:	01.05.2021. - 30.04.2024.
Source of funding:	Horizon 2020 ECSEL Joint Undertaking
Partners: (Latvian partners in bold)	• Infineon Technologies AG- coordinator • **Institute of Electronics and Computer Science (EDI) (Latvia)**

	• **Smartsol SIA (Latvia)** • And 38 others from Germany, Austria, Norway, Belgium, Czech Republic , Italy, Netherlands , Lithuania, India.
Short overview:	"Digital technologies are a significant enabler for attaining sustainability goals in mobility and transportation. The EC is taking initiatives to ensure that digital technologies such as AI, 5G, IoT, and cloud/edge computing can accelerate the transition of the automotive industry to electrical, autonomous, connected, and shared vehicles. [..] The AI4CSM project will develop advanced electronic components and systems (ECS) and architectures for future mass-market ECAS vehicles. [..] AI4CSM will deliver key innovations in technical areas including sensor fusion and perception platforms; efficient propulsion and energy modules; advanced connectivity for cooperative mobility applications; vehicle/edge/cloud computing integration concepts; new digital platforms for efficient and federated computing; and intelligent components based on trustworthy AI techniques and methods. ECAS vehicles enabled by embedded intelligence and functional integration for future mobility become the pivotal factor for the automotive sector to address the Green Deal principles. "[1]
Main results in regard to Industry 4.0:	Planned results described in overview section. According to [1], EDI will develop hardware for AI-based near field, high resolution 360- degree perception system, AI algorithms for the detection and classification of different surrounding objects with high accuracy, and implementation of developed algorithms in Infineon Aurix PPU.
References:	1. https://www.edi.lv/en/projects/10788/

Title:	**Trustworthy and Smart Actuation in IoT systems**
Acronym (if any):	**ENACT**
Website:	https://www.enact-project.eu/
Period:	01.01.2018 – 31.12.2020
Source of funding:	H2020
Partners: (Latvian partners in bold)	• Sintef As (Norway)- Coordinator • Ca Technologies Development (Spain) • Ca Spolka Z Ograniczona Odpowiedzialnoscia (Poland) • Ca Technology R&D Limited (United Kingdom) • Evidian Sa (France) • Indra Sistemas Sa (Spain) • Fundacion Tecnalia Research & Innovation (Spain) • Tellu As (Norway) • Centre National De La Recherche Scientifique Cnrs (France) • Universite Cote D'azur (France) • Universitaet Duisburg-Essen (Germany) • Istituto Per Servizi Di Ricovero E Assistenza Agli Anziani (Italy) • **Baltic Open Solutions Center (Latvia)** • **Institute Of Electronics And Computer Science (EDI) (Latvia)** • Stiftelsen Sintef (Norway) • Tellu Iot As (Norway) • Montimage Eurl (France) • Beawre Digital Sl (Spain)

Short overview:	"To unleash the full potential of IoT, realizing the digital society and flourishing innovations in application domains such as eHealth, smart city, intelligent transport systems, and smart manufacturing, it is critical to facilitate the creation and operation of trustworthy Smart IoT Systems. Since smart IoT systems typically operate in a changing and often unpredictable environment, the ability of these systems to continuously evolve and adapt to their new environment is decisive to ensure and increase their trustworthiness, quality and user experience. The DevOps movement advocates a set of software engineering best practices and tools, to ensure Quality of Service whilst continuously evolving complex systems and foster agility, rapid innovation cycles, and ease of use. Therefore, DevOps has been widely adopted in the software industry. However, there is no complete DevOps support for trustworthy smart IoT systems today. The main technical goal of ENACT is to develop novel IoT platform enablers to: Enable DevOps in the realm of trustworthy smart IoT systems, and enrich it with novel concepts for end-to-end security and privacy, resilience and robustness strengthening trustworthiness, taking into account the challenges related to "collaborative" actuation and actuation conflicts. Facilitate the smooth integration of these to leverage DevOps for existing and new IoT platforms and approaches (e.g., FIWARE, SOFIA, and TelluCloud)."[1]
Main results in regard to Industry 4.0:	"ENACT supports DevOps practices during the development and operation of trustworthy smart IoT systems by offering software tools, called "enablers", for each of the seven stages of the DevOps life-cycle model [3]." Book "DevOps for Trustworthy Smart IoT Systems" documents the results of the project (available here: https://nowpublishers.com/Article/BookDetails/9781680838244) EDI will define the requirements for future IoT systems in intelligent transport usecase, testing of developed solutions and will provide the infrastructure and platform for the showcase and validation of ENACT results with train transport [2].
References:	1. https://cordis.europa.eu/project/id/780351 2. https://www.edi.lv/en/projects/trustworthy-and-smart-actuation-in-iot-systems-enact-2/ 3. https://nowpublishers.com/article/Chapter/9781680838244?cId=978-1-68083-825-1.ch1

Title:	**Artificial Intelligence for Digitizing Industry**
Acronym (if any):	**AI4DI**
Website:	https://ai4di.eu/
Period:	01.05.2019 – 30.11.2022
Source of funding:	H2020-EU.2.1.1. - INDUSTRIAL LEADERSHIP
Partners: (Latvian partners in bold)	• Infineon Technologies AG (Germany)- coordinator • **Institute Of Electronics And Computer Science (EDI) (Latvia)** • And 46 other partners from Germany, Austria, Czech Republic, Italy,

	Norway, Latvia, Taiwan, Belgium, Lithuania, France, Greece, Finland
Short overview:	"AI4DI aims to strengthen and expand AI usage in European industry digitization process. Enabling of performance, industry and humanity by AI for digitising industry is the key to push the AI revolution in Europe and step into the digital age. Potential users of AI are not sufficiently supported to facilitate the integration of AI into their applications. Existing services providing state of the art machine learning (ML) and artificial intelligence solutions are currently available in the cloud. AI4DI project aim is to transfer machine learning and AI from the cloud to the edge in manufacturing, mobility and robotics. To achieve these targets AI4DI will connect factories, processes, and devices within digitised industry by utilizing ML and AI for human machine collaboration, change detection, and detection of abnormalities."[1]
Main results in regard to Industry 4.0:	According to [3], project works with AI technologies in such industrial applications as: Food and Beverage, Industrial Machinery, Automotive, Semiconductor and Transportation and plans to provide a deployment plan showing how to develop and valorise AI technology in each of those industrial sectors. "The project will deliver several solutions including different AI-based functions and will be validated in 15 industrial demonstrators such as: ● An application for analysis, planning and decision-making powered by AI-based methods for the complex logistics control processes, such as supply chain control strategy and distributed and secure computing with data anomaly checks. ● An innovative edge-based system with integrated Machine Learning (ML) algorithms for 3D image analysis, trends recognition and full supervision availability for improved product quality. ● An automated wood machinery with Augmented reality (AR), Voice recognition and direct operator interaction to enhance safety and productivity on autonomous and collaborative robots and machine tools in their interaction with human operators."[4] Contribution of EDI [1]: ● develops cognitive sensing to perceive and understand dynamically changing environment for randomly dropped object detection, pose estimation and pick-up by an industrial robot – AI is used to analyze the data of a stereo vision system, which incorporates processing on the edge (FPGA based SoC) [1]. ● together with partners enables robots of any size to "feel" – a reflectometric sensor is proposed featuring miniaturized electronics and single-channel measurement also for large scale areas. Neural networks are used to map the sensor signal to the apparent deformation which is related to the touch input or collision event. ● together with partners develops technologies to detect the position between the robot and surrounding objects, and to allow unobtrusive/contactless interaction between the operator and the robot.
References:	1. https://www.edi.lv/en/projects/artificial-intelligence-for-digitizing-industry-ai4di/ 2. https://ai4di.eu/

	3. https://ai4di.automotive.oth-aw.de/library/brochures 4. https://www.tttech.com/innovation/research-projects/ecsel-artemis/ai4di/
Title:	**Development of microrobot based on visual recognition and machine learning for manipulation of individual living cells**
Acronym (if any):	**RoVam**
Website:	https://www.edi.lv/en/projects/development-of-microrobot-based-on-visual-recognition-and-machine-learning-for-manipulation-of-individual-living-cells-rovam/
Period:	01.01.2021. – 31.12.2023.
Source of funding:	Unknown
Partners: (Latvian partners in bold)	• **Institute Of Electronics And Computer Science (EDI) (Latvia)** • Lithuania • Taiwan
Short overview:	"We are aiming to create new type autonomous flexible microrobot for the manipulation of individual living cells. The problems in micromanipulation systems are: they are usually not autonomous, and do not recognize the objects, therefore only highly skilled person can work with the system. Our system will solve these problems: it will be smart, autonomous, and will automatically process data obtained from measurements."[1]
Main results in regard to Industry 4.0:	Planned results according to [1] are: 1) micro-positioning system, which allows to displace the manipulating tool in 3D space; 2) video recognition system for the micro-objects recognition; 3) machine learning system for the control. Tasks to be performed by EDI [1]: 1) Development and implementation of the recognition system, which will be able to: detect biological object contained in the small amount of the solution, determine object center co-ordinates and pick-up point by defining object boundaries and shape; 2) Implementation of a calibration technique for coordinate system alignment for imaging and mechanical manipulator systems.
References:	**1.** https://www.edi.lv/en/projects/development-of-microrobot-based-on-visual-recognition-and-machine-learning-for-manipulation-of-individual-living-cells-rovam/

Title:	**Intelligent Motion Control under Industry 4.E**
Acronym (if any):	**IMOCO4.E**
Website:	https://cordis.europa.eu/project/id/101007311
Period:	09.2021.-08.2024.
Source of funding:	H2020-EU.2.1.1. - INDUSTRIAL LEADERSHIP
Partners: (Latvian partners in bold)	• SIOUX CCM (Netherlands) - coordinator • **AS Madara Cosmetics (Latvia)** • **Institute Of Electronics And Computer Science (EDI) (Latvia)** • Netherlands, Czech Republic, Spain, Greece, Ireland, Italy, Belgium, Latvia, Poland, Denmark, Romania, Finland, Switzerland
Short overview:	"The broad IMOCO4.E challenge is to bridge the gap between the latest research results and best industrial practice in digital twins, AI and

	advanced mechatronic motion control systems. IMOCO4.E strive to create solid and unimpeachable knowledge for optimizing machines and production lines over their whole lifecycle."[1] "IMOCO4.E project aims to push mechatronic systems to the limits, make them smarter and more configurable. This will be achieved by combining and exploiting novel sensory information, model-based approaches, AI, machine learning and industrial IoT philosophies. IMOCO4.E will provide edge-to-cloud intelligence for machines, robots and other human in the-loop automation systems. [..] the project will help shape the future of Industry 4.0 manufacturing in Europe. It will both perceive and control complex machines and robots. Specifically, it will deliver a reference architecture that will be verified in applications for semiconductors, packaging, industrial robotics and healthcare."[2]
Main results in regard to Industry 4.0:	Planned results according to [1] are: Software and Hardware building blocks (BBs), edge-to-cloud distributed and featuring standardized interfaces, will be developed to deliver a complete IMOCO4.E reference framework. These building blocks will embed the latest thinking from the academic community and, moreover, can be enhanced in future with new research results. The project will deliver a flexible, scalable, future-proofed and fully functional product architecture to be exploited in industry in high-performance motion control applications with several overlaps to health, mobility and supply chain management domains. Planned contribution from EDI [1]: "EDI continues to research and develop intelligent industrial robots. Our first challenge is to demonstrate the ability of an adaptable robot to work on real production lines, where the robot must be able to take objects of different types and sizes from a random pile and place them in the appropriate size sockets. The second challenge is to make this robot to be quickly retrainable by anyone to work with previously unseen objects. "
References:	1. https://www.edi.lv/en/projects/intelligent-motion-control-under-industry-4-e-imoco4-e/ 2. https://cordis.europa.eu/project/id/101007311

Title:	**Industrial inertial wireless sensor** **Industrial inertial wireless sensor part 2**
Acronym (if any):	**IIWS**
Website:	https://www.edi.lv/en/projects/industrial-inertial-wireless-sensor/ https://www.edi.lv/en/projects/industrial-inertial-wireless-sensor-iiws-part-2/
Period:	01.05.2020. - 30.09.2020. 01.01.2021. – 30.06.2022. (part II)
Source of funding:	ERDF
Partners: (Latvian partners in bold)	• **Institute Of Electronics And Computer Science (EDI) (Latvia)**
Short overview:	"Industrial inertial wireless sensor (IIWS) performs measurements of movements of a mechatronic machine. [..] Movement measurements allow to register information about changes in the position of the machine, making it possible to assess the absolute position, vibration or other physical changes of the equipment after performing the data

	processing. The proposed technology, in the context of mechatronics and robotics, addresses a number of industrial production challenges. By evolution of Industry 4.0 concept, where various mechatronic and robotic hardware is supplemented with different sensors to enhance the efficiency of performance and production, industry starts to require industries need new and reliable sensors. Moreover, since many of these mechatronic and robotic systems have moving and rotating components, when installing sensors on these, there is no option to install wiring harnesses, to ensure power supplying and communication capabilities, therefore industry starts to see demand rising for sensors, which have power supply and radio communication module installed in themselves."[1] Overview of the part II [2]: "Various analogue solutions for monitoring concrete structures have been available for many years, but those are not easy to use. Also traditionally this is a time-consuming process and construction company employees usually have to come to the construction site in order to carry out specific measurements or to read measurements generated by various sensors. [..] The EDI solution to monitor concrete behavior and shrinkage fits perfectly into the general process of construction digitization[..]"
Main results in regard to Industry 4.0:	The main aim is to advance this technology [Industrial inertial wireless sensor] to TRL7 level [1]. "The main target [of part II] is to develop modern IoT solution – to secure wireless communications between sensors that can monitor concrete structures, concrete hardening , shrinkage process and hand held end-user equipment. This includes the creation of a convenient graphical interface design and the ability to use the solution remotely via a cloud server when responsible persons are located in company office." [2]
References:	1. https://www.edi.lv/en/projects/industrial-inertial-wireless-sensor/ 2. https://www.edi.lv/en/projects/industrial-inertial-wireless-sensor-iiws-part-2/

5.5 Appendix 5:

Companies

Title:	Autentica
Website:	https://www.autentica.lv/lv/
Short overview of involvement in Industry 4.0 (activities/results/etc.):	SIA Autentica is an IT company engaged in digitisation, automation and robotisation of business processes. Their clients are public authorities as well as medium and large companies in the Baltics and Scandinavia [1]
Reference:	1. https://www.autentica.lv/lv/par-mums/

Title:	Squalio
Website:	https://squalio.com/
Short overview of involvement in Industry 4.0 (activities/results/etc.):	The company offers data and AI services like data analytics, data visualisation, automation and AI for industries (finance, transport and logistics, retail, healthcare, education, human resources) [1]
Reference:	1. https://squalio.com/services/data-ai-services/

Title:	Emergn Latvia
Website:	https://www.emergn.com/
Short overview of involvement in Industry 4.0 (activities/results/etc.):	The company, among other services, offers data analytics and intelligent automation [1, 2]
Reference:	1. https://www.emergn.com/data-and-analytics/ 2. https://www.emergn.com/intelligent-automation/

Title:	LVM GEO
Website:	https://www.lvmgeo.lv/en/
Short overview of involvement in Industry 4.0 (activities/results/etc.):	LVM GEO offers a collection of geospatial information technology (GIT) products and services. LVM GEO services are [1]: ● Geographic information system development ● Spatial planning optimisation model development ● GIS consulting and project management ● GIS data management and analysis ● Remote sensing services
Reference:	1. https://www.lvmgeo.lv/en/about-lvm-geo

Title:	dots.
Website:	https://www.wearedots.com/en
Short overview of involvement in Industry 4.0 (activities/results/etc.):	One of the product types of this company is related to cybersecurity [1]
Reference:	1. https://www.wearedots.com/en/protect

Title:	Peruza
Website:	https://peruza.com/

Short overview of involvement in Industry 4.0 (activities/results/etc.):	The company's core competence comes from processing small pelagic fish production from ship to shelf. PERUZA is researching new Artificial Intelligence-based vision systems that will allow ensuring processing and quality checks for more quality products. [1]
Reference:	1. https://peruza.com/contact-us/#aboutus

Title:	Systemview
Website:	https://systemview.lv/
Short overview of involvement in Industry 4.0 (activities/results/etc.):	The enterprise helps companies implement efficient Internet of Things (IoT) solutions. They offer services in [1]: 1. Remote reading of water meters 2. Waste monitoring 3. Asset protection 4. Smart street lighting 5. Building energy efficiency 6. Smart parking 7. Air quality monitoring 8. Water quality monitoring 9. Other solutions 10. Safety of seniors
Reference:	1. https://systemview.lv/

Title:	Digital Mind
Website:	https://en.digitalmind.lv/
Short overview of involvement in Industry 4.0 (activities/results/etc.):	The company provides solutions in intelligent process automation and cloud business application [1]
Reference:	1. https://en.digitalmind.lv/

Title:	cognizant
Website:	https://www.cognizant.com/lv/en
Short overview of involvement in Industry 4.0 (activities/results/etc.):	The company offers services in the fields of artificial intelligence, cloud enablement, intelligent process automation, and security [1]
Reference:	1. https://www.cognizant.com/lv/en

Title:	Geomatic
Website:	https://www.geomatic.lv
Short overview of involvement in Industry 4.0 (activities/results/etc.):	The company offers augmented reality services, among others. This service is intended both for builders and designers to show what the planned buildings and structures will look like in a real environment. [1]
Reference:	1. https://www.geomatic.lv/en/services/augmented-reality/

Title:	Baltic3D
Website:	Baltic3D.eu
Short overview of involvement in Industry 4.0 (activities/results/etc.):	Founded in 2013, Baltic3D.eu is the regional market leader in High Performance 3D Industrial Printing. As the official representative of Stratasys (one of the largest Industrial 3D Machine manufacturers in the World), Baltic3D is a one-stop shop for Industrial Customers in Europe: from in-house 3D modelling to series production with Quality Assurance and delivery to your Factory door-step within days. [1]
Reference:	1. https://www.baltic3d.eu/baltic3d-team

Title:	Cyber Circle
Website:	https://cybercircle.eu/
Short overview of involvement in Industry 4.0 (activities/results/etc.):	The company is a professional cyber security expertise provider in active cyber defence and advanced cyber education [1].
Reference:	1. https://cybercircle.eu/

Title:	Lightspace
Website:	https://lightspace3d.com/
Short overview of involvement in Industry 4.0 (activities/results/etc.):	Lightspace is a Deep-tech company with its R&D laboratories, industrialisation and fabrication facilities developing key technologies for the next generation of augmented reality. A global leader in volumetric, multi-focal and light field technologies.[1]
Reference:	1. https://lightspace3d.com/products/

Title:	SIA "Robologic"
Website:	https://robologic.group/about-us/
Short overview of involvement in Industry 4.0 (activities/results/etc.):	ROBOLOGIC company specialises in any complexity process automation. Its main services include online and offline robot programming, electrical engineering and PLC programming Thanks to our qualified specialists, "Robologic Group" provides a service for full or partial automation of any process: from small business algorithms to high-powered line production [1]
Reference:	1. https://robologic.group/about-us/

Title:	Tilde
Website:	https://www.tilde.lv/
Short overview of involvement in Industry 4.0 (activities/results/etc.):	The company is a leader in language processing technology, offering machine translation tools and solutions, virtual assistants, voice technologies [1]
Reference:	1. https://www.tilde.lv/

Title:	LMT
Website:	https://www.lmt.lv/lv/
Short overview of	The company introduces 5G technology and participates in many

involvement in Industry 4.0 (activities/results/etc.):	technologically advanced projects that include cloud computing, artificial intelligence and cybersecurity [1]
Reference:	1. https://www.lmt.lv/lv/

5.6 Appendix 6: Additional statistics and economic indicators on digitalisation, digital skills and Industry 4.0

Additional enterprise indicators pertinent to electronic information sharing

Indicator	Year when data is provided	Bulgaria	EU-27
Enterprises using CRM to analyse information about clients for marketing purposes (% of enterprises)	2021	11%	19%
Enterprises using CRM to capture, store and make available clients' information to other business functions (% of enterprises)	2021	15%	34%
Enterprises whose business processes are automatically linked to those of their suppliers and customers (% of enterprises)	2017	17%	18%
Enterprises using automated data exchange with other ICT systems outside the own enterprise (% of enterprises)	2012	49%	52%
Enterprises using automated data exchange for receiving orders from customers (% of enterprises)	2010	29%	26%
Enterprises using automated data exchange for sending or receiving data to / from public authorities (% of enterprises)	2012	45%	38%
Enterprises using automated data exchange for sending or receiving transport documents (% of enterprises)	2012	16%	24%
Enterprises using automated data exchange for sending orders to suppliers (% of enterprises)	2010	13%	30%

Enterprises that share electronically information suitable for automatic processing with external business partners or on the SCM with suppliers or customers (% of enterprises)	2010	39%	51%
Enterprises that share electronically information suitable for automatic processing within the enterprise and with external business partners (% of enterprises)	2010	24%	34%
Enterprises that regularly share electronically information with customers on inventories, production plans or demand forecasts (% of enterprises)	2010	9%	9%
Enterprises using automated data exchange for sending or receiving product information (% of enterprises)	2011	31%	34%
Enterprises using automated data exchange for sending payment instructions to financial institutions (% of enterprises)	2012	24%	37%
Enterprises using automated data exchange for sending / receiving data to / from public authorities and using internet for treating an administrative procedure completely electronically (% of enterprises)	2011	28%	22%
Enterprises using automated data exchange for sending / receiving data to / from public authorities and using internet for returning filled in forms (% of enterprises)	2012	43%	34%
Enterprises who share electronically information with suppliers and customers on inventory levels, production plans, demand forecasts or progress of deliveries (% of enterprises)	2012	26%	13%

Additional enterprise indicators pertinent to Industry 4.0 technologies – Internet of things

Indicator	Year when data is provided	Bulgaria	EU-27
Use smart meters, smart lamps, smart thermostats to optimise energy consumption in the enterprise's premises (% of enterprises)	2021	3%	6%
Use sensors, RFID or IP tags or internet-controlled cameras to improve customer service, monitor customers' activities or offer them a personalised shopping experience (% of enterprises)	2020	4%	5%

Use movement or maintenance sensors to track the movement of vehicles or products, to offer condition-based maintenance of vehicles (% of enterprises)	2020	6%	7%
Use sensors or RFID tags to monitor or automate production processes, to manage logistics, to track the movement of products (% of enterprises)	2020	2%	3%

Additional enterprise indicators pertinent to Industry 4.0 technologies – Artificial Intelligence

Indicator	Year when data is provided	Bulgaria	EU-27
Enterprises with a chat service where a chatbot or a virtual agent replies to customers (% of enterprises)	2020	2%	2%
Enterprises use one AI system (of E_CHTB, E_BDAML, E_BDANL, E_RBTS) (% of enterprises)	2020	5%	6%
Enterprises use two AI systems (of E_CHTB, E_BDAML, E_BDANL, E_RBTS) (% of enterprises)	2020	0%	1%
Enterprises use AI technologies for performing analysis of written language (% of enterprises)	2021	1%	3%
Enterprises use AI technologies for converting spoken language into machine-readable format (% of enterprises)	2021	1%	2%
Enterprises use AI technologies for generating written or spoken language (% of enterprises)	2021	0%	1%
Enterprises use AI technologies for identifying objects or persons based on images (% of enterprises)	2021	1%	2%
Enterprises use AI technologies enabling physical movement of machines via autonomous decisions based on observation of surroundings (% of enterprises)	2021	0%	1%
Enterprises' AI technologies were developed by own employees (% of enterprises)	2021	1%	2%
Enterprises' AI technologies were commercial software or systems modified by own employees (% of enterprises)	2021	1%	2%

Enterprises' AI technologies were open-source software or systems modified by own employees (% of enterprises)	2021	1%	2%
Enterprises' AI technologies were commercial software or systems ready to use (% of enterprises)	2021	2%	4%
Enterprises' AI technologies were developed or modified by external providers (% of enterprises)	2021	1%	3%

Additional enterprise indicators pertinent to Industry 4.0 technologies – Big Data

Indicator	Year when data is provided	Bulgaria	EU-27
Analyse big data from other sources (than E_BDASDS, E_BDALOC, E_BDASM) (% of enterprises)	2020	2%	3%
Analyse big data internally using natural language processing, natural language generation or speech recognition (% of enterprises)	2020	0%	1%
Analyse big data internally using other methods (than E_BDAML, E_BDANL) (% of enterprises)	2020	5%	5%

Additional enterprise indicators pertinent to Industry 4.0 technologies – 3D Printing

Indicator	Year when data is provided	Bulgaria	EU-27
Use 3D printing for prototypes or models for sale (% of enterprises)	2020	1%	2%
Use 3D printing for prototypes or models for internal use (% of enterprises)	2020	2%	3%
Use 3D printing for goods for sale, excluding prototypes or models (% of enterprises)	2020	0%	1%
Use 3D printing for goods to be used in the enterprise's production process, excluding prototypes or models (% of enterprises)	2020	1%	2%

Additional enterprise indicators pertinent to Industry 4.0 technologies – Automation

Indicator	Year when data is provided	Bulgaria	EU-27
Use service robots for surveillance, security or inspection tasks (% of enterprises)	2020	1%	0%
Use service robots for transportation of people or goods (% of enterprises)	2020	0%	1%
Use service robots for cleaning or waste disposal tasks (% of enterprises)	2020	0%	1%
Use service robots for warehouse management systems (% of enterprises)	2020	0%	1%

Additional enterprise indicators pertinent to Industry 4.0 technologies – Cybersecurity

Indicator	Year when data is provided	Bulgaria	EU-27
Enterprises experienced at least once problems due to ICT security incident: unavailability of ICT services (% of enterprises)	2019	13%	10%
Enterprises experienced at least once problems due to ICT security incident: destruction or corruption of data (% of enterprises)	2019	7%	6%
Enterprises experienced at least once problems due to ICT security incident: disclosure of confidential data (% of enterprises)	2019	1%	1%

5.7 Appendix 7: Higher Education programs relevant to Industry 4.0

Source: National Evaluation and Accreditation Agency (https://www.neaa.government.bg/)

University	Programs in areas enabling Industry 4.0 skills (Bachelor, Masters or Doctoral programs)	Programs directly related to Industry 4.0 (Bachelor, Masters or Doctoral programs)
American University in	Computer Science (Bachelor)	

Bulgaria	Information Systems (Bachelor)	
Bourgas Free University	Software Engineering (Bachelor and Masters) Computer modelling (Bachelor) Applied Informatics (Bachelor) Business information technologies (Masters) Computer systems and technologies (Bachelor and Masters) Informatics (doctoral)	Artificial Intelligence and Robotics (Masters) Information security (Masters)
Varna Free University "Chernorizets Hrabar"	Digital Economics (Bachelor) Informatics and Computer Science (Bachelor) Digital Marketing and Web Design (Masters) Software Engineering (Masters) Software Engineering and Management (Masters) Information systems and Technologies, Informatics and Computer Science (Doctoral)	Data Science (Masters) Cybersecurity (Masters)
"St. Cyril and St. Methodius" University of Veliko Tarnovo	Informatics (Bachelor) Computer Science (Bachelor) Software Engineering (Bachelor) Information Brokering and Digital Media (Bachelor) Informatics – Information Systems (Masters) Informatics – Corporate Network Architecture (Masters) Computer Science – Applied Computer Science (Masters) Web technologies and Software Development (Masters) Informatics (Doctoral)	Informatics – Data Security (Masters)

"Georgi Benkovski" Bulgarian Air Force Academy		Electrical engineering, Electronics and Automation (Bachelor and Masters) Automated information processing and management systems (Doctoral)
Naval Academy "N. Vaptsarov"	Information and Communication Technologies (Bachelor and Masters)	Cybersecurity (Bachelor and Masters) Automated information processing and management systems (Doctoral)
Higher School of Transport "Todor Kableshkov"	Communication and computer equipment and systems (Bachelor and Masters)	Network and information security (Masters)
Varna University of Management	Software systems and technologies (Bachelor)	
High College of Telecommunications and Posts	Network communication (Bachelor) Computer administration of software applications (Bachelor) Software design (Bachelor) Computer technologies (Bachelor) Mobile communications and Internet (Masters) Information Technologies (Masters)	High Tech Cybersecurity (Bachelor) Cybersecurity of communication technologies (in Bulgarian and English)
Military Academy "G. S. Rakovski"	Communication Networks and Systems (Doctoral)	Cybersecurity (Doctoral)
European Polytechnical University	Applied Informatics (Bachelor) Management of information (Masters)	Information security (Masters) Personal data security management (Masters)
University of Economics – Varna	Informatics (Bachelor, Masters, Doctoral) Informatics and Computer Science (Bachelor)	

	Mobile and web technologies (Bachelor and Masters) Computer Science (Masters)	
National Military University "Vasil Levski"	Communication technologies (Bachelor and Masters) Computer systems and technologies (Bachelor and Masters) Communication networks and systems (Doctoral)	Cybersecurity (Bachelor and Masters) Artificial Intelligence (Masters) Computer systems and cybersecurity (Bachelor) Automated information processing and management systems (Doctoral) Automation, information and control technology (Bachelor and Masters) Automated information processing and management systems (Doctoral)
New Bulgarian University	Informatics (Bachelor and Doctoral) Information technologies (Bachelor) Network technologies (in English) (Bachelor) IT project management (Masters) Software technologies on the Internet (Masters) Telecommunications and computer technologies (Bachelor) Innovation and entrepreneurship in computer and communication technologies (Masters) Innovations and technologies in modern business (Masters) Telecommunications (Doctoral)	Knowledge mining and big data (Masters) Cybersecurity (Masters)
"Paisii Hilendarski" Plovdiv University	Informatics (Bachelor) Business Information Technologies (Bachelor) Software Technology and Design (Bachelor)	Software technologies – Artificial Intelligence (Masters) Cybersecurity (Masters)

	Software Engineering (Bachelor) Business informatics (in English) (Masters) Software technologies - graphics and user interfaces (Masters) Software technologies - mobile systems and applications (Masters) Software technologies - software architectures and tools (Masters) Business software technologies (Masters) Software development and deployment (Masters) Computer and communication systems (Bachelor) Information and computer engineering (Bachelor and Masters) Telecommunication and information systems (Bachelor and Masters)	
"Angel Kanchev" University of Ruse	Informatics (Masters and Doctoral) Computer Science (Bachelor) Informatics and information technologies in business (Bachelor) Software Engineering (Bachelor and Masters) Technologies for digitally programmed machines (Masters) Computer technologies in Mechanical Engineering (Masters) Computer systems and technologies (Bachelor and Masters) Telecommunication systems (Bachelor and Masters) Telecommunication networks (Masters) Internet and mobile communications (Bachelor) Information and communication	Computer control and automation (Bachelor) Automation, information and control technology (Bachelor and Masters) Automation and mechatronics (Masters) Automation and computer systems for automation (Masters) Automation of production (Doctoral) Automation in non-material sectors (Doctoral) Communication networks and systems (Doctoral) Automated information processing and management systems (by industry sector) (Doctoral)

	technologies (Bachelor) Computer systems and networks (Masters)	
Sofia University "St. Kliment Ohridski"	Informatics (Bachelor) Computer Science (Bachelor. Doctoral) Software engineering (Bachelor) Information systems (Bachelor, Masters, Doctoral) Information technologies (Doctoral) Software technologies (Doctoral) Discrete and algebraic structures (Masters) E-business and e-governance (Masters) E-business (Masters) Information technology services and projects (Masters) Distribution systems and mobile technologies (Masters) Software technologies (Masters) Technologies for knowledge and innovation (Masters) Technological entrepreneurship and innovation in information technology (Masters) Computer engineering (Bachelor) Communications and Physical Electronics (Bachelor and Masters) Wireless networks and devices (Masters) Communication and computer technology (Masters)	Embedded systems (Masters) Mechatronics and robotics (Masters) Artificial Intelligence (Masters) Protection of information in computer systems and networks (Masters) Information extraction and knowledge discovery (Masters) Data Science (Doctoral)
D. A. Tsenov Academy of Economics	Business informatics (Bachelor) Information systems and technologies in business (Masters) E-business and digital markets	

	(Masters)	
Technical University - Varna	Computerized technologies in mechanical engineering (Bachelor and Masters) Communication and computer technologies (Bachelor and Masters) Tech entrepreneurship and innovation (Bachelor) System programming (Doctoral) Computer systems and networks (Doctoral) Communication networks and systems (Doctoral)	Repair and operation of mechatronic devices (Bachelor) Industrial and building automation (Bachelor) Automation and computer systems for information and control (Bachelor and Masters) Robotics and Mechatronics (Bachelor) Siemens PLC control technologies (Masters) Mechatronics (Masters) PLC and PC-based control technologies (Masters) Automation of production (Doctoral) Automated information processing and management systems (Doctoral)
Technical University - Gabrovo	Computer technologies in mechanical engineering (Bachelor and Masters) Computer systems and technology (Bachelor and Masters) Communication technique and technologies (Bachelor and Masters) Mobile and satellite communications (Bachelor) Innovation and investment management in industry (Masters) Optical and quantum electronics (Doctoral) Industrial electronics (Doctoral) Computer systems and networks (Doctoral) Communication networks and systems (Doctoral)	Mechatronics (Bachelor and Masters) Automation, information and control technology (Bachelor and Masters) Computer Aided Design in Industry (Bachelor and Masters) Elements and devices in automation and computer technology (Doctoral) Automation of engineering work and automated design systems (Doctoral) Automated information processing and management systems (Doctoral)

Technical University - Sofia	Informatics and software sciences (Bachelor and Masters) Informatics (Doctoral) Computer technologies in mechanical engineering (Bachelor) Telecommunications (Bachelor and Masters) Computer and Software Engineering (Bachelor and Masters) Information technologies in industry (Bachelor) Information technologies (Masters) Telecommunications Engineering (Bachelor) Computer Science and Engineering (Bachelor and Masters) Computer systems and technologies (Bachelor and Masters) Computer technology and applied programming (Masters) Computer technologies in the non-material sectors (Masters) Innovative information and communication technologies (Masters) Innovative communication technologies and entrepreneurship (Masters) Electronic control (Masters) Computer Business Informatics (Masters) Management and business information systems (Bachelor) Devices and systems for analytical measurements and control of environments (Doctoral) Industrial electronics (Doctoral) Automation in the non-material sectors (Doctoral)	Digital industrial technologies (Bachelor and Masters) Mechatronics (Bachelor and Masters) Mechatronic systems (Bachelor and Masters) Analysis of large data sets and streams (Masters) Systems with artificial intelligence (Doctoral) Computer-aided design and technologies in mechanical engineering (Bachelor and Masters) Automation of engineering work and automated design systems (Doctoral) Automated information processing and management systems (Doctoral) Bioautomatics (Doctoral) Elements and devices of automation and computer technology (Doctoral)

	System programming (Doctoral) Computer systems and networks (Doctoral) Note: some programs are available in English, German and/or French	
Trakia University	Information technologies in economics and management (Bachelor) Business informatics (Masters) Information technologies (Bachelor) Software engineering (Bachelor) Information and communication technologies in business and public administration (Masters) Information and communication technologies in business and public administration (Masters)	Automation and computer systems (Bachelor and Masters) Automation of engineering work and automated design systems (Doctoral) Automated information processing and management systems (Doctoral)
University of National and World Economy	E-government (Masters) Smart cities (Masters) Intellectual property and business (Bachelor and Masters) Business informatics and communications (Bachelor and Masters) Digital economy (Masters) Corporate strategies and digital transformations (Masters)	
University of Library Studies and Information Technologies	Information technologies (Bachelor) Computer Science (Bachelor) Information brokering (Bachelor) Information systems and technologies (Masters) Software architectures and quality management (Masters) E-business and e-management (Masters)	

	Information technologies and financial engineering (Masters) Software engineering (in Bulgarian and English) (Masters) Technological entrepreneurship and innovation in the information technologies sector (Masters) Digital technologies in the creative and leisure industries (Masters) Information systems and technologies, informatics and computer science (Doctoral)	
University of Food Technologies - Plovdiv	Business information technologies (Masters) Computer systems and technologies (Bachelor and Masters) Computer systems and networks (Doctoral) Communication and computer technologies (Doctoral)	Automation, information and control technology (Bachelor and Masters) Automation of production (Doctoral)
Prof. dr. Asen Zlatarov University - Bourgas	Computer systems and technologies (Bachelor and Masters) Software engineering (Bachelor) Software technologies (Masters)	Artificial Intelligence Systems (Doctoral)
University of Chemical Technology and Metallurgy	Automation and information technologies (bachelor and Masters) Information Technologies (Masters)	Automation of engineering work and automated design systems (Doctoral) Automated information processing and management systems (Doctoral) Automation of production (Doctoral)
Shumen University "Bishop Konstantin of Preslav"	Informatics and information technologies (Bachelor, Doctoral) Informatics (Doctoral) Computer Informatics (Bachelor) Computer information technologies	Computer technologies for the automation of production (Bachelor and Masters) Automated information processing and management

	(Bachelor) Information technologies in the economy (Bachelor) Software technologies (Masters) Software engineering (Masters) Communication and information systems (Bachelor and Masters) Communication networks and systems (Doctoral)	systems (Doctoral)
Southwest University "Neofit Rilski"	Informatics (Bachelor and Masters) Information systems and technologies (Bachelor and Masters) Business informatics and econometrics (Masters) Computer systems and technologies (Bachelor and Masters) Communication technologies (Bachelor and Masters)	