PRAMONĖ 4.0

MINISTRY OF THE ECONOMY AND INNOVATION

Lithuanian Industry Digitisation Roadmap

2019-2030

Foreword

TOWARDS DIGITISED INDUSTRY

Virginijus Sinkevičius

Minister of Economy and Innovation

Following a year-long period of consultations at the National Industry 4.0 Platform, we are proud to present the Lithuanian Industry Digitisation Roadmap 2019-2030. This ambitious plan will serve as a guidance for industry digitisation efforts following the Industry 4.0 initiatives across Europe to make the local manufacturing more proficient and competitive. It is the first milestone for the new Smart Specialization Strategy and its priority areas as well as serving as basis for the Science, Technology and Innovation Strategy and the National Progress Programme.

The Roadmap aims to assist in steering the Lithuanian manufacturing industry development towards global advancement. The Industry 4.0 movement started in Germany in 2011 is now the driving force behind the European industry transformation. It introduces digitisation as the next stage of mechanization, automation and robotization. With the advent of Smart Factories, Cyber-Physical Systems and everything interconnected with Internet of Things and Cloud-Based Technologies, Industry 4.0 seeks to make the manufacturing processes integrated across a multitude of levels within supply chains.

Manufacturing industry digitisation materializes along the implementation of the latest manufacturing technologies. By employing these technologies, manufacturing processes can be virtualized and become remotely accessible through the use of Internet. This provides benefits of enhanced prediction, precision, planning, monitoring and control. Therefore, digitisation is essential aiming to ensure industry's innovative capacity and means of the next era of modern manufacturing – the on demand mass production of high quality customized products.

Foreword

DIGITISATION – THE KEY TO ECONOMIC GROWTH

Gintaras Vilda

Vice-Minister of Economy and Innovation

The national innovation ecosystem is greatly affected by the general business environment in Lithuania. Favourable business conditions make Lithuania a perfect country for investments in digital technologies. Below are the reasons why.

First of all, setting up a business in Lithuania takes only a few days and can be done online. Due to simplicity of procedures for setting up a business, the World Bank ranked Lithuania as one of 15 most business-friendly countries in the world.

Secondly, Lithuania's e-infrastructure is leading in the EU. It is highly-advanced and is considered among the best in the world. Lithuania is ranked 1st globally for fulfilling business needs for ICT and is a regional leader for bandwidth and fibre-optics infrastructure.

Moreover, innovation-friendly environment and linkages are the strongest Lithuania's innovation dimensions. In order to utilize the existing strengths and improve the outcomes of the Lithuanian innovation performance, the Government has started to implement the Innovation Reform. It was launched in the spring 2018 by the Prime Minister.

Lithuania's economic growth strategy seeks to further enhance the productivity growth and increase the industry's competitiveness. In 2017, Lithuania was the EU leader in terms of productivity growth. Currently, the focus is to maintain the momentum and reduce the productivity gap in the medium-term.

Therefore, the Ministry of Economy and Innovation puts a lot of effort to develop the high-tech sector. Lithuanian knowledge-intensive sectors, such as life sciences, photonics, machinery industry, mechatronics, electronics and information technology, are expanding. The number of firms in medium- and high-tech sectors is rising.

In 2016, 47% of Lithuanian companies were involved in R&D&I activities. It was the second highest percentage in the EU. That year SMEs' investments in R&D&I activities was 1.3 bn EUR and business sector's income from commercialization of new products reached 6.6 bn EUR. This is twice as much as in 2014 and 3 times more compared to the data of the year 2010. By 2020, the Ministry expects the share of innovative companies to increase to 53%, a 3% GDP increase, a 7% average wage increase and a 10% export increase on top of the regular forecast of economic growth.

However, manufacturing industry strengths and weaknesses must be evaluated in the light of other European countries for it to remain competitive. Currently Lithuanian companies are well interconnected in the European value chains and export markets, and have the capacity to expand. While Lithuanian industry is yet to face several challenges, it firmly keeps ahead of other European nations in its motivation of becoming a strong innovator and a renowned high-technology hub at the European level. EU Structural Funds give a huge boost for the support of these aims. The robust local innovation ecosystem and the network of intermediaries creates additional opportunities.

This determination is also supported by being implemented and planned actions. After a long process of analysis and rounds of working group and expert discussions that involved representatives from industry and academia as well as policy-makers through the National Industry 4.0 Platform, the Vision 2030 for Digitalized Lithuania and actions to be carried out to achieve it were confirmed. The Action Plan, which is the core of this Roadmap, will define the next steps to be taken in order to establish measures for the support of industry's digitisation.

By implementing the excluded key measures as a matter of greatest concern, the Ministry shows its commitment to provide the expected benefits to the whole manufacturing industry, individual businesses, innovators and eventually all Lithuanian citizens.

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1. EU Perspective[3]

"Bring industry's weight in the EU GDP back to 20% by 2020"

The Political Guidelines for Mr Juncker's Presidency of the European Commission underlined the importance of a strong and high performing industry for the future of Europe's economy, and the need to bring industry's weight in the EU GDP back to 20% by 2020. This vision is supported by the President of the European Parliament with the statement that 80% of all innovation and exports comes from industry, as do many jobs and for that reason, the main focus of EU policies must be strengthening Europe's industrial base.

"EU strives to create one large Digital Single Market"

EU efforts to a fully developed Digital Single Market, reflected specifically in initiatives like "Digitising European Industry", "European Platform of National initiatives on Digitalisation", "European Catalogue of Digital Innovation Hubs", which lead to :

- Up to € 415 billion in additional growth;
- opportunities for the creating of new start-ups and business models;
- allow companies (especially SMEs) to grow and innovate in a market of over 500 million people;
- 36 million direct jobs;
- strong value chains enhancing innovation and digitisation;
- supportive research base, competence centres and Digital Innovation Hubs;
- technological breakthroughs in areas like robotics, Internet of Things, artificial intelligence, cybersecurity, energy systems;
- disruptive business models with a focus on big data, interactions, interoperability and service components.

The Tallinn Digital Summit of September 2017 and the Conclusions of the European Council of 19 October 2017 indicated the need for Europe to invest in digitising our economies and addressing the skills gap to maintain and enhance European competitiveness, our quality of life and social fabric.

The European Council concluded that the digital transformation offers immense opportunities for innovation, growth and jobs, will contribute to our global competitiveness, and enhance creative and cultural diversity.

"Despite efforts, Europe is still lagging in digitisation"

Despite efforts, Europe's role in the global data and platform economy is limited and the uptake of digital technology by SMEs is low: 90 % of SMEs and 60% of large companies are lagging behind.[4] Indeed, Europe lags behind in many areas compared to major competitors such as the US, Japan, South Korea and increasingly China. Therefore, adequate policies, actions and investments are needed to reap the full potential of the digital revolution and to accompany the transition.

Managers of European companies claim that they have difficulties in assessing the ROI in digital innovations, have problems trusting the technology, are not sure about the maturity of those technologies, compatibility/ interoperability with legacy systems, are afraid of being locked in with one vendor. [5]

Traditional sectors and SMEs are particularly lagging behind in their digital transformation. Recent studies estimate that digitisation of products and services will add more than €110 billion of revenue for industry per year in Europe in the next five years.

[3] Officially endorsed by EC DG-CNECT
[4] Berger (2015). The digital transformation of industry. EU study.
[5] Roundtable on Digitizing European Industry. Working group 1 report. 2017 June.
[6] Manufacturing risk index 2018

2. Lithuanian Perspective

"Lithuania is already above the EU target: 20.4 % of GDP is generated by the manufacturing sector"

Manufacturing is the largest sector of the Lithuanian economy, generating 20.4% of Lithuanian Gross Domestic Product. Manufactured goods account for more than 80% of total exports of Lithuanian goods and services. The manufacturing sector has played a key part in the dynamic growth of Lithuanian exports and is critically important to the Lithuanian economy. Since the end of the global financial crisis, Lithuanian manufacturing production has expanded by 62% and is already significantly above the pre-crisis level. This expansion was driven by several factors. First of all, after the global financial crisis, Lithuanian manufacturing has significantly increased its attention on expansion into foreign markets as the share of exports, in total sales, of goods from Lithuanian manufacturing rose to 62% in 2017, up from 52% in 2007. Secondly, gradual recovery in the EU region, which accounts for 80% of exports of goods of Lithuanian origin, has also played a significant part. Lastly, increased integration of Lithuanian manufacturing industry into the EU manufacturing value chains, coupled with an increased number of manufacturing businesses in Lithuania, have also had a positive impact on the expansion of the Lithuanian manufacturing sector and its output.

Lithuania exports are heavily dominated by export of goods (manufactured by industrial businesses), which account to almost 80% of total export of goods and services. In comparison with other EU member states, Lithuania stands out as the country with particularly significant share of export of goods in GDP (62% of GDP). Lithuanian manufacturing, which is heavily linked with export markets, has been growing dynamically ever since 2010. In the last 5 years alone, manufacturing output rose by almost a third and is 34% above the pre-crisis level. Lithuanian manufacturing sector has not only been growing in terms of production output, but also in terms of the number of businesses (companies). Since 2010 the number of enterprises operating in manufacturing sector rose by 28%, or by 1 468 new businesses.

"Lithuania is rated No.1 in Europe and No.2 in the world (after China) on attractiveness in global manufacturing, according to the Manufacturing Risk Index (2018)"

Both Lithuanian manufacturing (which has significantly increased its focus on export development after the crisis) and Lithuanian exports registered record growth in 2017. The geographic composition of Lithuanian exports remains very homogenic, with the EU accounting for around 80% of total exports of goods of Lithuanian origin. Germany is its largest export partner, accounting for 12.5% of total exports.

Stable operating environment and good quality/cost ratio has made Lithuania no. 1 in Europe and no. 2 in the world (after China), according to the Manufacturing Risk Index (2018), which analyses the attractiveness for global manufacturing. Even in less optimistic scenarios (cost increases, less stable operating conditions), according to the same index, Lithuania is still rated amongst the Top 5 global manufacturing destinations in the world.[6] The improving investment climate is also reflected in the shifting trends in Foreign Direct Investment coming into Lithuania. Lithuania has become a popular destination for manufacturing sector entities.

"A major challenge for Lithuania is to decrease its dependence on contract manufacture of low value-added products"

Although productivity in Lithuanian manufacturing is rising, the increase in productivity is much less than that of labour costs. Whilst labour costs rose by more than 40% during the last 5 years, productivity in the Lithuanian manufacturing sector increased by only 14%. This could well be a major hindrance to the Lithuanian manufacturing sector's competitiveness in the future.

Together with a rapid rise in labour costs and lagging productivity, the dominance of low-tech sectors in Lithuanian manufacturing could complicate the situation for Lithuanian manufacturing in future. The low and medium-low tech manufacturing sectors generate approximately ¾ of the total manufacturing output, sales revenue and value-added in Lithuanian manufacturing; 85% of all employees in the Lithuanian manufacturing sector are employed in low and medium-low tech manufacturing. In 2017, the low-tech manufacturing sector accounted for 55% of the total output of Lithuanian manufacturing, while the share of the medium-low-tech sector accounted for 19% of the total output. The medium-high-tech sector generated 22% of the output of the

Lithuanian manufacturing industry, while the high-tech sector generated 3.6% of output.

A slight decline in the low-tech sector's share in output and a small increase in the higher technology sector's share in the total output of Lithuanian manufacturing can be observed. For example, in 2017, as compared to 2010, the share of low-tech sector manufacturing output dropped from 56.6% to 54.9%; while the medium-high-tech sector's rose from 16.1% to 19.1%. The high-tech sector's share rose slightly, from 3.1% in 2010 to 3.6% in 2017.

Nevertheless, Lithuanian manufacturing remains heavily dependent on lower value-added contract manufacturing services. This can be illustrated by the productivity figures from Eurostat. For example, data from Eurostat shows that in 2015, each employee in the Lithuanian manufacturing sector generated €19,100 in value-added per year; in comparison, the EU average stands at €62,000 per year – more than 3 times higher than the Lithuanian manufacturing sector. In Germany, the figure stands at €73,600 per annum.

The rapid pace of industrial automatisation and robotisation in the EU will also affect business and contract manufacturing relationships between the various EU member states. To maintain and develop contract manufacturing relationships with the core EU member states, Lithuanian manufacturing businesses will have to follow suit and join the "automatisation and robotisation race" in the EU, which will further improve productivity and process efficiency. Otherwise, businesses risk disintegration from manufacturing value chains in the EU.

Therefore, it is vital for Lithuanian manufacturing companies to maintain their competitiveness. This means a substantial increase in productivity levels and investments in creation of higher value-added products. However, the global economy is close to reaching its peak and the EU economy's growth is likely to slow. Instead of investments in additional manufacturing capacity, this suggests investments in smart manufacturing equipment and/or processes, and R&D.

"Highly qualified engineers, technicians and machine operators are the most demanded by the industry"

Since 2013, the number of people employed in industry has grown steadily, through the recovering export markets and increased investment in development and new technologies. Therefore, industry's development has led to an increased demand for machine and plant operators in the labour market.

According to the Employment Opportunities Barometer of the Lithuanian Employment Office, the following specialists have significant employment opportunities in industrial enterprises:

- Electrical engineering technicians;
- Mechanical engineering technicians;
- Technology and manufacturing engineers.

Regarding highly qualified employees, the following positions offer significant employment opportunities in industrial enterprises:

- Electrical engineers and electrical contractors;
- Metalworkers and installers;
- Metalworking machine tools operators;
- Machine operators for the manufacture of plastic products.

Still, unemployment in the industry was 21489 positions (as of January 1, 2018). Meanwhile, vacancies in the industry amounted to 21.5%. The main reason why vacancies are not filled despite a high unemployment rate could be that a typical unemployed person is an older man with a secondary education. This shows that, in order to fill vacant jobs in the industry, it is necessary to have a higher qualification (almost 57% of all job offers are for skilled workers), have at least 1-2 years of experience, be motivated to learn new things and work in a team, have digital skills, communicate in English, etc.

23% of employers from industry (mostly - 92% representatives of SMEs) took part in the survey, aimed at identifying labour market trends in the coming years, organized by the Lithuanian Employment Service[7]. The result of the survey showed that in industry, labour demand in 2018 will be 18%, and qualified workforce will be allocated 78% of all job offers, while demand for the unskilled workforce will decrease. This trend is projected to continue in the coming years, as unskilled workers will be replaced by machines.

66% of employers from industry surveyed claimed they face a challenge to find employees, and the training of newly recruited employees lasts for approximately half a year. This creates additional costs and prevents companies from expanding their business more quickly. Insufficient motivation and competence, emigration, high competition with other employers are just a few reasons indicated by interviewees. Although appropriate education, qualifications, and work experience are needed and valued by the employer, personal characteristics are no less important - motivation, ability to quickly adapt to innovation and experience are the most important factors when choosing an employee. Continuing lifelong learning, skills development (especially digital skills) will continue to be crucial in the industry.

3. Local Ecosystem

The current Lithuanian ecosystem connected to industry digitisation initiatives relies on three blocks of actors:

- Solution providers
- End-users
- Supporting organizations

The main challenge in such a system is to create linkages between the different actors and to facilitate the flow of ideas, investments, and knowledge across all the institutions.

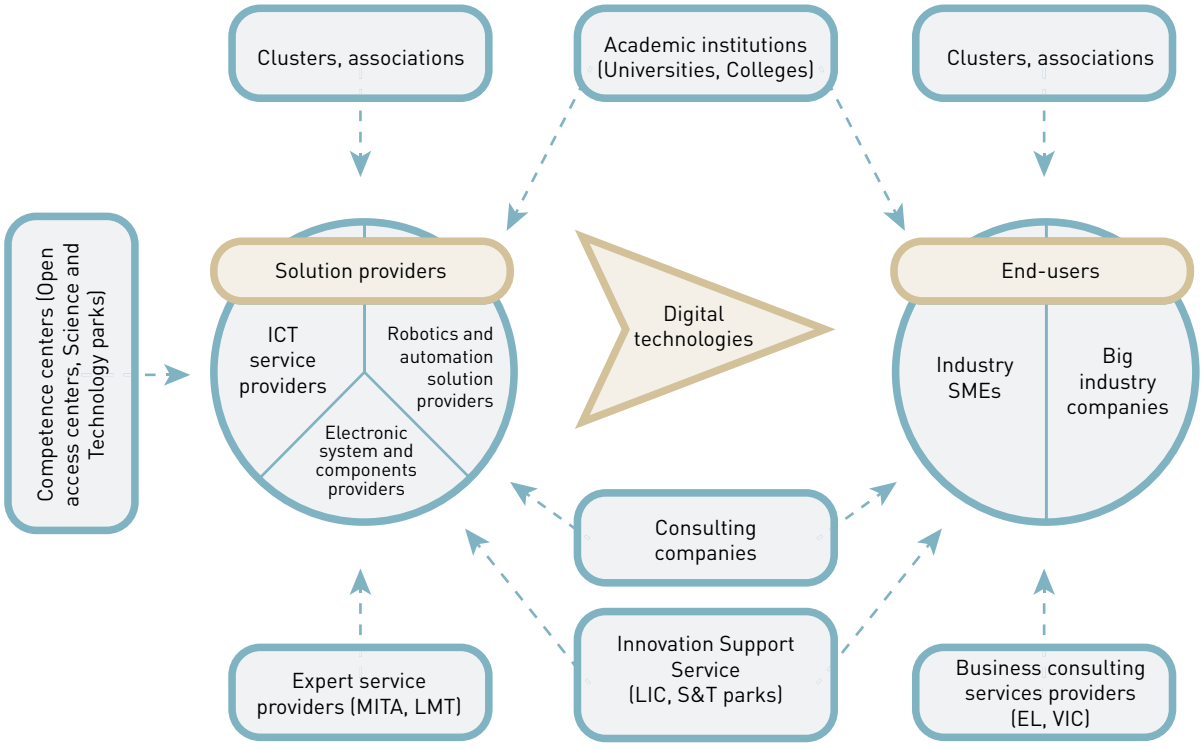

Figure 1. Lithuanian ecosystem for industry digitisation

In order to solve this challenge, the national industry digitisation platform "Pramonė 4.0" (Industry 4.0) was established. The platform unites all the major stakeholders and is the main consensus-building instrument in the ecosystem.

The idea of the platform was developed by the German-Baltic Chamber of Commerce (AHK) together with

[7] Lithuanian employment in 2017. Trends and future forecasts

the Engineering Industries Association of Lithuania (LINPRA), the Lithuanian Confederation of Industrialists (LPK), the Information and Communication Technologies Association (INFOBALT), Vilnius Gediminas Technical University (VGTU) and Kaunas University of Technology (KTU), in July 2016. The Minister of the Economy and Innovation of the Republic of Lithuania supported the initiative and took the role of steering and coordinating the platform.

The platform currently operates at 3 different levels:

- **The National Industrial Competitiveness Commission "Pramonė 4.0" ("Industry 4.0").** Led by the Minister of the Economy and Innovation, the Commission consists of the high-level representatives from LPK, LINPRA, INFOBALT, Lithuanian Robotics Association (LRA), the Lithuanian Innovation Centre (LIC), Lithuanian Business Confederation (ICC LITHUANIA), Government of the Republic of Lithuania, Ministry of Education, Science and Sport, Ministry of Social Security and Labour and the Centre for Physical Sciences and Technology (FTMC).
- **The Coordination group** contains the same stakeholder representatives as the Commission and, in addition, includes representatives from AHK, KTU and VGTU. The Coordination group contains members who directly work on digitisation issues.
- **Thematic working groups** that work in the areas of digital manufacturing, services promoting digitisation, standardisation and legal regulation, human resources and cyber security. More than 80 experts from business, industry, academia and public sector are involved in the activities of the platform through working groups.

The platform seeks to achieve competitiveness and productivity in industry, as well as promoting the integration of digital solutions and new technologies in industry. The platform serves as a venue for the early stage and active involvement of major stakeholders (including businesses) at various levels (The "Pramonė 4.0"Commission, coordination group, working groups), thus helping to create an active dialogue between industry, research, education and governmental institutions, helping to anticipate change, adapt to future needs, and propose the most efficient solutions for the digitisation of industry.

4. Benchmarking with selected EU Countries

When benchmarking Lithuania against a selected number of EU countries - Germany, Denmark, Finland, Sweden, Belgium and The Netherlands, a set of following indicators was assessed:

- Share of manufacturing in GDP (%)
- Share of medium-high-tech sector within total manufacturing (%)
- Turnover per person employed (TEUR/year)
- Proportion of employees in the manufacturing sector, of total employment (%)
- Average hourly wage rate in manufacturing (EUR/hour)
- Labour productivity in manufacturing (TEUR/year)

The results of benchmarking against these indicators is reflected in Figure 2 below.

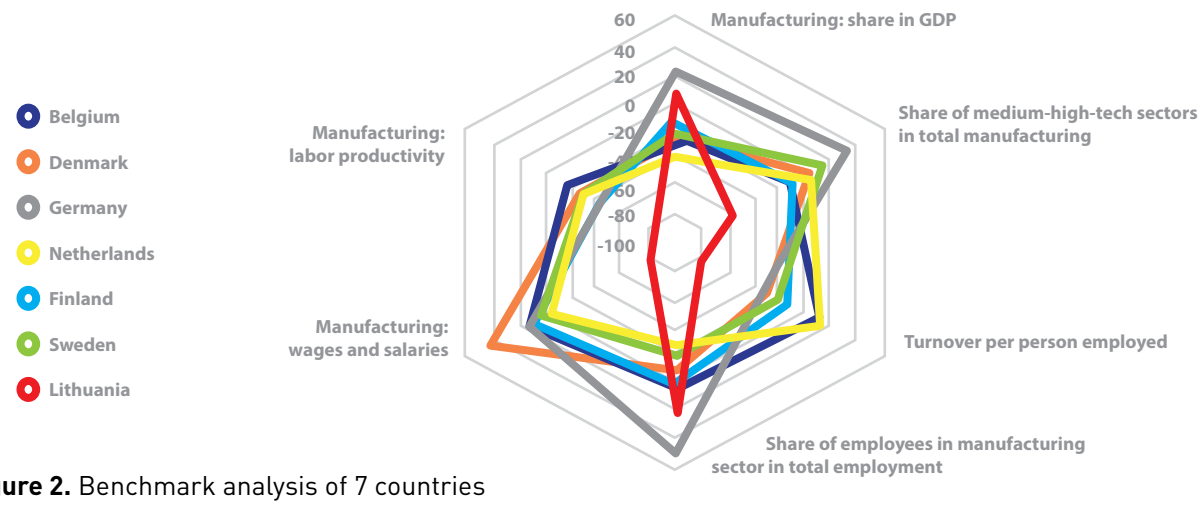

Figure 2. Benchmark analysis of 7 countries

The benchmarking shows that although Lithuania has some advantages in the share of manufacturing and share of employees in manufacturing, there is a clear gap in labour productivity and in the share of medium-high-tech sector. Although wages and salaries are rising disproportionately more rapidly in comparison to productivity, there is still much room for growth in this area, as well as in increasing turnover per person employed. Moreover, the percentage of personnel costs within total manufacturing expenditure did not change in Lithuania during the period 2010-2015, which may indicate that Lithuania underinvests in automatisation and robotisation.

5. The Most Influential Technological Trends for Lithuanian Industry Digitisation

There was a series of working groups of Lithuania Industry 4.0 round table debates and analysis of technological foresights.[8] After this, working groups agreed on the following list of technologies that will have the biggest impact on the digitisation of Lithuanian industry up to 2030.

The types and descriptions of the technologies align with recent recommendations from the working group reviewing the Lithuanian Smart Specialization Strategy. There is a strong correlation between Lithuanian priorities for future investment in R&D and the technologies described below. This list will also serve as a guide for the next funding period, 2021-2026.

A major challenge still remains: how to turn current and future public R&D investments made under the Smart Specialization Strategy into commercial products which are installed and tested in Lithuanian industry companies and later scaled up, worldwide.

Additive manufacturing (AM) is based on additive fabrication principles, whereby a structure is formed directly from a digital model. This technology overarches other technologies currently trending, such as 3D Printing, Rapid Prototyping (RP), Direct Digital Manufacturing (DDM), and goes particularly well with On Demand Manufacturing (MOD). Depending on the technique, additive manufacturing can easily be complemented by other technologies, e.g. lasers in the sintering and melting of the materials.

Automation is a technology that enables processes to be performed without human participation in the technological process – and therefore replaces human workers in control of, or monitoring, tasks. In an industrial setting, it concerns manufacturing, material handling and quality control. However, not all tasks can currently be automated. Although automation leads to a reduction of the manufacturing workforce, supervision of the automated operations by employees is still necessary, in order to prevent costly and potentially hazardous malfunctions.

Robotics is an integrative field of engineering disciplines concerned with the design of robots. Industrial robotics specializes in the creation of robot systems used for manufacturing. Industrial robots are programmable mechatronic systems with between three to eight operable mobile axes. Robots are either fixed (attached to the frame) or autonomous (with free movement on the floor or other surface). Typically, industrial robots have many and various applications. They are advantageous in their great endurance, speed and precision, and are irreplaceable in especially tedious or dangerous tasks.

Mechatronics is a synergistic integration of engineering fields such as mechanics, electronics, informatics and control systems, with input from many other technological domains. Mechatronics is crucial in Computer Integrated Manufacturing (CIM) and in the establishment of Flexible Manufacturing Systems (FMS). It also forms the basis for automation systems and robotics; all existing Computer Numerical Control (CNC) systems are full-featured mechatronic systems. In the near future, mechatronics will play a significant role in Cyber-physical Systems (CPS) used for monitoring, coordination, control; integrated by a computing and communication core.

§ Mainly High-level strategy groups on Industrial technologies under the European Commission review of key enabling technologies (KETs), EC (2016) study on advanced manufacturing technologies, Factories of the Future roadmap, Robotics 2020 Multi-annual roadmap, foresights by Imperial College London, Gartner and McKinsey group insights

Smart Sensors are devices that are capable of selective detection and filtering of incoming information. Therefore, they allow the automated collection of data with less environmental noise and more accuracy. Ordinary sensors, however, can only acquire object information and convert it into an electrical signal, which is then transmitted to a measuring or control instrument. With sensors, no matter which type, measurements of almost any physical property can be obtained. Recent developments focus on improved performance, better integration, multi-parameter sensing, built-in intelligence, secure and safe operation and networking by design.

Photonics is the science and technology that encompasses all technical uses of light – photon generation, detection, and control. Within a broad field of applications, there are a few areas particularly relevant to Industry 4.0, such as lasers, high-speed optical links, sensors and optoelectronics (e.g. LEDs). Digitisation processes are expected to contribute to the convergence of processing and communication photonics. The latest improvements in laser technology have achieved shorter pulse durations, shorter wavelengths and higher power than before. In an industrial setting, lasers can be applied particularly well in additive manufacturing, material processing, photolithography, telecommunications, sensor systems and precision measurements.

Internet of Things (IoT) is an interconnected network of physical devices that may contain electronics, software, sensors, actuators and connectivity components, by which they can communicate and exchange data. Industrial Internet of Things (IIoT) is regarded as a subset of IoT and is synonymous with Industry 4.0. Therefore, its implementation is expected to create new business models, improve productivity, exploit analytics for innovation, and to transform the workforce. In manufacturing, IIoT relies on the concept of Cyber-Physical Systems (CPS): the interface between the human and cyber worlds that would translate collected data into actionable information. Cloud computing and big data are also relevant in IIoT.

Cyber Security is the protection from cyberattacks of internet-connected systems of hardware, software and data. Industry and business analysts, as well as the EU, promote a holistic approach to cyber security in efforts to digitalize industry, whereby measures are integrated throughout the hardware and software development life cycle and across multi-layered supply and value chains, by design. However, the integration of physical and digital systems (also known as IT/OT convergence) in the paradigms of Cyber-Physical Systems (CPS), Industrial Internet of Things (IIoT), cloud-based design and manufacturing, reveal new vulnerabilities and threats to value chains, smart factories and products.

Cloud Manufacturing (CMfg) represents networked manufacturing, which is based on on-demand access to diversified and distributed resources and operates through temporarily formed cyber-physical production lines. The benefits of such a model include enhanced efficiency, reduced product lifecycle costs and optimal resource allocation. Moreover, the cloud manufacturing process is agile, highly scalable, accessible and virtualizable. It incorporates big data and exploits best IoT and cloud computing capabilities. The effectiveness of cloud manufacturing can be further enhanced by integrating Business Management Systems (BMS) and Lean manufacturing principles in the production process.

Automated Warehouse Management Systems (WMS) refers to software designed to control and administer processes associated with the inbound and outbound movement of materials and goods. The supervised operations include inventory management, picking and auditing. As a stand-alone system or a module, WMS can be integrated with an inventory management system and/or a transportation management system (TMS) and together, comprise parts of a larger Enterprise Resource Planning (ERP) system or a comprehensive supply chain execution suite. With the advent of Industry 4.0, the manufacturing process will increasingly be controlled by Cyber-Physical Systems (CPS), which, if integrated with a smart WMS, would increase their responsiveness and flexibility.

Artificial Intelligence (AI) describes the ability of software or machines to imitate the mental proficiency of humans. In manufacturing, it allows machines to perform human-like tasks and automate processes. AI can contribute to a significant improvement in productivity, as well as efficiency. It heavily relies on **Big data**, which refers to all data collected from sources within a smart factory, including manufacturing equipment, machine controllers, sensors, WMS/ERPs, etc. The aggregated input has a determinant role in the control of manufacturing operations that are facilitated by high-performance ICT infrastructure if IoT and CPS concepts are integrated in the production and services processes via the cloud.

Augmented Reality (AR) refers to digital information overlay on an image displayed on a user's device in real-time, the experience of which can be extended with other sensory aids. It is related to a concept of **Virtual Reality (VR)** and is synonymous with Mixed Reality (MR: hybrid reality or computer-mediated reality). In manufacturing, AR can effectively reduce occurrences of human error, fix inefficiencies and cut down costs as well as improve performance. A good example of virtual reality use in manufacturing is digital twin technology (making a virtual copy of – for e.g. – designs, production lines, processes, products).

Business Management Systems (BMS) are tools for strategic planning and the tactical implementation of decisions. These activities mostly involve planning, monitoring and control. BMS can also include tools developed for Enterprise Resource Planning (ERP), Manufacturing Execution Systems (MES), Customer Relationship Management (CRM), Human Resource Management (HRM), Product Lifecycle Management (PLM), and Supply Chain Management (SCM). Implementation of such systems would assist in achieving vertical and horizontal integration: one of the goals promoted by the Industry 4.0 movement.

This list represents the Lithuanian experts' consensus on the technologies that will have the biggest impact on the digitisation of the Lithuanian manufacturing industry to 2030. They are worth considering as areas of focus in the development of the Lithuanian Smart Specialization Strategy, to formulate research and public investment priorities and to inform the design of study and education programmes.

6. Integration in International Value Chains

Based on our national ecosystem model, which clearly separates the end-users from the solution providers and the supporting actors, two different kinds of value chains were analysed.

The following criteria were used in the analysis:
- Export size
- Production structure
- Share in the economy
- Development trends
- Productivity

The following value chains for **end-users** were identified:
- Machinery and equipment
- Timber and furniture
- Electrotechnics
- Plastics
- Food

The following value chains for **solution providers** were identified:
- Information and communication technologies (ICT)
- Automation and robotics
- Digital manufacturing processes technologies (electronic systems and components providers)

7. Lithuanian Industry Digitisation Will Rely on the Following Strengths

- **The manufacturing sector represents an optimal share in the Lithuanian economy,** since it accounts for a little more than 20% of Lithuania's GDP.
- **Manufacturing companies are well integrated into international value chains**, since more than 60% of local production is exported abroad. The share of capital and intermediate goods exported in regards to all export, during the first part of 2017, consisted of 11.8% and 51.4% respectively. [9]
- **Public and private IRT infrastructure is well-developed** – is consistently updated, provides world-class internet access and allows faster implementation of digitisation.
- **The growing capacity of digitisation solutions providers** who supply a wide range of services by participating in local and global value chains.

8. Lithuanian Industry Digitisation Will Address the Following Weaknvesses

- **Local industry is dominated by SMEs with low-level technology readiness**, which currently limits investment in the overall advancement of manufacturing.
- **Production is dominated by contract manufacturing of low value-added products**, which limits the need for cutting-edge technological solutions and does not require much cooperation between Lithuanian research and industry.
- **Insufficiently balanced state of the labour markets** and discrepancies between education and industry's needs.
- **The fragmented digitisation incentives system**, which consists of many elements, with poorly functioning links between them.
- T**he slowly developing partnership culture,** which hinders collaboration and cooperation between major actors in the ecosystem, as well as in ordinary B2B relationships.

9. Vision 2030 – a digitalized Lithuania

Following the SWOT analysis performed collaboratively by workgroup experts working together, the vision concerning the future of digitalized Lithuanian manufacturing sector for the year 2030 was established. The vision unites industry stakeholders in seeking a common goal – to ensure Lithuania's global competitiveness. The vision will also guide strategic actions implemented by the Government.

Internal/Company-related factors:

- Lithuania is dominated by relatively small, smart and agile factories manufacturing higher value-added products for niche markets; flexible organisations able to diversify rapidly to meet changing market needs.
- Lithuanian capital and foreign capital companies operating in Lithuania are deeply embedded in international value chains through ownership, production partners and realization markets.
- Lithuania is a 'testbed' for new cutting-edge technological solutions created across Europe, Japan and USA – first deployed in Lithuanian industry for demonstration purposes; then, spread across all of Europe. Therefore, Lithuanian solution providers and solution integrators always work with the latest technologies.

External/Environmental factors:

- Lithuania provides access to a variety of specialists that the industry demands, as required, for digitisation.
- Lithuania provides opportunities for lifelong learning, non-formal education and competence enhancement, through industry-university/college-cooperation.

[9] Foreign trade in March 2017

- Lithuania is a destination of choice for talented professionals from abroad and international students (who stay and work in Lithuania after their studies).
- Lithuania remains in the top EU member states that continually sustain a state-of-the-art infrastructure for industry development (accessible transportation, logistics, and energy in every corner of the country, as well as ICT appropriate to the 5G network and Industry 4.0).

Regional ambitions:

To become an industry leader for digitisation in a geographical territory within the regions covering: Lithuania, Latvia, Estonia, Belarus, North of Poland; with aspirations to catch up with Finland, Sweden, Denmark.

10. Strategic Pillars Supporting the Vision

Based on the previous analysis, the results of workgroup discussions and subsequent recommendations, an industry digitisation action plan supported by 4 pillars - **Knowledge, People, Infrastructure, and Environment** - was proposed. Each of these foundations encompasses distinct target priorities identified by experts and addressed by specific policy measures.

Knowledge considers technologies and business models that will become integrated through value chains.

People refers to policy-makers, researchers and creators, enablers, and intermediaries that will play a critical role in the digitisation of industry along the private sector and investors.

Infrastructure regards services infrastructure, demonstration infrastructure, and R&D infrastructure which, when combined, will provide the best possible conditions for manufacturing innovation.

Environment concerns the legal and regulatory environment, standards, and incentives system that will embed industry in a smoothly performing facilitation network within the local ecosystem.

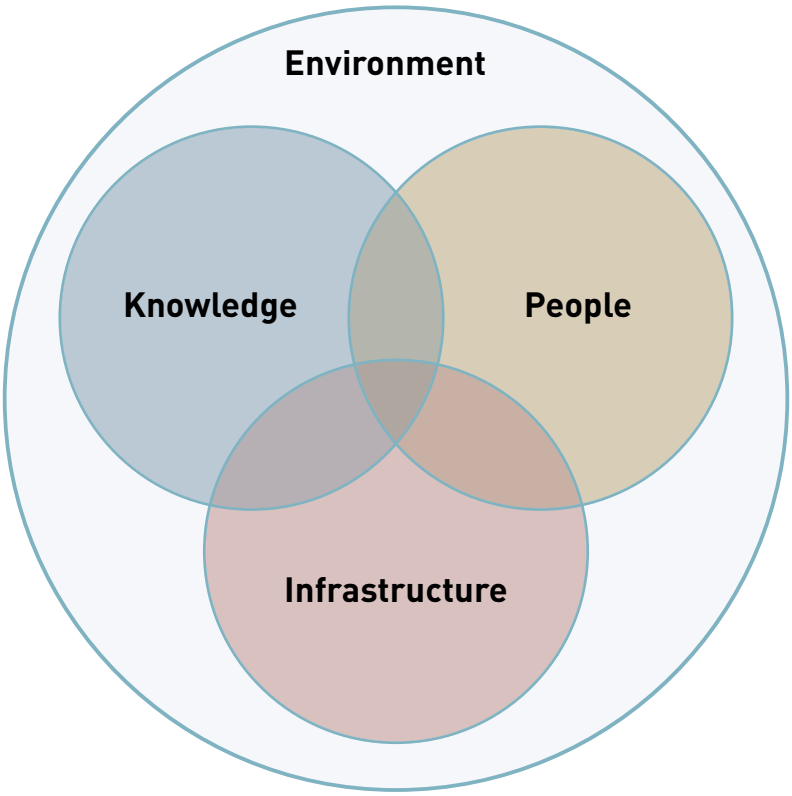

Figure 4. Strategic pillars

11. Taking Action

Strategic pillars cover areas that are in most need of action in order to achieve the digitalized industry's vision by 2030. To overcome these chaltlenges, digital competences and skills must be developed to assist companies in creation, adoption and implementation of digitisation solutions. By using opportunities provided by digitisation, companies would become enabled to increase their productivity, production value and to internationalize. These are the key measures to accomplish that:

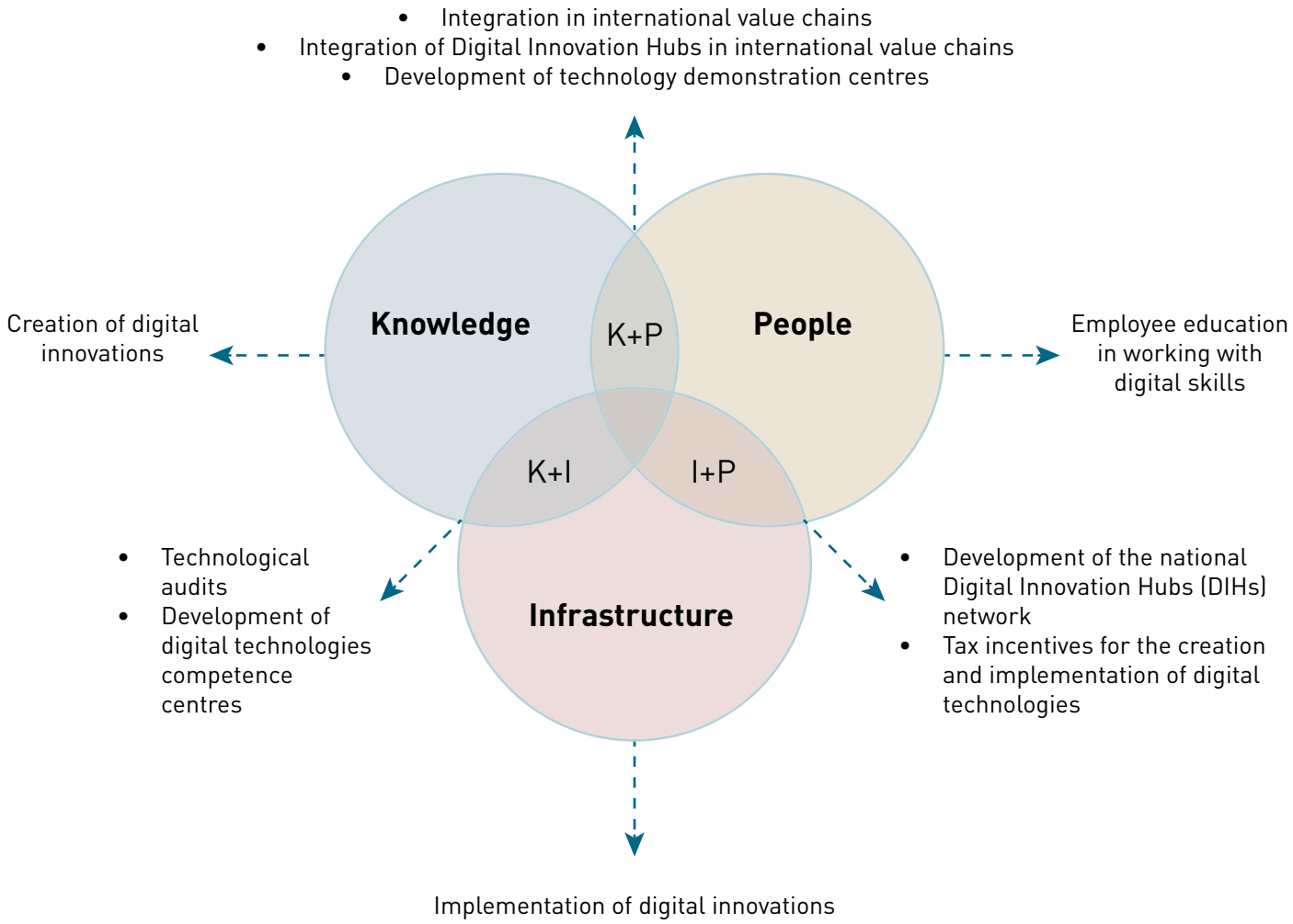

Figure 5. Key measures

These actions are designed to reflect the following phases with the greatest focus on the next public investment period, 2021-2027:

- 2019-2020 (short-term measures, serving as the preparatory stage for the period 2021-2027)
- 2021-2027 (medium-term measures, reflecting the main period in relation to the EU funding period and the Horizon Europe programme. The year 2026-2027 will be allocated for this particular period's initial impact assessment and preparation for the period 2028-2034, including the assembly of a Corrective Action Plan)
- 2028-2030 (long-term measures, relating to the country's overall strategy "Lithuania 2030" and focusing on the implementation of lessons learned and corrective actions from the period 2021-2027)

Implementing these measures are expected to grant the following **benefits**:

- Higher rankings/better ratings across a range of indicators that measure the state's performance in digitisation and/or innovation at European level and globally
- An increased number of companies carrying out innovation activities
- An increased number of companies that benefit from tax reliefs
- A growing share of GDP generated by high-tech companies
- An increasing number of employees working in high-tech companies
- A more effective innovation system
- Better adaptation to pan-European and global standards
- New services for businesses
- The national network of Digital Innovation Hubs that provide specialized digitisation services
- An increased ratio of medium to high-tech companies compared to all companies
- An increased number of registered patents
- A reduced regulatory burden for companies carrying out innovation activities
- An increased number of PhDs working in the field of industry digitisation
- Reviewed and updated study programmes
- New and interdisciplinary study programmes in relation to industry digitisation
- New scientific and technology demonstration equipment
- An increased number of professionals attracted to industry from abroad
- Increased private company investments in innovation activities
- Increased added-value generated by manufacturing enterprises
- Increased manufacturing companies' turnover
- An increased number of projects funded via public-private partnerships
- An increase of exports in identified value chains
- An increased number of companies that benefited from state support to get involved in international value chains