SO RIS
Sieć Regionalnych
Obserwatoriów Specjalistycznych

Technology Development Program of the Silesian Voivodeship for 2019-2030

Katowice, 12.2018

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The hereby document was elaborated by a team of experts
at the Marshal's Office of the Silesian Voivodeship
and Specialized Observatories in the fields of:
Nanomaterials and Nanotechnologies
Production and Processing of Materials
Technologies for Energy Sector
Technologies for Medicine
Technologies for Environment Protection
Technologies for Aviation Industry
Information and Telecommunications Technologies

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Explanation of abbreviations

R&D	Research and development activity
B2B	Transactions between two or more economic entities *(business-to-business)*
B2C	Relations between enterprises and individual customers (*business-to-consumer*)
CNC	Computerized steering of numerical devices
ESA	European Space Agency
ESCA	European Secretariat for Cluster Analysis
GUS	Central Statistical Poland
IBnGR	*Institute for Market Economics*
ICT	Information and Communication Technologies
BSI	Business Support Institutions
IT	Information Technologies
KSSE Co.	Katowice Special Economic Zone
IPC	International Patent Classification
SMEs	Small and Medium Enterprises
RES	Renewable Energy Sources
GDP	Gross Domestic Product
NACE Rev. 2	Polish Classification of Activities 2007, compiled on the basis of the Statistical Classification of Economic Activities in the European Community – NACE Rev. 2.
SG OP	Smart Growth Operational Programme
I&E OP	Infrastructure and Environment Operational Programme
EDP	Entrepreneurial Discovery Process
TDP	Technology Development Program of the Silesian Voivodeship for 2010-2020
TDP 2010-2020	
RIS	Regional Innovation Strategy
ROP SV	Regional Operational Programme of the Silesian Voivodeship for the years 2014-2020.
ROP SV 2014-2020	
SO RIS	The Network of Regional Specialized Observatories
SO RIS in EDP	The Project of the Network of Regional Specialized Observatories in the Entrepreneurial Discovery Process
SWOT	Method of Strategic analysis (*strengths, weaknesses, opportunities, threats*)
SV	Silesian Voivodeship

Key Terms

Technology

- method of processing natural goods into useful goods (products), as well as the applied science about the processes of creating products from starting materials. The following criteria for the division of technologies are used: a) types of obtained products (e.g. paper technology, machine construction technology), b) type of processed material (e.g. wood technology), c) applied method (e.g. chemical technology, mechanical technology)[1],
- set of elements of practical and theoretical knowledge, skills of its application (know-how), methods, procedures, experiments and physical devices [2],
- method of carrying out the production or processing ~~process~~ and the field of technology, which deals with the development of new methods of products production or processing of raw materials [3].

Technological area - a group of technological directions with a specific specialization.

Technology group - technological direction with a specific specialization.

Node technologies[4] – technologies strongly dependent on the development of other technologies in the region or conditioning the development of other technologies in the region.

Island technologies [5] – technologies unrelated to other technologies of the region and not conducive to the development of other technologies in the region.

Endogenic technologies [6] – technologies created and / or improved in the region, which products have a good position on external markets.

Exogenic technologies[7] – technologies originating from outside the region, which should be treated as worth developing / improving.

Entrepreneurial discovery process (EDP) - the process of selecting priorities and allocating resources through the participation of stakeholders from the world of entrepreneurship (including companies, universities, public research institutes, independent innovators), who should select the most promising areas for future development of the region[8].

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[1] Grudzewski M., Hejduk I. K., *Zarządzanie technologiami. Zaawansowane technologie i wyzwanie ich komercjalizacji*, Warszawa, 2008

[2] Dosi G., Pavitt K., Soete L., (red.) *The Economics of Technical Change and International Trade,* Harvester Wheatsheaf, New York 1990

[3] Słownik języka polskiego, pod red. W. Doroszewskiego, PWN

[4]Based on the Technology Development Program of the Silesian Voivodeship for the years 2010-2020, Katowice, 2010, p.113

[5] Ibid

[6] Ibid

[7] ibid

[8] *Guide to Research and Innovation Strategies for Smart Specializations* (RIS 3), European Union, 2012

Innovation -the result of all scientific, technical, organizational, financial and commercial activities that actually led or were intended to lead to changes in products, processes, organization, marketing[9].

Smart Lab (SL) - focus groups that gather companies from the selected economic area. In the assumption, ten leading companies participate in SL meetings - selected during interviews, representing an area with potentially many endogenous assets (e.g. intelligent architecture, recycling, CNC machines). Representatives of R&D centres, universities and research centres, BSIs and local authorities also participate in SL. The "Smart Lab" meetings are the main element of the proposed EDP and smart specializations policy. The purpose of these meetings is to verify, refine and/or modify existing smart specializations, as well as identify those that emerge [10].

Living lab - a laboratory which main task is to provide space and resources for research organized by enterprises (in the B2B model) or enterprises with participation of users (in the B2C model)[11].

[9] OECD/Eurostat, *Oslo Manual 2018: Guidelines for Collecting, Reporting and Using Data on Innovation,* 4th Edition, The Measurement of Scientific, Technological and Innovation Activities, OECD Publishing, Paris/Eurostat, Luxembourg, 2018.

[10] World Bank Group, W kierunku innowacyjnej Polski: Proces przedsiębiorczego odkrywania i analiza potrzeb przedsiębiorstw w Polsce, 2015

[11]Regional Innovation Strategy of the Silesian Voivodeship for the years 2013-2020, Katowice 2012

1 Introduction

The Silesian Voivodeship remains one of the main driving forces of the Polish economy, which is confirmed by its 2nd place in the creation of the country's GDP and the 4th place in the share in GDP per capita [12]. The economic and scientific potential of the region resulting from the concentration of enterprises in various sectors of the economy, including those belonging to the group of high and medium-high technologies or knowledge-intensive services and many scientific centres with diverse educational, research and development competences, makes the region one of the top innovators in the country, ranked on the 7th place in the evaluation of innovation among regions in the country and on the 198th place among the regions of Europe according to the Regional Innovation Scoreboard 2017[13]. Data on the region's innovation indicate that it has been characterized by a declining dynamics of growth in recent years. This change and the budget perspective 2014-2020 as well as the subsequent programming period have been an impulse for reviewing and updating solutions regarding technological development and support for innovation in the Silesian Voivodeship.
In order to comprehensively diagnose the development directions of the voivodship in terms of innovation, monitoring tools and methods for assessing the directions of development of technological areas in Silesia have been developed, which became the basis for the development of the Technology Development Program of the Silesian Voivodeship for 2010-2020 (TDP). That document, constituting an innovative approach to identifying, monitoring and stimulating the pro-technological development of the region, was adopted in 2011 as a strategic development plan for the region, taking into account the context of financial perspective “Horyzont 2020” and the results of regional foresight called "Priority technologies for the sustainable development of the Silesian Voivodeship".

At the same time, as a result of the implementation of subsequent system projects implemented by the Silesian Voivodeship together with regional partners, the Network of Regional Specialized Observatories (SO RIS) gradually developed in the TDP document, the task of which is to integrate the actors of the innovation ecosystem around development challenges of regional areas of specialization. The currently existing Observatories carry out tasks related to:

- support and improvement of regional development management in the scope of: regional scientific and technological potential, positioning of key technological areas and evaluation of the effectiveness of activities aimed at creating a regional policy of pro-technological development of the Silesian Voivodeship and strengthening of regional specialization,
- strengthening the region's adaptive potential, regional market for research services and regional personnel by building relations between the R&D sector, enterprises, BSIs and regional authorities,
- development of knowledge, competence and exchange of experience.

[12] Gross domestic product per capita and gross value added in the voivodships' breakdown in 2016, GUS Warszawa, 28.09.2018.
[13] Regional Innovation Scoreboard 2017, Internal Market, Industry, Entrepreneurship and SMEs, European Union 2017

SO RIS in EDP

Since 2017, the following Observatories have been operating in the Silesian Voivodeship:

- **Specialized Observatory in the area of Technologies for Medicine (**leader: Upper Silesian Agency for Entrepreneurship and Development Ltd. , Professor Zbigniew Religa Foundation of Cardiac Surgery Development, Institute of Medical Technology and Medical Equipment ITAM in Zabrze, Silesian University of Technology - Faculty of Biomedical Engineering),
- **Specialized Observatory in the area of Technologies for Energetics** (leader: Science and Technology Park "Euro-Centrum" Ltd., Regional Development Agency in Czestochowa **Co.**),
- **Specialized Observatory in the area of Information and Telecommunications Technologies** (leader: Science and Technology Park "TECHNOPARK GLIWICE" Ltd.),
- **Specialized Observatory in the area of Technologies for Environmental Protection** (leader: Central Mining Institute),
- **Specialized Observatory in the area of Production and Materials Processing** (leader: Silesian University of Technology, Faculty of Organization and Management, Institute of Non-Ferrous Metals),
- **Specialized Observatory in the area of Technologies for the Aviation Industry** (leader: Silesian Science and Technology Centre of Aviation Industry Ltd.),
- **Specialized Observatory in the area of Nanomaterials and Nanotechnologies** (leader: University of Silesia in Katowice, Foundation of Nanotechnology and Nanoscience Support NANONET, Institute of Non-Ferrous Metals, Centre of Polymer and Carbon Materials Polish Academy of Sciences).

Institutions associated within the Network of Regional Specialized Observatories fulfil the tasks resulting from the agreement concluded in partnership , and the role of the leader of the entire Network is performed by the **Marshal's Office of the Silesian Voivodeship**.

Dynamic changes in the economy caused by the ongoing transformation of the region, the blurring of borders between industry sectors as a result of diffusion and transfer of innovation, setting new directions in the European and global economy and changes in the socio-economic environment have resulted in a review and update of the existing Technology Development Program so that it could respond to new challenges and become the basis for programming the development of the region in the 2020+ perspective.

The technological areas identified in the TDP document for 2010-2020 are still represented in the Silesian Voivodship, but the structural changes taking place there caused by global trends and national and regional conditions and endogenous factors resulted in a revision of their scope and an attempt to identify new development niches. Therefore, the technological areas identified in the TDP document were the starting point for conducting a critical analysis of the current state and then formulating strategic recommendations. At the stage of diagnosis of the current state of technological development of the region, there were difficulties with the unambiguous assignment of technology to one technological area. This state of affairs is the result of a widespread process of diffusion and mutual penetration of product and process innovations, existence of open innovations and global trends related to combining innovations from various fields.

The TDP update was carried out and took into account the new approach to programming and management of the innovative development of the region which is the process of entrepreneurial

discovery [14]. This process consists in selecting the most promising areas for the region's development in the future by stakeholders from the business sector. The aim is also to demonstrate where the region is the best at research, development and innovation. This process has a direct impact on the creation and implementation of the Regional Innovation Strategy for smart specialization and it is conducted in the region on many levels, which ensures its validity and objectifies the obtained results.

Entrepreneurial Discovery Process, carried out in the Silesian Voivodeship [15]for the needs of the TDP update, was associated with the methodological approach programmed in the Technology Development Program of the Silesian Voivodeship for the years 2010-2020, which allowed the evaluation and update of the list of priority technologies and technology groups and the indication of new technological areas. The TDP update was carried out in two ways and included the implementation of the project for technological areas where Specialist Observatories and evaluation studies operate for technological areas in which Specialized Observatories have not been established so far – i.e. technological area, transport and transport infrastructure as well as machine, car and mining Industry[16]. Activities implemented in the project formula (project "The Network of Regional Specialized Observatories in the Entrepreneurial Discovery Process (SO RIS in EDP)) included a large consortium, where the leader was the Marshal's Office of the Silesian Voivodeship, and the institutions involved in the Network of Regional Specialized Observatories (SO RIS), under which a number of measures intensifying dialogue with stakeholders (i.e. researching the needs of entrepreneurs and scientific units) and inventory of the market offer of BSI and R&D in the region were implemented, which ultimately affected the involvement in the work on updating a broad group of actors of the innovation ecosystem of the Silesian Voivodeship.

Logic of activities in the project (Figure 1), the purpose of which was, among others, the TDP update, included the following phases:

- **Diagnosis, Analysis**, in which using available quantitative data (public statistics, data of the Patent Office, industry reports, etc.) annual reports elaborated by SO RIS and information obtained in the process of researching the needs of entrepreneurs (249 direct interviews) and R&D units (10 direct interviews) and inventory of the market offer, verification and evaluation of technological areas was carried out,
- **Confronting, Verification**, where the results of the diagnosis and pre-defined technological areas together with technology groups and technologies were subjected to expert verification, which allowed their evaluation and indication of priority development directions. This process was supported by expert panels.
- **Synthesis, Defining, Updating**, where the strategic orientation and formulating recommendations for the innovative technological development of the Silesian Voivodeship was indicated. As part of the TDP update, the monitoring system was reviewed and supplemented, including the time period at which the list of key technologies for the region's

[14] Foray D. i in., Smart Specialisation – The Concept, a Policy Brief of the Knowledge for Growth Expert Group advising the then Commissioner for Research, Janez Potočnik 2009

[15]Report on the evaluation study, entitled " Entrepreneurial Discovery Process in the context of Silesian Voivodeship innovation development to 2020", Central Mining Institute - Marshal's Office of the Silesian Voivodeship, Katowice 2017.

[16]Report on the evaluation study, entitled "Future industries with the potential to stimulate technological development of the Silesian Voivodeship, including the innovation potential of traditional sectors - transport and machine industry", a consortium of ECORYS Polska Spółka z o.o. and SEENDICO Doradcy Radło & Wspólnicy sp. j., 2018.

development should be updated. The implementation model of TDP (road map) completes the works carried out at this stage.

The diagnosis and verification phases were accompanied by a continuous process of animation of entrepreneurs' cooperation, which included information meetings, organization of smart labs and living labs, as well as others that tightened the exchange of experiences between various groups of stakeholders. The process of animating cooperation influenced ongoing work on updating the TDP.

The result of the first stage of work performed by SO RIS is an in-depth diagnosis of the technological areas, the synthetic results of which are presented in this document. The diagnosis was referred to the status from 2010, from which the first TDP document was valid. Additionally, at the stage of sectoral documents' study, the main trends in technological development were determined, which also result from regional trends diagnosed by Observatories. The diagnosis allowed to redefine the scope of technological areas, giving a starting point for delineating the directions of technological development of the region and for specifying areas of regional specialization.
The second stage of the work was an in-depth reflection on the priority directions of technological development. The knowledge of independent experts and conclusions from evaluation studies carried out by the Marshal's Office of the Silesian Voivodship were used there. This stage of work led to the development of strategic goals and recommendations for the updated TDP and the development of a Program monitoring system.
As part of the second stage of the work, an implementation model for the updated TDP document was prepared, which presents the implementation system of the main arrangements included in the TDP document and forms, undertakings and milestones related to the implementation of recommendations included in the TDP.

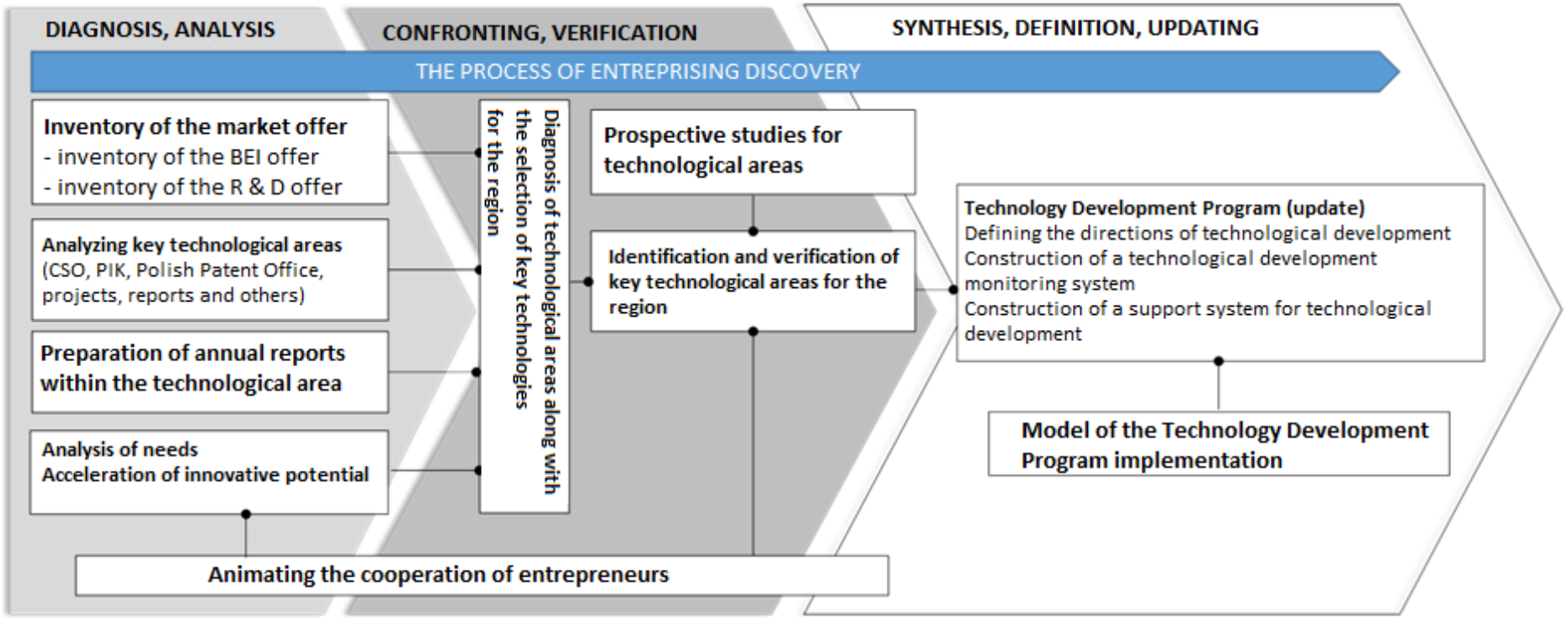

Figure 1. Logic of works on updating the Technology Development Program
Source: own study of Specialized Observatories

2 State and conditions of technological development of the voivodeship

2.1 Priorities of technological development resulting from strategic documents

The development of innovative technologies is the driving force of the modern economy and provides the implementation of the development visions of countries and regions. A number of analysed strategic documents[17] points to contemporary economic, social and environmental challenges that direct the demand for new technologies and the related needs. The priority of the innovative development of the Silesian Voivodship is the use of diversified potentials and synergies between actors of the innovation ecosystem in creating favourable living conditions based on access to high-standard public services and a modern and technologically advanced economy. Thus, the region, which is one of the strongest in economic and scientific terms in Poland, must ensure sustainable development in various areas and fields of life, using, among others, the latest technological solutions, which is realized through:

- developing innovation of business entities,
- increase in the number of developmental investments in the region,
- increasing professional activity and improving the qualifications of the region's inhabitants,
- improving the quality of the natural environment,
- improving the city's development conditions,
- development and modernization of transport infrastructure,
- using the potential of the Silesian Voivodeship to ensure energy security of the country and the development of innovation in the energy sector.

An in-depth analysis of regional, national and international strategic documents carried out by individual Observatories within the framework of the project SO RIS in EDP allowed for the establishment of a list of priorities for the region's pro-technological development.

Technologies for medicine (health care)	• Telemedical technologies • Material technologies in medicine • Technologies of regenerative medicine • Artificial organs • Technologies, devices and medical products • IT medical tools • Technologies aimed at obtaining essential progress in the field of combating civilization diseases
Technologies for energy and mining industry	• High-efficiency technologies that limit greenhouse gas emissions and other environmental pollutions ("clean technologies") • Development of high-efficiency poly-generation and cogeneration

[17]A broad analysis of program and strategic documents and industry reports carried out by SO RIS will be posted on the SO RIS website, the most important for the considered document was "Śląskie 2020+" Development Strategy of the Silesian Voivodeship,
Regional Innovation Strategy of the Silesian Voivodeship for the years 2013-2020, Strategy for Responsible Development for the period up to 2020 (including the perspective up to 2030), Europe 2020 – A European strategy for smart, sustainable and inclusive growth and the Program for Silesia.

	• Generation of energy from renewable sources, improvement of the efficiency of obtaining energy from RES, development of prosumer energy • Energy production from waste and alternative fuels • Energy storage using various technologies • Development of intelligent networks and interconnections, especially connections between the network and renewable energy sources • Dissemination and development of energy-efficient buildings
Technologies for protection the environment	• Innovative solutions and technologies in water and sewage management (technologies in the field of water quality improvement for consumption and economic purposes, technologies of water treatment and recovery and reducing its consumption, technologies of wastewater treatment and recovery of water and other raw materials from wastewater) • Technologies aimed at rational and effective management of mineral resources (promotion of modern technologies in the coal mining sector to increase competitiveness, improve work safety, protect the environment and create the basis for technological and scientific development) • Innovative recovery technologies, including recycling; waste-free or low-waste innovative production technologies and safe methods of waste management • Environmental technologies aimed at minimizing negative consequences for the environment, reduction of low emissions and technologies conducive to adaptation to climate change • Biotechnologies for the production of innovative bio-products, advanced biomass processing for special chemical products, application of modern biotechnologies in environmental protection
Information and telecommunications technologies	• Telemedical technologies • The Internet technologies • Intelligent networks and their architectures, systems and applications • Geoinformatics • Analysis of large data sets
Production and processing of materials	• Production of metallic, ceramic and polymer products • New materials for "green energy" • Smart materials (liquids and magnetic powders), e.g. in medicine • Unconventional materials for 3D printing • Technology of non-metallic multifunctional materials • Materials based on rhenium - arms industry, aviation • Composite products • New materials in mining (composites, nanobarriers) • Low-emission and energy-saving technologies for metal products • Components for machines for the mining and energy industries • Modern material coatings • Refined metallurgical products • Energy-efficient technologies for the utilization of metal waste • Materials reinforced with carbon nanotubes • Products from processing non-ferrous metals (rods, profiles, rods,

	etc.)
Design and manufacturing technologies in the aerospace industry and aviation industry	• Automation and robotics of manufacturing processes • Personalization of technological solutions and products • Development of autonomous vehicles and aircraft • The development of electromobility, including energy storage • Personalization of technological solutions and products • Development of the Polish space industry - increasing innovation and competitiveness of industry, increasing the efficiency and effectiveness of public administration, meeting defence and national security needs • Increasing airport capacity and creating airport infrastructure together with infrastructure management systems
Nanomaterials and nanotechnologies	• Nanomaterials and composites • Nanoelectronics • Nanooptics • Nanophotonics • Nanobiotechnology • Nanomedicine • Nanomagnetism • Filtration and membranes • Tools or devices in the nanoscale • Catalysis • Modelling and simulation software

Source: SO RIS analysis

The identified list of priority technological areas relevant for the region's pro-technological development results from the diagnosed changes taking place in the region, stemming from the following conditions:

- technological (development of knowledge resources and R&D potential, technical and technological achievements, professionalization of BSIs, technological convergence, supply of professional R&D services),
- economic (capital intensity, access to external funds, GDP growth, investment attractiveness),
- social (improving the standard of living, increasing spatial mobility, decreasing the number of people at working age),
- demographic (depopulation, lengthening the average age of life),
- economical (progressive influence of international corporations, global competition for raw materials and resources, development of interdisciplinary branches of the economy, demand for energy),
- environmental (reducing pressure on the environment and natural resources, effective management of raw materials, adverse climate change),
- political and legal (social corporate responsibility, tightening environmental standards, community markets).

A broad understanding of the term "technology" - both as a product and a process, but also the scale of application of technology - laboratory, supporting research and industrial implies the need to conduct activities related to the systematization and description of technological areas. The TDP

document in this regard meets the difficult challenge facing the region, the main advantage of which are the strongly developing technologies that, upon merging and penetrating constitute the basis for determining smart specializations.

2.2 Analysis of the potential of technological areas of the Silesian Voivodeship

2.2.1 Technological and innovative potential of the region

For the purpose of describing the potential of the region, statistical information was first used, which is supplemented by detailed qualitative and quantitative analyses carried out by individual Observatories. The analyses were conducted in relation to 2010, i.e. the period from which the first version of the document was in force.

2.2.1.1 Economic potential

Silesian Voivodeship is one of the most economically attractive regions in Poland, which is confirmed by the high GDP value generated in the region. This position of the region is affected by a number of factors related mainly to the industrial character of the region, which has been determined by economic and technological development [18]. According to the data of the Central Statistical Poland (GUS), the number of people living in the Voivodeship in 2017 constituted 11.8% of the population of Poland. In the Silesian Voivodeship, the age structure of the population in 2017 was as follows: in pre-working age 16.9% of people, production-age 61.1% and post-working 22.0% (Poland respectively: 18.0%, 61.2% and 20.8%). A significant share of people in working age creates an opportunity for economic and scientific development, however, the growing number of post-working age population is worrying. The main potential for human capital creation in the Silesian Voivodship is formed by 34 universities in which over 100,000 students are educated, that is 8.9% of students in the country.

In the economy of the Silesian Voivodship, in 2017, there were almost 469.9 thous. entities of the national economy, and the average employment in the enterprise sector amounted to 756.9 thousand people [19], which gives significant opportunities for creating economic development for all sectors of the economy concentrated in the region. The Silesian Voivodeship occupies the second place in terms of the number of entities in the economy and the number of employees, immediately after the Mazovian Voivodship. However, in 2010-2016, the dynamics of the growth in the number of business entities was below the average for the country in the Silesian Voivodeship and amounted to 108.4%, while for the country it was at the level of 113.6%.

Table 1. Number of business entities in the Silesian Voivodeship

PCA Section (Polish Classification of Activities)[20]	Year				
	2010	2013	2014	2015	2016

[18] Investment attractiveness of the regions 2017 - Silesian Voivodeship, **Collegium of Business Administration** Warsaw School of Economics, November 2017, GUS data

[19] Communication on the socio-economic situation of the Silesian voivodship in December 2017, Central Statistical Poland, Katowice 2018

[20]The presented sections of PCA are shown in international conversion maps as the most closely related to the technological development of the regions.

PCA Section (Polish Classification of Activities)[20]	Year				
	2010	2013	2014	2015	2016
Mining and extraction (Section B)	270	284	289	316	340
Industrial processing (Section C)	21 715	22 421	23 055	23 569	24 205
Production and supply of electricity, gas, steam, hot water and air for air conditioning systems (Section D)	255	279	276	314	348
Water supply; sewerage and waste management and activities related to reclamation (Section E)	921	1 005	1 022	1 056	1 023
Architecture (Section F)	25 647	24 592	24 915	25 938	27 225
Wholesale and retail trade; repair of motor vehicles, including motorcycles (Section G)	68 786	66 188	65 526	65 012	64 244
Transport and storage (Section H)	16 136	16 003	16 376	16 648	17 207
Accommodation and food service activities (Section I)	6 177	6 223	6 379	6 493	6 197
Information and communication (Section J)	5 969	7 460	8 022	8 375	9 128
Activities related to real estate market services (Section L)	4 051	4 865	5 123	5 473	5 954
Professional, scientific and technical activities (Section M)	20 198	23 125	24 859	25 545	27 530
Administrative and support services activities (Section N)	5 847	6 335	6 714	6 998	7 437
Silesian Voivodeship	**175 972**	**178 780**	**182 556**	**185 737**	**190 838**
Poland	**1 537 337**	**1 549 172**	**1 601 841**	**1 659 133**	**1 746 682**

Source: GUS data, Local Data Bank

At the same time, the dynamics of the increase in the number of employees amounted to 102.0%, while for the country the dynamics amounted to 107.6% in the same period.

Table 2. Number of persons employed in the Silesian Voivodeship

PCA Section (Polish Classification of Activities	Year [persons]				
	2010	2013	2014	2015	2016
Section B	113 301	109 204	98 495	95 639	86 897
Section C	323 772	322 461	327 944	337 104	350 799
Section D	23 355	20 065	18 762	16 885	16 873
Section E	19 868	19 625	19 690	19 917	20 368
Section F	118 581	110 043	107 413	106 897	109 113
Section G	250 373	239 844	241 968	241 942	245 920
Section H	79 157	77 393	79 003	82 560	84 409

Section I	27 941	28 294	28 545	28 041	28 537
Section J	24 350	25 900	29 606	28 760	31 443
Section L	24 264	25 883	26 696	26 566	35 215
Section M	58 919	62 785	66 459	66 488	69 508
Section N	60 323	55 124	57 276	62 373	68 003
Silesian - altogether	**1 124 204**	**1 096 621**	**1 101 857**	**1 113 172**	**1 147 085**
Poland	**8 310 494**	**8 146 884**	**8 355 371**	**8 589 796**	**8 944 330**

Source: GUS data, Local Data Bank

The dynamics of value added maintained at a high level in 2010-2015[21] amounted to 120.5%, while in the country it was equal to 125.6%.

Table 3. Gross value added in the Silesian Voivodeship

PCA Section (Polish Classification of Activities)	Year [thousand PLN]			
	2010	2013	2014	2015
Section A	1 229	1 478	1 395	1 275
Section B	14 177	13 792	12 784	11 653
Section C	35 654	40 380	44 679	49 205
Section D	5 095	5 848	5 268	5 344
Section E	2 189	2 483	2 653	2 739
Section F	13 398	14 237	15 129	15 920
Section G	31 152	34 864	33 532	34 453
Section H	7 645	9 387	10 216	11 247
Section I	1 792	2 032	2 202	2 257
Section J	3 201	3 909	4 158	4 549
Section K	4 677	5 534	5 934	5 828
Section L	8 227	8 296	8 794	8 620
Section M	7 372	8 404	9 131	9 991
Section N	2 686	3 639	3 742	3 925
Section O	8 426	9 106	9 250	9 437
Section P	6 909	7 574	7 786	8 113
Section Q	6 894	8 201	8 510	8 769
Section R	1 127	1 191	1 270	1 348
Section S	1 878	2 500	2 695	2 729
Section T	244	318	249	263
Silesian - altogether	**163 972**	**183 173**	**189 377**	**197 665**
Poland	**1 271 475**	**1 470 917**	**1 525 004**	**1 596 366**

Source: GUS data, Local Data Bank

[21] According to the 30.09.18 condition, data for 2016 were not made available in the Local Data Bank of the Central Statistical Poland

A decreasing share of the mining and extraction sector in the generation of jobs and added value for the increase in the share of industrial processing is visible.
As the largest industrial region in Poland, Silesian Voivodship definitely occupies a leading position in terms of competitive position in many types of industry. Silesian Voivodship is characterized by significant shares in the domestic production sold in such types of production as [22]:

- metal production (54%),
- mining and extraction (42%),
- production of motor vehicles, trailers and semi-trailers, excluding motorcycles (41%),
- production of metal products (24%),
- production of products from other non-metallic mineral materials (20%),
- production of rubber and plastic products (15%),
- production of electrical equipment (13%),
- production of machinery and equipment (12%),
- production of groceries (8%).

The significant predominance of heavy industry strongly determined the technological development of the voivodship, but the share of other sectors of the economy is gradually increasing. Nevertheless, the growth rate of sold industrial output in 2010-2017 was below the national average in Silesian Voivodship and amounted to 127.4%, while in the country it amounted to 143.1%.

Table 4. Sold production of industry in the Silesian Voivodship

	Year [thousand PLN]			
	2010	**2015**	**2016**	**2017**
Silesian - altogether	175 963,6	194 586,6	206 226,2	224 219,9
Poland	945 306,9	1 197 028,5	1 236 375,4	1 352 954,7

Source: GUS data, Local Data Bank

The presented economic situation of the voivodship based on general statistical data was deepened by Specialized Observatories. The synthetic results are shown below.

Technologies for medicine (health care)

- The specificity of the medical devices sector in Poland, but also in the Silesian Voivodeship is the large fragmentation and concentration of producers on individual products and competences.
- The sector of producers of medical devices generally comprises small and medium-sized enterprises.
- The estimated value of the market for Polish medical devices according to Polish Investment and Trade Agency is 2.9 billion USD[23]
- The value of sold production in 2016 in the medical equipment sector exceeded 3.5 billion PLN in Poland.[24]. One of the growth aspects for sales is the export of medical devices, which shows a growing trend,

[22]Statistical Bulletin of 2017, www.stat.gov.pl (data refer to 2016)
[23]Press briefing, Polish Investment and Trade Agency, SALMED 2018
[24] Statistical Bulletin of 2017, www.stat.gov.pl (data refer to 2016)

as in 2016 it amounted to 1.35 billion USD, and in 2017, 1.8 billion USD.[25]

- The offer of medical devices on the Polish market is wide and comparable to the most advanced countries in the world. The Polish specialty is hospital furniture, surgical, diagnostic and bactericidal lamps, dressings and hygiene materials, technologically advanced products (surgical instruments, implants).
- The Silesian Voivodship dominates in such areas of medicine as cardiology and cardiac surgery, in the field of orthopaedics and traumatology of the musculoskeletal system, in the field of transplantology, in the field of medical rehabilitation, in the field of clinical oncology, oncology and paediatric haematology or oncological rehabilitation.
- The region constitutes a strong academic resource in the field of staff education in the field of technologies for medicine.
- There are several universities and research institutes associated with the development of technologies for medicine in the Silesian Voivodeship. These are key units conducting research, but also cooperating with the economic sector, which allows to create innovative solutions in the field of technology for medicine. These units have wide recognition not only in Poland. Those units are: Medical University of Silesia in Katowice, Silesian Centre for Heart Diseases in Zabrze, Professor Zbigniew Religa Foundation of Cardiac Surgery Development in Zabrze, Silesian University of Technology Faculty of Biomedical Engineering, American Heart of Poland Co., Tissue Bank of the Regional Centre for Blood Donation and Haemotherapy in Katowice, Institute of Medical Technology and Equipment ITAM in Zabrze, District Hospital of Orthopaedics and Trauma Surgery named after Dr. Janusz Daab in Piekary Slaskie, Independent Public Clinical Hospital named after Andrzej Mielęcki in Katowice, Burn Treatment Centre in Siemianowice Silesian, SP ZOZ ,, Repty" Silesian Rheumatology and Rehabilitation Hospital named after gen. J. Ziętka in Ustroń, Silesian Medical Technology Park Kardio-Med Silesia Ltd.
- 978 entities operate in the region [26]. These data do not include drug manufacturers and distributors as well as pharmaceutical substances, because in accordance with the Law on Medical Devices, these substances are not included in medical devices.
- The following are the leading manufacturers of medical devices in the Silesian Voivodeship ,identified by the observatory technologies for medicine: ASTAR ABR A. Jędrzejowski R. Dziendziel GP, BHH Mikromed Ltd., EGZO Tech Ltd., Medical Tools Factory CHIRMED M. Dyner, FAMED Żywiec Ltd., FORMED Pro Ltd., F.R.K. Intra-Cordis Ltd., INNOW Ltd., L.P.., Kardio-Med Silesia Ltd., OPTOPOL Technology Ltd., PHU TECHNOMEX Ltd., Reha-Bed Ltd., VIMEX Ltp., ZARYS

[25]Press briefing, Polish Investment and Trade Agency, SALMED 2018

[26] based on the Polish Classification of Activities (NACE Rev. 2) 26.60.Z - Production of irradiation equipment, electromedical and electrotherapeutic equipment, and 32.50.Z - Production of devices, instruments and medical devices, including dental

	International Group Ltd., L.P.., among companies operating in the field of ICT use in medicine, the following manufacturers may be indicated: WASKO Co., KAMSOFT Co., COMARCH, Future Processing, 2KMM Ltd., The Farm. • In addition to the above manufacturers of medical devices on the basis of the analysis of implemented projects with funds allocated for increasing innovation in enterprises under the ROP, the region of technologies used in dentistry and the use of 3d printing in medicine is strongly visible in the region. • The company: Philips Polska is one of the main investors in the region in the field of medical devices and technologies • The activity in the field of patent applications is demonstrated by technical universities, research institutes from the region, as well as enterprises themselves, to which, due to their specificity of products, we can include, e.g. Medical Technology Agency Atmed J. Rafalska, LABIOT Laboratory of Biotechnology & Medical Practice, Department of Medical Supplies "DEMED" Ltd., Sanitary Equipment Factory "SANMED" Ltd., PPH KAMED-Plus A. Góral, INVENTMED Ltd., • The structure of generating electricity in Silesian Voivodeship is based mainly on the hard coal, however, the increase of the usage of renewable energy sources is noticed. • The decreasing share of mining and exploitation sectors in generating workplaces is observed, but even so, the share in domestic industrial production in terms of mining and exploitation is still distinct and amounts to 42%[27]. • Large concentration of both the industry and generation capacity, the need for transforming the energy sector and the growing social awareness connected with environmental contamination encourage the development of new technologies. • According to GUS data, the number of companies within the energy sector at the end of 2017 was 620 and the number of revenue from the sale of products, goods, and materials was 15 664 260 000 PLN[28]. • The number of people working in energy sector in the Silesian Voivodeship was 15 611. • Approximately 19% of the country's energy is generated in the Silesian Voivodeship. The electricity generation in 2016 amounted to 27 251.7 GWh and the electricity consumption evolved to a level of 25 522 GWh.
Technologies for energy sector and mining	- Technology development through companies sector includes: - High efficiency technologies that limit the emission of greenhouse gases and other environmental contaminations ('clean technologies') **-** The development of high efficiency polygeneration and cogeneration - Generating energy from renewable sources, the improvement of efficiency of obtaining energy from RES (Renewable energy sources), development of distributed energy. -Generating energy from waste

[27] Statistical Bulletin from 2017, www.stat.gov.pl (data concern 2016)

[28] Local Data Bank – Central Statistical Poland https://bdl.stat.gov.pl/BDL data for the year 2017

Technologies for environment protection

and alternative fuels- Energy storing with the usage of different technologies- The development of intelligent networks and inter-system connections, especially connections between network and renewable energy sources- The promotion and development of construction that is energy efficient.

- In the Silesian Voivodeship the leading company in the scope of generating electricity and heat processes is the Tauron Group.
- Other large economy operators within the region nowadays include i.e.: Fortum Power and Heat Polska Ltd., CEZ Polska Co., PGE Group, GK Elektrociepłownia Będzin Co., Sumitomo SHI FW Energia Polska Co., RAFAKO Co.
- The Silesian Voivodeship has a huge innovative potential in the field of energy due to a large number of generation units, the presence of lead energy groups, the natural resources connected with mining and the intensive energy development as well as the huge number of emerging companies.
- The number of patent applications in the area of electrical engineering, lightning and heating places the Silesian Voivodeship on the second place in the country.
- Technical colleges as well as the regional research institutes show patent applications' activity.
- The crucial contribution into innovation is ensured by entities focused on industrial technology as well as industrial science parks.
- The activity in the field of new technologies is also observed in SMEs sector.
- The analysis of statistics related to the pace of indicators' changes describing economic area[29], indicates that NACE Rev. 2 sectors strictly related to environmental protection i.e. collection, purification and distribution of water and businesses linked to waste collection, treatment, and disposal as well as materials' recovery show the crucial development potential at national level.
- The potential of the technology for environmental protection is made up of the sectors strictly related to environmental protection as well as of the industrial sector and service sector. In terms of NACE Rev. 2, the potential of the area is made up of entities from agriculture, mining, industrial processing, generating electricity, constructing, trade, transport, information and communication and professional activity. On the basis of Specialist Observatory's estimation in accordance with the GUS public inaccessible statistical data, the economic potential of the technological area at the end of 2015 comprised more than 3 200 entities and the dynamics in respect of year 2013 was ca. 97%. The area's added value is ca. 47.2 million PLN and the dynamics in respect of year 2013 amounted to 108%. Net revenues from products sale (device, service) amounts to 168 million and their dynamics in respect of year 2013 is 107%.
- GUS data validate the rise of used fixed capital formation in environmental protection. At the end of 2016, expenditure for fixed

[29] Location indicators: added value, net revenues from sale of products

capital formation aimed to protect the environment and related to energy saving, amounts to 30.1 PLN per one citizen in the voivodeship (for comparison, in 2010 it was 27.6 PLN). That value exceeded the average of the country that amounts to 11.6 PLN.

- The development of environmental technologies by the business sector is related i.e. to implementing the solutions in water and sewage management system, waste (including packaging recycling), energy generation, raw materials and remediation.
- Large and/or vital business entities from the region that implement technologies to protect the environment include i.e. Fortum CO., TAURON Wytwarzanie CO.
- The entities that generate the most innovative solutions in the field of technology for environmental protection include i.e. Regional Center of Water and Wastewater CO. (RCGW), Ekoinwentyka, Aquaren Ltd., Ltd. P.., Makpol Recykling Ltd.
- The sector is based mainly on business sector's commercial activity. In the Silesian Voivodeship there is a small dependency of sector's activity on public sector's contracts. The technological area is well supported in terms of education. There is a strong will to increase the number of IT graduates in the framework of Silesian universities. Students find well paid jobs at the beginning of their careers (they find those jobs within the region of Silesia.) Due to numerous universities and industrial nature of the region there are many international IT-related corporations within the Silesia conurbation and start-up types of companies are being built. There is a strong representation of IT-related companies in the region (they show a high dynamic in increasing the number of obtained pro-innovative grants and the high service export rate in the pattern of incomes. As a strong technological and academic measure the region is also showing a strong internal market in the scope of service and IT products (in IT sectors). The automation process of internal productive resources and the development of big companies (i.e. zone companies) causes a strong need for suppling dedicated technologies and involving high-class specialists. Internal connecting of the region and approaching big technological cities with ease (Kraków, Wrocław, Łódź) makes the Silesian Voivodeship perceived as the main location of its activity in the eyes of ICT sector's companies.
- Within the Polish ICT sector the activity is carried out by 113 446 business entities. Most entities are located in the Mazovian Voivodeship – 30.46% of all the ICT companies in Poland, while the Silesian Voivodeship is on the second place countrywide in this respect with a figure of 9.93%.
- In the Silesian Voivodeship in 2016, ITC sector comprised 11 167 companies which constituted 2.4% of all of the business entities registered in Silesia in the REGON database. Since 2010 a constant growth of ICT sector's business entities has been observed (understood as three units of section J.) In 2016 in the Silesian Voivodeship, 34% more companies were in operations than in 2010.

Information and telecommunication technologies

An average annual increase of the number of companies in the analysed period of time was 6.6% and the highest increase (year-on-year) was reported in 2013 - the number of ICT companies in Silesia rose by 8.3% in relation to 2012. Between 2010 and 2016 there were distinct differences in the number of ITC companies that functioned in different segments linked to ICT activity. The highest increase of Silesian companies (in relation to 2010) was observed in the segment linked to software and counselling in the IT field (increase of 40 %.) In the telecommunication segment the increase of companies was at the level of 22% and in the service segment - - 15%[30][31].

- In the Silesian Voivodeship in 2016 the ICT sector was characterized by positive balance of entities newly registered and removed from the REGON register (736). Among the newly registered entities in the Silesian Voivodeship the ITC companies amounted to 2.2% of all the companies. The newly registered companies were registering the activity mostly in sectors related to software and counselling in the IT field and the associated activity (J62)[32].
- In 2016 in J NACE Rev. 2 section within the Silesian Voivodeship, 20 280 persons were employed which signifies 7.5% of all the employed persons in Poland. The distribution of employed persons in companies to and above 49 employers is more or less equal and amounts to from 47% to 53%[33].
- ITC market is the driver of growth for many companies, including production of machines and devices, construction, energy, medicine, automotive sector as well as public service sector. The world is becoming more and more connected, and at the same time, it is becoming more dependent on external factors such as: stability of energy systems, security in the data transfer networks, ethic aspects connected to personal information for sale. Despite of the lasting for the couple of years technological race within the internet of things, intelligent city, industry 4.0, social media or even autonomous vehicles, the questions about whether or not the western and eastern cultures are ready to change their lives enough to fully absorb ICT technologies.
- As a result of the carried out studies it has been shown that the priority technologies for the Silesian Voivodeship are as follows: B4.Technologies producing software.

[30] ICT sector is understood as: J61 – Telecommunications, J62 – Activity related to software and consulting in the scope of IT and the related activity, J63 – Service activity in the scope of information.

[31] Own elaboration on the basis of data from Local Data Bank, GUS summary: Business entities and ownership and structural transformations; Entities of national economy according to REGON database (quarterly data; Entities according to sections and parts of NACE Rev. 2and private sectors) Data as per 05.03.2018

[32] Own elaboration based on data from Local Data Bank, GUS summary: Business entities and ownership and structural transformations; Entities removed from the REGON register , entities of national economy/ Newly registered entities of national economy within REGON register. Entities unregistered according to sections and parts of NACE Rev. 2 and private sectors/ Newly registered entities according to section and parts of NACE Rev. 2 and private sectors. Data as per 20.03.2018

[33] Own elaboration on the basis of Local Data Bank, GUS summary: Labour Market, Employees, employed and average employment according to NACE Rev. 2; Employed in national economy according to sections, ownership sectors and gender. Data as at 29.11.2017

B6. Technologies supporting the sector of creating video games.
B8. Technologies producing microchips and storage media.
C2. Monitoring technologies with the use of satellite imagery.
F8. Technologies of artificial intelligence and machine learning.
A4. Information and telecommunication technologies in space and satellite engineering.
B7. Technologies of industrial computer systems.
F2. Technologies supporting the internet of Things.
F7. Technologies assisting organization of production and projecting of production systems.
Those technologies are of crucial importance in development and, at the same time, the Silesian Voivodeship has the necessary potential to develop and implement them. Most of those technologies are endogenic by nature that is why they are rightly prioritized in region's technological policies.

- In times of globalization and international cooperation which is most distinctly noticeable in information technology and telecommunication sector, we have attempted to identify trends from the ICT sector, which development is achievable in the Silesian Voivodeship: information society, data mining, e-education, e-administration, telemedicine, smart city, the internet of things, cloud computing, industry 4.0. Bearing in mind a dynamic development of information and telecommunication technologies and their unrelenting impact on the way that society is organized, we reckon that the abovementioned trends will in the future correspond to the main directions of ITC development in the Silesian Voivodeship.
- In the region, companies such as *software house* act, among which the leading ones include: Euvic, The Software House, xSolve, IT kontrakt, JCommerce, Netizens. Technologies of artificial intelligence are developed in the region by: Future Processing, Stanusch Technologies. Technologies of the internet of things are the domain of the already mentioned: JCommerce, Future Processing, and FPInstruments. A unique at a global level processor designer is the company Digital Core Design, while the producers of computer memory are the Goodram Wilk Elektronik brands. Technologies for industry 4.0 are developed by UIBS Teamwork, AIUT, Wasko and JCommerce. The producers of video games in the Silesian Voivodeship include i.e.: Carbon Studio, iDreams, The Farm, Destructive Creations.
- The main investors in the region are companies such as: Evatronix, Future Processing, IBM, Kamsoft, Euvic Games, Digital Core Design, Wilk Elektronik, COIG, WASKO, AIUT.
- For the right use of significant potential of production technologies and processing materials it is important to overcome not only the technical barriers, but also the socio-economic ones, further to economic barriers and improvement of financing the science research mechanisms in the Silesian Voivodeship. The main meta-trends, on which the modern development of the field of production and processing materials is based, apply mainly to issues as follows:

Production and processing of material

energy savings, productivity and security.

- The Silesian Voivodeship is marked by significant shares in domestic marketed production in the types of production that are strictly related to the following technological areas:
  - manufacture of basic metals (54% of domestic production in 2016),
  - manufacture of motor vehicles, trailers, semi-trailers, excluding motorcycles (41% of domestic production),
  - manufacture of articles of metals (24%),
  - production of articles of vulcanized rubber and plastic (15%),
  - production of electrical devices (13%),
  - production of machines and devices (12%).
- In the Silesian Voivodeship there are 12 500 (according to Eurostat data from 2016) functioning companies related to the production and processing of materials, which amounts to 18.5% of the entire region's entities. There are over 180 000 employed persons (according to Eurostat data from 2016.) The sales revenue from products generated by the researched area amounts to 57 004 612 PLN, which amounts to ca. 24% of the total revenue amount in the Silesia Voivodeship. Net revenue from selling goods and materials is 4 760 922 PLN, which amounts to 4% of the net revenues from sale of goods and materials.
- At present, modern, homogeneous materials and composite materials are used in the production processes. In that way the large scale usage of modern metal, polymeric and ceramic materials is highlighted. This applies to, among others, technologies of energy generation and energy storing, energy equipment, detectors and sensors, intelligent coatings and membranes, composite materials for aviation, 3D printing and medical devices. Metallic materials such as: steel, aluminium, and copper are the most often used materials in construction, automotive sector and energy sector. The development of polymeric materials is connected with the development of such sectors as: packaging, medicine, electronics, transport and communication, apparatus and parts of machinery, households, cosmetics, furniture and construction. The use of ceramic materials is widespread in chemical industry, environmental protection industry, energy industry, machinery industry and in housewares industry as well.
- The Silesian Voivodeship houses the largest producer of steel in Poland (ca. 5.0 m. Mg in 2017) – ArcelorMittal Poland CO. in Dąbrowa Górnicza, whose share in domestic steelmaking amounts to 70%. The employment exceeds 10 000 people of which almost 7 000 are employed in the Silesian Voivodeship. The biggest investments in the region are ecological investments and energy-saving investments and they amount to 700 million PLN. A partnership is of great social importance due to the level of employment. Companies still pose a threat to ecology. The undertaking in Dąbrowa Górnicza itself radiates 1 500 mg of particulate matter per year and the level of recovery of waste is low (6%-63 %.) Recycling of water cycle does not exceed 56%.

The second leading company of metallic materials is Zinc Smelter Miasteczko CO. in Miasteczko Śląskie. This is the second largest producer (over 40% of domestic production) of zinc (ca. 80 000 mg) and lead (ca. 20 000 mg) in Poland. The directions of development of the steelworks apply to: new products and new technologies (constructing the line for zinc alloys manufacture on the basis of manufactured zinc) and measures to limit the emission of particulate matter, carbon dioxide and sewage treatment (41 projects worth 170 million PLN). 700 persons are employed there. The third important producer in the region is Orzeł Biały CO. in Piekary Śląskie, which is the leader in the market of refined lead producers in Poland and the largest company specialized in worn-out lead batteries recycling. The envisaged directions of company development are as follows: the project of the research and industrial facility along with infrastructure and then building it, the research project and building electrolyte filtration system and research facility for slag. Moreover, the key entities producing metallic materials in the Silesian Voivodeship are i.e. Smelter Pokój CO., Smelter Łabędy CO., Mill of Thick Sheets Batory, Alchemia Group CO., GPT Stal Solution Ltd., Metal Mill 'Dziedzice' CO., GP BSK Return CO., Power Cable Factory CO., Eltron-Kabel SJ, Manex Ltd., Aluprof CO., YAWAL CO., Gral Ltd. Cable Factory GLIWICE CO. What is more, among the foundries one may distinguish: Metal Foundry Szopienice Ltd., Odlewnia Żeliwa Simiński-Ordon Ltd., 'ALcast' G.P., GZUT CO., Brembo Poland Ltd., TraksaTeksid Iron Poland Ltd., Spyra Primo Poland Ltd., Izo-Erg plc, Klimas Wkręt-Met, Polting Foam Ltd., GTX Hanex Plastic Ltd. There are also companies from the group of ceramic materials which operate in the Silesian Voivodeship, among which there are: Ceramo Ltd. and IZO Zakład Izolacji Ogniotrwałych Ltd. In the field of composites production, the most distinctive ones are: NBL Kompozyty Ltd., Nobile Sports Ltd., Alumast CO., Energy Composites Ltd., Aga Kompozyty Ltd., Ankra Ltd.

- There are a few universities and research institutes related to technology development and processing of materials which are based in the Silesian Voivodeship. Those are the key units conducting research, which assists in creating personal solutions and changing exogenous technologies into endogenous ones. Those units are widely recognized not only in Poland. The following universities should be highlighted: The Silesian University of Technology (Materials and Metallurgy Engineering Department), The Częstochowa University of Technology (Manufacturing Engineering and Materials Technology Department), ATH in Bielsko-Biała (Production and Materials Technology Studies Department) and the Silesian University (IT and Materials Studies Department.) In our Voivodeship there are also many research institutes, among which the following are worth noting: The Stanisław Staszic Memorial Iron Metallurgy Institute, Non-ferrous Metals Institute, Welding Institute, Ceramic and Building Materials Institute, Refractory Institute in Gliwice.

Design and processing technologies in aviation industry and space industry

- Many innovative companies in the field of surface treatment, polymeric, ceramic and composite materials operate in the voivodeship. The leaders of these fields of production and processing have been presented within the main field of producers.
- Innovations emerging in this field are the inspiration for automotive, energy and space industry.
- At the end of 2017 in the Silesian Voivodeship there were 342 functioning companies[34] (section C department 30) which is in a broad sense the sector of production of the remaining transport equipment.
- The actual economic potential of the analysed technological area illustrates an increase of the number of members of the Silesian Aviation Cluster (from the year 2017 it has been operating under the name National Key Cluster) from 15 members in 2009 to 62 members in 2018 - those entities form a group of companies and R&D units that produce and develop goods and service of similar purposes. [35]
- The specific quality of technological area in the Silesian Voivodeship is specialization in regard to designing and producing light aircrafts (including unnamed platforms) with the use of composite structures.
- The space industry is now beginning to have special importance for reinforcing the region's innovation. Poland having joined European Space Agency was a milestone for the space industry (2012).
- The space sector in the region functions in both the *upstream* segment (technology production) and the *downstream* segment (technology usage); in that way grounds for manufacturing companies' development have been created (e.g. structural elements of aircrafts) as well as for service companies' development (the usage of satellite data)
- What is important in order to achieve a clear advantage over rivals in the field of technology is an interdependence of ICT sector, which gives an opportunity to create multifunction and innovative solutions.
- The leading entities in the technological field include:

a) in aviation industry:
- Avio Aero Ltd. (turbos of aero engines)
- The Silesian Science and Technology Centre of Aviation Industry Ltd. (composite structures of aircrafts)
-Silesian University of Technology, Mechanical-Technological Department
-Aviation Company Margański & Mysłowski CO. (aircrafts)
-Composite Structure Plant Andrzej Papiore (aircrafts)
-Avionic Air Force J.Bolesław Kawik Leszek Matuszek (aircrafts)
-Artus Aircraft Ltd. (aircrafts)
- Aero Login Ltd. (unmanned platforms)
-Flytronic Ltd. (unmanned platforms)

b) in space industry sector:
-Silesian Science-Technology Centre of Aviation Industry Ltd. (composite

[34] GUS data, Local Data Bank, July 2018
[35] Data passed on by the Silesian Aviation Cluster

Nanomaterials and nanotechnologies	structures of aircrafts) -KB Labs Ltd. (air software) - Future Processing Ltd. (Earth imagery and service related thereto) • The second position (after the Mazovian Voivodeship) in the country in terms of the number of entities investing in research and development, of which the majority of invested capital (more than 54%) was targeted at development activities in companies, in the area of engineering and technical studies.[36] • There is a large number of the expert personnel that has qualifications related to nanomaterials and nanotechnology field and infrastructure resources' field (scientific-research apparatus) designed to carry out R&D work in the field of Nanomaterials and Nanotechnology. • The economic potential of the area, on the basis of the analysis of performed projects in the region, amounts to 25% of entities bearing internal costs for research and development activity, which gives 132 business entities[37]. Among business entities located in the Silesian Voivodeship and active in nanomaterials and nanotechnology field one may indicate: Tauron Polska Energia, Węglokoks, TRW, Magneti Marelli, Valeo, Hutchinson Poland, Nexteer Automotive, Marco, Prevac, Farby Kabe, Arsanit, Lakma Strefa, Lakma Sat, Multitech, Helioenergia, Abraksas, Magneto, Elbit, EMAG-Serwis, Dynamic Technologies, 3D Gence, Profplast, Izo-Erg Coating's, Progresja, Polwat, Plasma System, Nanochem, NanoChemTech, Elplast, ITP System, Winiplast, Mstermodel, Maschinada, Małachowski, Ad Moto • The average percentage of expenditure for research and development in relation to total expenditure on research and development works in the region at the national level was estimated at 5%. 25% of people perform R&D work - 4529 persons. • The increase of research and development potential is linked mainly to a great deal of R&D work and projects in this field borne by scientific units and companies (93 301 896.59 PLN in 2015, 16 304 369.78 PLN in 2016) The increase of R&D potential is related to vast expenditure for research infrastructure so that research can be carried out in this area; • An academic activity has shown a significant development potential in the recent years (approx. 50% of companies set up by universities and scientific institutes were built in order to commercialize solutions from NN field.) • Technologies developed by the business sectors: - engineering nanomaterials (functional composites, layers, nano - optoelectronics, nano magnets); - active nanomaterials (biological and catalytically active nanoparticles, nano-reactor); - medical nano-devices (robots and medical equipment, biomimetic devices)

[36] GUS, Research and development activity in Poland in 2016
[37] Ibid

-membranes and filtration
-biomimicry
- devices and processes of nanomaterials forming nanotechnological devices
- software for modelling and prediction of nanomaterials and nanotechnology
- Among large entities in the region that invest in this sector one may find: Tauron Polska Energia, Węglokoks, TRW, Magneti Marelli, Valeo, Hutchinson Poland, Nexteer Automotive, Marco, Prevac, Farby Kabe, Arsanit, Lakma Strefa, Lakma Set.

Source: SO RIS analyses

2.2.1.2 Innovation in the Silesian Voivodeship

The rate of increase of expenditure for innovative activity in the Silesian Voivodeship between 2010 and 2016 was below country-wide average and amounted to 83.5% in the voivodeship and 112.9% in the country.

Table 5. Expenditure on innovation and R&D activity of enterprises (in services and in the industry) in the Silesian Voivodeship

NACE Rev. 2 Section	Year [in thousand PLN]			
	2010	2014	2015	2016
B-E Sections	4 037 838	3 467 593	3 537 681	3 281 733
F-U Sections	591 906	517 832	732 924	522 733
Silesian – in total	4 629 744	4 200 517	4 060 414	3 863 766
Poland	34 548 060	37 616 823	43 734 944	39 010 907

Source: GUS data, Local Data Bank

Innovations in the Silesian Voivodeship have been described with the use of data on an innovative and patent activity of industrial and service companies. Years between 2014 and 2016[38] were analysed and results were demonstrated in the diagrams (Fig. 2 and 3) and differentiated by innovation types. Data were demonstrated with regard to sections and departments, which emphasizes the economic dimension of innovation. The largest share of companies that implement product innovations in the Silesian Voivodeship occurred in section C department 20 (*Production of chemicals and chemical articles*.) In 2015, product innovations for section C department 21 dominated (*Production of basic pharmaceutical substances, medications and other pharmaceutical products.*) In the case of service sector, the companies that implemented product innovations are characterized by moderate advantage at the national level. In that case innovations occur in such sections as: section H department 52 (*Storing and service activity supporting transport*), section M department 72 (*Scientific research and development work)* and section M department 73 (*Advertisement, market investigation and public opinion investigation*). The process innovation in the Silesian Voivodeship dominated in section C department 19 (*Manufacturing and processing of coke and refining of crude oil products*.) On a national scale, the process innovations dominated in companies of section D department 35 (*Generating and distribution of electricity, gas, water vapour,*

[38] Innovation activity of enterprises in the years 2014-2016, GUS, Warsaw-Szczecin, 2017

hot water and air for air-conditioning systems). In the case of service sector, the companies that implemented process innovations are characterized by moderate advantage at national level and according to the collected data they concentrate both on section J department 62 (*Activity connected with software and counselling in the IT field and related businesses*) and on section M (*Professional, scientific and technical activity*.)

The share of companies that implement organizational innovations in the Silesian Voivodeship was the largest in section C department 29 *(Manufacturing and processing of coke and refining of crude oil products*) and 20 (*Production of chemicals and chemical articles),* while at the national level this type of innovation dominated in section C department 21 (*Production of basic pharmaceutical substances, medications and other pharmaceutical products.)* In case of service sector in the Silesian Voivodeship organizational innovations are the most widespread in section H department 52 (*Storing and service activity supporting transport)* and in section M.[39]

The last group of analysed innovations are marketing innovations, which occurred in the region most frequently among the companies of section C department 26 (*Production of computers, electronic and optical devices*), department 30 *(Production of worn-out transport equipment*), and department 21 (*Production of basic pharmaceutical substances, medications and other pharmaceutical products)* In the case of service sector, companies that implemented marketing innovations are characterized by moderate advantage at the national level and according to data, most of the implemented innovations occur in section J department 61 (*Telecommunication*) and in section M. The Voivodeship stands out against the country with respect to the revenues from the sale of new products or advanced products. The Voivodeship is also distinguished due to the attained incomes for this purpose. In the Silesian Voivodeship more than 10% of the revenues from sale is generated by innovative products. The region has one of the highest rates in Poland with regard to generating revenues from innovative products' sale (in general). It should be added however, that in territorial terms, in 2016, the largest share of revenues from new or significantly advanced products' sale in the value of the revenues from the sale in total, was observed in industrial companies from such Voivodeships as: Lower Silesian Voivodeship – 14.2% and Pomeranian Voivodeship – 11.9%. The Silesian Voivodeship was on the third place with a result of 11.9%. It does not change the fact that the percentage of revenues from the sale of new and significantly advanced products in the value of the revenues from sale in total is higher in industrial companies in the Silesian Voivodeship than in Poland in general, as an average of the country in 2016 amounted to 8.1%. In the region there was also a higher value of share from sold production of new/significantly advanced products in industrial companies than an average of the country between 2013 and 2016.

Table 6. Net revenues from sales of innovative products as the share of total net revenues from sales in industrial enterprises

Specification	Year [%]			
	2013	2014	2015	2016
Poland	8,65	8,78	9,50	8,12
Silesian Voivodeship	10.09	10.73	10.93	10.39

Source: GUS data, Szczecin

[39] Analysis of patent activity was carried out on the basis of data from the Patent Office of Poland and GUS.

Table 7. Sold production of industry of new or significantly improved products in industrial enterprises as the share of total value of sale of products

Specification	Year[%]			
	2013	2014	2015	2016
Poland	11.5	11.6	12.5	10.4
Silesian Voivodeship	13.1	13.7	13.9	12.1

Source: GUS data, Szczecin

In comparison to other regions in Poland, the Silesian Voivodeship shows a low level in terms of implementing both new and improved products (10.2% of companies) and processes as well (10.9% of companies) by industrial companies. Only 6% of industrial companies implemented at least one product innovation or significantly advanced innovation on the market. The biggest drop in the country of the share of industrial companies which implement innovations was observed in the Silesian Voivodeship.

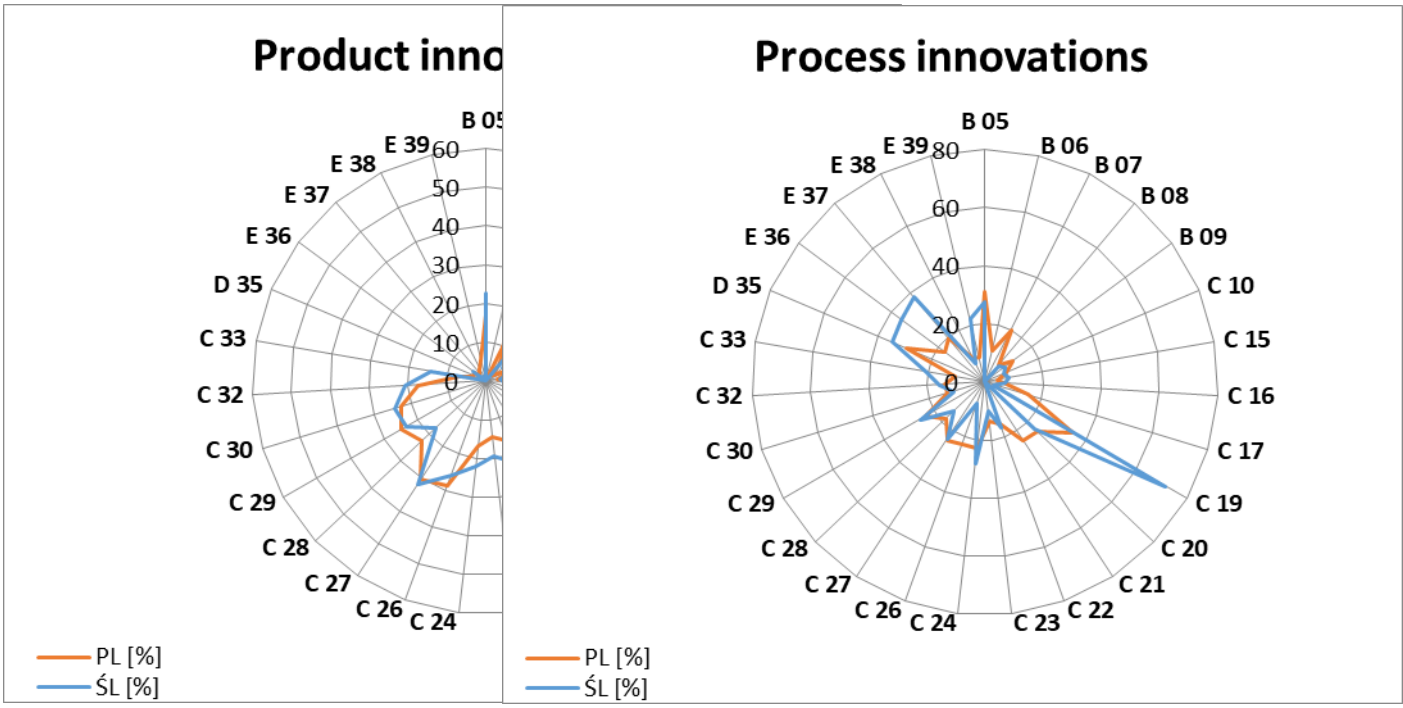

Figure 2. Innovation activity (product and process innovations) of enterprises in the Silesian Voivodeship and in Poland (adequate sections and divisions of NACE Rev. 2 shown in the Figure) Source: GUS data

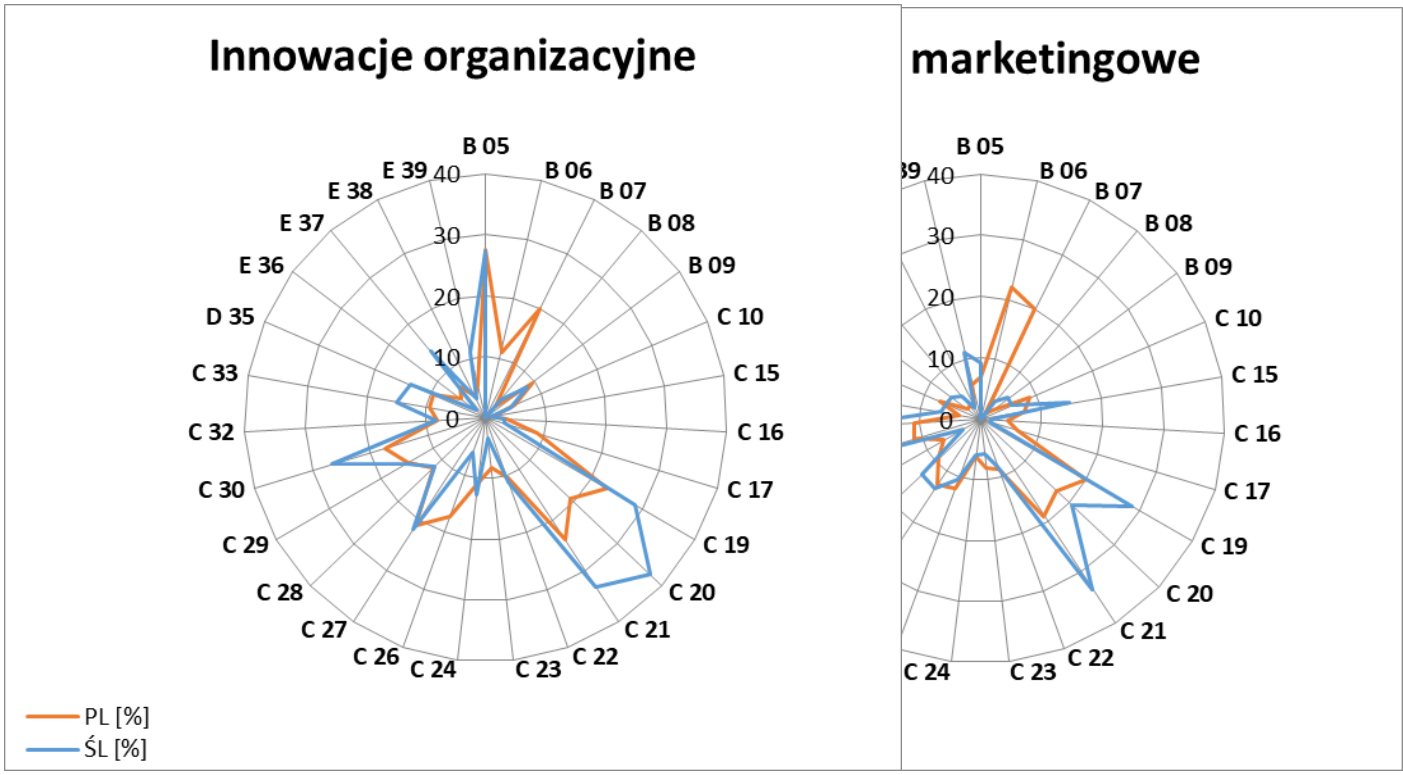

Figure 3. Innovation activity (organizational and marketing innovations) of enterprises in the Silesian Voivodeship and in Poland (adequate sections and divisions of NACE Rev. 2 shown in the Figure) Source: GUS data

The value of expenditure for innovative activity in the sector of enterprises which includes i.e. research and development work (R&D), knowledge acquisition from external sources, purchase of software, capital expenditure in fixed capital formation essential for implementing innovations, staff training related to innovative activity, marketing related to new or significantly advanced products, and other preparations to implement product and process innovations, amounted in the Silesian Voivodeship in 2016 to 3 281.70 million PLN. The largest share was provided by capital expenditure related to devoting financial resources for machines, technical devices, tools and for the means of transport. At national level, a percentage of industrial companies that cooperated[40] with each other in the field of innovative activity in relation to most of the companies in 2016, amounted to 6.7%. The percentage of service companies amounted to 3.9%, whereas in the Silesian Voivodeship it was respectively 7.9% of industrial companies and 3.2% of service companies. Over the past few years, an alarming, gradual drop of companies' expenditure on innovative activity in relation to GDP may be observed.

Table 8. Expenditure on innovation activity in industrial enterprises for product innovations in 2015-2016

Specification		Poland		Silesian Voivodeship	
		2015	2016	2015	2016
Overall, including		28 920.70	28 304.70	3 359.60	3 281.70
Expenditure for research and development work		4 838.30	5 191.00	1 060.20	915.5
Expenditure for knowledge acquisition from external sources and software		578.9	164.3	#	9.2
Capital expenditure	for buildings, structures and lands	7 438.40	7 562.80	330	336.1
	for machines, technical devices and tools and means of transport	14 861.20	13 971.90	1 787.30	1 903.40
Expenditure for staff training related to innovative activity, and marketing related to new or significantly advanced products		472.9	205.9	20.9	11.4

Source: Statistical Journal for industry 2016, GUS, Warsaw 2017 and Statistical Journal for industry 2017, GUS, Warsaw 2018

Analyses carried out in the framework of the Network of Regional Observers show that companies in

[40] *In accordance with GUS definition: cooperation in the scope of innovative activity means an active participation in joint projects concerning innovative activity with other enterprises or non-commercial institutions. Such cooperation may be of prospective and long-term nature and does not need to entail straight away direct, measurable economic benefits for the participating partners. Standard ordering of works among external contractors without an active participation in their realization cannot be considered as cooperation in the scope of innovative activity.*

the Voivodeship most frequently undertake the simplest form of an innovative activity, i.e. purchase of specific machines, devices or software. In the context of involvement in the innovative activity, companies also show constraints in regard to the competent human capital.
In terms of programming the technological development of the region, patent activity of companies is crucial. In terms of the number of obtained patents, the most essential sectors in the Silesian Voivodeship are: energy, production and processing of materials, transport and transport infrastructure as well as machinery industry, automotive industry, aviation industry, and mining industry. Those areas cover overall of 56% of all patents in the Silesian Voivodeship and 80% of patents in the framework of the regional specializations of the Silesian Voivodeship, obtained since 2000. More detailed analysis of patent activity, carried out on the basis of codes of the International Patent Classification (IPC), enabled to select the areas of the biggest potential. The area possessing the technological advantage in the Silesian Voivodeship in terms of the highest number of granted patents and also in terms of the high share in domestic number of granted patents is E2 *Hydraulic engineering; foundation work; earthworks* that involves the technological fields related to mining.

Table 1 Analysis of technological areas based on the patents granted in the Silesian Voivodeship in terms of the International Patent Classification (IPC) classes

IPC Code	Number of assigned patents	Share in the national number of assigned patents	Place among the regions in terms of the number of assigned patents
A6 Health; rescue services; leisure	73	16.40%	3
B2 Moulding	59	12.90%	3
B6 Transport	75	18.90%	2
E0 Construction	76	16.60%	2
E2 Water construction, foundations; earthworks	111	66.50%	1
G0 Appliances	66	10.80%	3

Source: Report from the evaluation entitled „ entrepreneurial discovery process in the context of innovative development of the Silesian Voivodeship until 2020" Central Mining Institute – Marshal Office of the Silesian Voivodeship, Katowice 2017

Similarly to the case of granted patents, the process of identification of technological areas has been carried out on the basis of the data considering reported patents.

Table 10 Analysis of the technological areas based on the submitted patents in the Silesian Voivodeship in terms of the International Patent Classification (IPC) classes

IPC Code	Number of submitted patents	Share in the national number of submitted according to the code	Place among regions in terms of the number of reports
A4 Household or personal use items	31	12.00%	3
A6 Health; life rescue; entertainment	102	11.70%	3
B0 Separation; mixing	85	17.60%	1

IPC Code	Number of submitted patents	Share in the national number of submitted according to the code	Place among regions in terms of the number of reports
B2 Formation	117	18.00%	1
B3 Separation of solid from (…)	10	11.00%	2
B4 Printing	13	22.80%	1
B6 Transport	136	16.70%	2
B8 Micro-structural technology; nanotechnology	7	15.90%	3
C2 Metallurgy	74	30.10%	1
E2 Hydraulic engineering; foundation; earthworks connected with mining	109	59.90%	1
F0 engines or pumps	41	11.50%	3
F1 General technology	40	13.50%	3
F2 Lighting; heating	65	13.00%	2
G0 Devices	135	10.80%	3
G1 Musical instruments; acoustics; memorising of the information; details of devices	4	13.80%	3
C2 Metallurgy	125	16.20%	2

Source: Data of the Patent Office of Poland

The highest patent activity has been ascertained for the department B – *Various industrial processes; Transport*. The number of patent reports in this area as well as the number of granted patents was the biggest. The patent activity in the department E – *Construction; Mining* evolved at a comparable level. Apart from the patent activity of business entities, the patent activity of research units is also worth noticing. In 2013 and 2014 research units in the Silesian Voivodeship obtained respectively, 628 and 360 patents. It is clearly visible that both the number of patent reports and the number of granted patents have plummeted. Higher decrease of granted patents has been noted in case of scientific institutes (c.a. 50%) than in case of universities (c.a. 25%). Patent activity is, of course, only a piece of description of the real activity in terms of new technology and solutions, as in some technological areas, new solutions do not undergo this type of legal protection, as for example, in ICT. That is why, Regional Specialised Observatories play such an important role in full imaging of the development of technology in the Silesian Voivodeship.

2.2.1.3 Potential of the research and development work field

Economic and social growth is to a large extent determined by the growth of R&D activity and the innovativeness. The ability of implementing innovative solutions is determined by the possibility of using the survey results in economy, which in turn is dependent on the level and the advancement of the research and development activity. In relation to the above mentioned, expenditure on R&D

activity in the Silesian Voivodeship successfully grows. In 2005 it amounted to 428.5 million PLN, while in 2014 the number doubled – to more than 989 million PLN. EU funds[41] and the opportunity of financing the research and development projects play an essential role in this trend.

The Silesian Voivodeship is second, in terms of size, research and education centre in the country with a broad range of research-science or academic activity. In 2016 the number of entities, in which R&D activity appeared, totalled 528, 478 of which were found only in the business sector.
The ability of knowledge acquisition and the skill of its practical use in 2016 in the Silesian Voivodeship was offered by several-dozens of higher education institutions (3 universities, including medical university, 4 technical higher schools, 9 economic higher schools, 2 pedagogical higher schools, Sports Academy, 2 higher schools of arts, theological higher school and 19 other higher schools) as well as 23 units in another location, teaching a total of almost 130 thousand students.[42]
The biggest number of students have studied in the fields of: business and administration (20%), medicine (13%) and technical/engineering (11%). Other most frequently chosen courses of study were i.e. social courses (8%), pedagogical courses (7%), language courses (6%), production and processing courses (4%), as well as architecture and construction courses (4%).
The share of employment in the industry of high technology is the indicator of the production economy, which rests upon constant innovation through creative and inventive activity. The employment in the segments of high technology in the Silesian Voivodeship in 2010-2017 was characterised by the level of dynamics of 131.8%, while in the segment of knowledge-based services the dynamics of changes totalled 129.4%

Table 11. Employment in industrial technologies sector and knowledge-based services in the Silesian Voivodeship

Specification	Year [thousand persons]			
	2010	2015	2016	2017
Sector of industrial technologies				
High industrial technologies	35.2	40.2	42.3	46.4
Medium-high industrial technologies	116.2	140.1	166.0	181.1
Medium-low industrial technologies	110.3	133.4	160.3	172,5
Low industrial technologies	109.5	109.7	98.7	121,9
Sector of knowledge-based services				
High technologies	29.3	33.6	36.5	37.9
Market (excluding the services of financial intermediation and high technologies)	87.0	86.8	95.0	87.4
Others	368.2	364.0	372.1	396.5

Source: Eurostat data

The Internal expenditure on research and development business (R&D), which represents one of the most important parts of expenditure on the innovative activity, totalled 1 204 581.9 thousand PLN, in 2016 in the Silesian Voivodeship. Industry (sectors NACE Rev. 2: B, C, D, E) incurred 455 989.5 thousand PLN of the expenditure, while the sectors outside the industry field incurred 748 592.4 thousand PLN. External expenditures in 2016 for the (R&D) business according to (R&D) fields are

[41] https://www.slaskie.pl/content/przedsiebiorco-inwestuj-w-badania
[42] According to GUS, for: Higher Education Schools and their finances in 2016, GUS Warsaw 2017

shown on the graph (Figure 4). The biggest input falls on engineering and technical sciences (51%) and nature sciences (24%). The lowest input of expenditure is connected with the field of agricultural and veterinary sciences (4%), as well as with the field of humanities and arts (4%).

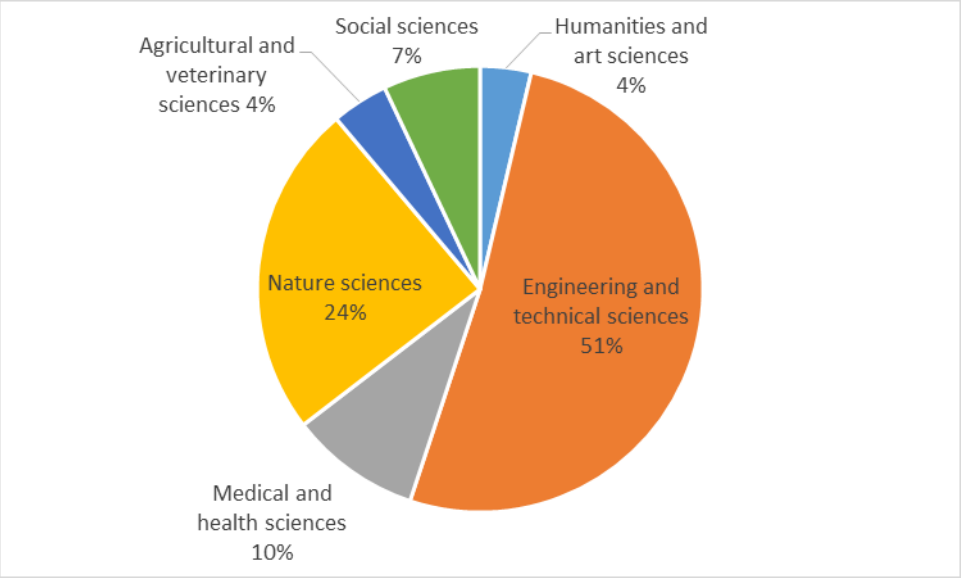

Figure 4 Intramural expenditures in 2016 for R&D activity by fields of R&D

Source: GUS data STRATEG

Within the framework of expenditures covered by the sectors not connected directly with scientific work, sectors connected with the transport and communication, which are characterised by a high level of expenditure for R&D activity, the following are worth noticing:

- production of vehicles, trailers and semitrailers, except motorcycles;
- information and communication,
- production of the other transport vehicles.

It is also worth noticing that the Silesian Voivodeship has favourable conditions for the transport development an indication of which is also the resolution which was passed on 7 April 2014 by the Voivodeship Sejmik of the Silesian Voivodeship on with regard to adoption of Strategies of the Transport System Development in the Silesian Voivodeship[43].

The indicator that has the biggest influence on the level of R&D expenses in the Polish private sector is the availability of a bigger number of external support forms, which makes the public programmes that support R&D business development directly stimulate the level of R&D expenses[44]. In the current period of programming for the years 2014-2020, this support is given by the level of the national programmes (SG OP, I&E OP), EU programmes (i.e. Horyzont 2020, The Research Fund for Coal and Steel), as well as regional programmes (in case of the Silesian Voivodeship ROP SV). The allocation for the increase of research and development activity of the companies, in accordance with the assumptions of ROP SV 2014-2020, will total 176 million Euro, which in comparison to the

[43] Resolution of the Sejmik of Silesian Voivodeship No. IV/49/7/2014 from 7 April 2014

[44] Ongoing evaluation of the implementation of Measure 1.2 Research, development and innovations in undertakings under the Regional Operational Programme for the Silesian Voivodeship for the years 2014-2020, Ecorys, 2017

internal expenditure incurred for R&D activity by companies from the Silesian Voivodeship constitute, on an annual average, c.a. 18% of these expenditure's value.

The information provided by the Network of Regional Specialised Observatories is a supplementation of the description of general diagnosis considering the innovation potential of the Silesian Voivodeship.[45]

Technology for medicine (health protection)	• The industry of medical devices is an important part of healthcare sector and has a particular interest in innovations, much bigger than other production sectors. • Advanced technologies of biomedical engineering stimulate the growth of inventiveness in the industry of medical devices. • In the area of technology for medicine, according to the European Patent Office, the number of patents has an upward trend, while in the area of pharmacists and biotechnology it remains on a 5 000÷6 000 level.
Technology for energetics and mining	• Silesian Voivodeship has a big innovative potential in the area of energy due to the big number of generation units, presence of leading energetic groups (Tauron), the natural resources connected with mining, intensive development of energy industry, and a big number of new companies. • The interest of the companies in R&D business in the area of limiting the emissions and energy storage, occurs on a large scale in the Silesian Voivodeship.
Technologies for environment protection	• Eco-innovations in production processes, or even in management, are a significant part of economic activity. Sector of eco-innovation is characterised by high dynamics of development. Each year, in the Silesian Voivodeship, approximately 12/13 patents are reported in the area of environmental protection. The biggest number of thematic relations can be found in production and processing of materials as well as in energetics. • In the area of technology for environmental protection, innovative business of companies is very distinguishable in comparison with the rest of the country, in terms of process, product, marketing, and organisational innovations, particularly in sections of: mining, industrial processing (fuel) and water and energy delivery as well as sewerage waste management and remediation. (sections B, C, D and

[45] The presented data constitute a synthesis of broad analyses

	E). • Network and cluster cooperation in the area of technology for environmental protection in the Silesian Voivodeship is being developed by initiatives, such as i.e. Silesian Water Cluster, Silesian Ecological Cluster.
IT and telecommunication technology	• Innovative potential, which is the base for a sector, is cumulated in the own activity of the companies. These companies, on their own or in value chains, accomplish development works, using mainly the existing and approved programming and engineering environments. • Network and cluster cooperation in the Silesian Voivodeship is being developed by initiatives such as: Silesian IT Cluster (slaskiklasterit.pl), Hub Club Cluster – Silesian ICT and Multimedia Cluster (hubclub.pl), e-South Cluster (epix.net.pl), Human Cloud Cluster (humancloud.pl). • New initiative which is based on ICT as horizontal technologies and connecting them with advanced usage in industry in the voivodeship is the Silesian Centre of Competence for Industry 4.0 which was established at the beginning of 2018. The Activity of the centre is directed towards the support of companies in the process of digital transformation based on artificial intelligence.
Production and processing of materials	• There are 4 industrial and technological parks in the Silesian Voivodeship, which are connected with the area of production and processing of materials, and 2 clusters: Cluster of Mining Machines and Polish Cluster of Aluminium, named National Key Cluster. • According to IBnGR research, since 2000,796 patents have been granted in the Silesian Voivodeship. They concerned inventions in the area of production and processing of materials.
Technologies of design and production in aviation and space industry	• Polish aviation sector is one of the most innovative in the national economy. Production capacity of companies in the aviation and space industry in the Silesian Voivodeship lies primarily in the offered quality of products and competitive labour costs. Polish network of manufacturing and service companies, which are supported by (R&D) centres, determine the potential to cooperation and the possibilities of commissioning orders for the production of replacement parts for the space and aviation sector. • A few companies in the Silesian Voivodeship successfully conduct projects related to the building of earth observation satellites. The activity of these companies involves not only downstream segment

	(transmission of satellite signals, processing of satellite data), but also upstream segment (i.e. production of space equipment and services within the scope of transporting). • Innovative activity in the area of aviation technologies is supported by Silesian Aviation Cluster.
Nanomaterials and nanotechnologies	• Research and development potential for the area of nanomaterials and nanotechnologies in the Silesian Voivodeship soared rapidly in years 2013-2016, which is reflected in the growth of expenditures on R&D works, exceeding 600% in years 2013-2016. • Among R&D projects with various level of technological readiness, 30% concerned the area of nanomaterials and nanotechnology.

Source: SO RIS analyses

Technology, entrepreneurs and scientists are currently creating one, common ecosystem for the innovation development of the Silesian Voivodeship. New trends and challenges for the technological areas in the Silesian Voivodeship are led by horizontal relations which enhance local value chains. The main, identified trends for the technological areas, which were the results of diagnostic analysis, have been shown below.

Technologies for medicine (health protection)	• Professionalization and improvement of medical services accessibility. • Continuation in growing of the number of students and graduates of medical studies, including Medical University of Silesia in Katowice • Continuation in advancement of science in medicine and in scientific achievements.
Technologies for energetics and mining	• Increase in demand for primary and electric energy. • Transformation of economy into low-carbon, including the increase in the use of renewable energy. • Development of technology in renewable energy production and energy storing. • Growing potential of digital economy. • Growing environmental awareness of the society.
Technologies for environmental protection	• Inclining pressure on environmental effectiveness of businesses. • Competition about resources, capital, labour and technology, which affect the state of natural environment and determine the

	development of new technologies. • Globalisation of local economies, which contribute to the adaptation and creation of new solutions in the area of environmental protection. • Growing importance of general purpose technologies, i.e. ICT, biotechnology. • Decrease in the amount of non-regenerative natural resources. • Increasing consumption of energy. • Changing social behaviours connected to growing ecological awareness. • Improvement of living standards and connected to it growth of expectations in the area of environmental quality. • General consumerism. • Increasing importance of social and organisational innovations (new models)
IT and telecommunication technologies	• Safety and stability of systems. • Transfer of large assets of data. • Development of artificial intelligence. • Internet of things. • Industry 4.0. • New business models. • Intelligent systems. • Geolocalisation.
Production and processing of materials	• Creation of functioning bases and implementation of circular economy. • Focus on the growth of creation and implementation of all kinds of innovations. • Energy efficiency in production, distribution and operation (including materials). • Assurance of safety and protection of the environment. • Decrease of material costs and increase of productivity (applies mainly to the processes of material production).

	• Usage of global resources • Increase in demand for materials (especially metal materials and polymers). • Growth of labour costs in processing of materials.
Transport and transport infrastructure	• Balanced development of industry sector • Development of artificial intelligence, apps and software for management systems, i.e. sale, storage. • Development of a single market of alternative fuels for the transport in Europe.
Technologies of design and production in aviation industry and space industry	• Development of technologies in advanced spaceship, components and material production. • Development of technologies in space industry (components for building of satellite structures and software).
Nanomaterials and nanotechnologies	• Leading involvement of nanotechnologies and nanomaterials in other technological areas – i.e. in the area of medicine, materials, and machines. But also in the areas of transport, environment and ICT. Particular impact of nano area can be seen in the automotive industry. • Growth of the infrastructural potential for the research and development work conduction. • Growth of competence of human resources in the area. .

Source: SO RIS analyses

2.2.2 Scope of technological areas

2.2.2.1 Methodological assumptions

The verification of technological areas has been accomplished by the experts as part of the SO RIS in EDP project, based on the so far settled strategies of the Technology Development Program of the Silesian Voivodeship for 2010-2020 and strategical diagnosis, carried out by each of Observatories, using individual methods and research techniques based on:

- analysis of strategical documents at European, domestic and regional level,
- analysis of world's trends,
- Analysis of quality and quantity data (i.e. GUS , Eurostat data),
- Experts' opinions

- Analysing the needs of entrepreneurs and R+D units,
- Opinions, reports, thematically concurrent evaluations with TDP areas,
- Evaluation of connections of areas with other technological areas, including the strength of influence resulting from the advancement of research and development works carried out in the voivodeship,
- Evaluation of nodal and island technologies based on the analysis of the frequency of existing connections between other technological areas.

2.2.2.2 Importance of technological areas for the Silesian Voivodeship's development

The Silesian Voivodeship is one of the biggest investment areas in Poland, as well as one of the strongest in terms of economic potential. Related to it, high level of urbanisation and industrialisation make the Silesian Voivodeship the region which undergoes perpetual changes. One of the ways to restore or enhance the environmental, economic or social attractiveness of the Silesian Voivodeship is the creation of innovative solutions in key areas of technological region, which will result in the development of the voivodeship and growth of its competitiveness.
Modern development processes, more and more often, run in a specific system of connections, which includes enterprise networks, research and development, non-governmental institutions, as well as public administration and citizen initiatives. The role of network relations, which simplify permeating of ideas and information exchange, is growing.
The diagnosis, which was carried out as a part of SO RIS in EDP project, has confirmed the big importance of technological areas for the innovation development of the Silesian Voivodeship. The synthesis, made on the basis of the evaluation carried out by the observatories, is shown below in the division on technological areas[46].

Technologies for medicine (health protection)	• There are factors (i.e. work conditions, quality of environment) which strongly affect the condition and state of health of residents in the Silesian Voivodeship. Phenomena, such as higher than national average ratio of premature births and congenital disorders, higher frequency of cancer suffering and shortened life period in full health, can be observed in the Silesian Voivodeship. • Silesian voivodeship has at its disposal intellectual and economic resources in the area of medicine and related to its advanced technologies of biomedical engineering (big number of medical and scientific centres). • Technological progress is a cornerstone for the refinement of medical services in the region, in many fields of prevention, treatment and rehabilitation and the recognition of medical engineering products. • The biggest development potential in terms of medicine and technology in the Silesian Voivodeship, is seen in areas such as:

[46] Diagnosis of technological-innovation potential elaborated by either of the Observatories under project SO RIS in EDP

	-cardiology, including paediatric cardiology and cardio surgery -oncology, including surgical oncology, oncological gynaecology, paediatric oncology and haematology, oncological radiotherapy, - orthopaedics and traumatology of musculoskeletal system, - medical rehabilitation - treatment of burn injuries and chronic wounds - transplantology • The development of medical technologies uses IT and telecommunication technologies within the research in *silico*[47] as well as within remote prevention and diagnostics, treatment on complicated cases, and formation of intelligent market systems or quasi-markets of service for policy holder.
Technologies for energetics and mining	• Energy field in Poland requires initiation of changes forced by i.e. growing demand for energy, ageing infrastructure, decreasing resources of fossil fuels, international obligations in terms of climate policy, the necessity to provide energetic safety and the limitation of dependence of energy sources importing. • Silesian Voivodeship is a perfect background for testing and a full-scale implementation or innovative solutions in the area of energy and mining. • The energy field constitutes the first and most important area of creation, testing, and the usage of intelligent network distribution technology. • There is a clear relation between technological progress, growth of safety level and effectiveness while decreasing of negative influence on the environment. • The market of energy saving technologies shows significant perspectives of development, especially in building engineering.
Technologies for the environment protection	• Due to the connection with the economic activity in the sectors of industry, service, and the public service, technologies for the environment protection are of horizontal nature. • Areas particularly important in the light of current needs in terms of environmental technologies development in the region are i.e. biotechnology, building engineering, environmental engineering, disposal of waste, management.

[47] Carried out with computer assistance (from English *in silico – in silicone*)

IT and telecommunication Technologies	• Rich structure of industry in the region constitutes a background for the implementation of modern ICT solutions, and the attractiveness of metropolitan area enforces the allocation of shared services centres, including ICT. • Broadly understood competencies in the region are high, however, they are not unique on a national and Central Europe level. • Companies and other entities from ICT sector function in regional networks, implement bigger projects together, and at the same time, they struggle with the accessibility of personnel. Important entrants in a national, and even international IT market function in the region. • Specialists needed for the sector are trained in some facilities in the region. It is also a place where research and surveys are conducted. • ICT sector in the Silesian Voivodeship faces a challenge of consolidation and domination of few global entrants. • ICT sector is a perspective one, which grows strongly on a global scale.
Production and processing of materials	• In the production processes, modern, homogenous, composite materials are being currently used. It highlights the broad scale in the usage of modern metal, polymeric and ceramic materials. • Strong regional research and education based in the area of technology as well as testing of materials generate a favourable environment for the development of enterprises in this area.
Technologies of design and production in the aviation industry and space industry	• The aviation industry in the Silesian Voivodeship is an essential factor for economic growth, but it requires the accessibility of technology at a global level. • Aviation industry, aviation transport, and space industry use multi-disciplinary technological solutions and constitute a cornerstone of the technological development in other branches of industry, such as automotive industry (usage of composites), and energetics. • Aviation technologies are characterised by high quality which focuses on the broadly understood safety. Technological specialisations of the region concentrate on the production of sailplanes, light aircraft, ultralights and unmanned aircraft; design and production of modules for aviation engines; production of advanced materials; survey of composite materials and structures; ICT systems for aviation. • Companies from the aviation sector, which work in the Silesian Voivodeship, are concentrated closely to Silesian Aviation Cluster, which awarded the highest certificate Gold Label of the European

	Secretariat of Cluster Analysis (ESCA). • It is a promising sector with an upward trend. It provides a raise of competitiveness on the European and international stage and makes the Silesian Voivodeship attractive in terms of investment and formation of workplaces for the high-class specialists.
Nanomaterials and nanotechnologies	• Nanomaterials and nanotechnologies constitute a dynamically developing area of technology which is of interdisciplinary and horizontal nature and has a growing potential; from obtaining materials with new properties for sectors such as automotive, aviation, and electronics to elaboration of new medications or research of complex cell structures for medicine and pharmacy. • Automotive is among more important areas in which nanomaterials and nanotechnologies are used in the Silesian Voivodeship. In this area Cluster Silesia Automotive & Advanced Manufacturing, which works in the area of advanced production systems (4.0 industry), plays an important role. • The development of the area related to nanomaterials and nanotechnology in the Silesian Voivodeship follows the European and international trends in this area. Research centres and specialised in this field business entities can be found in the Silesian Voivodeship.

Source: SO RIS analyses

2.2.2.3 Range of the technological areas described within the framework of SO RIS in EDP

The scope of technological areas was analysed by the Network of Regional Specialized Observatories[48] as well as within the framework of evaluation survey by Marshal's Office in the Silesian Voivodeship. The result of the conducted works was the update of technological groups and the technology in all technological areas, which includes their development, innovation and changing state of the art. The result of these works were changes of a structural nature – the technological groups were broadened or limited. Detailed scope of technological areas is shown in the attachment of the document. The structure of technological areas comprises an open catalogue which, over subsequent years, may undergo essential updates as the result of the conducted entrepreneurial discovery process.

[48] More information on the methodology of identifying the groups of technology in technological areas and their detailed scopes in materials disclosed on the websites of the Observers

2.2.3 The evaluation of technological groups and strategical orientations

2.2.3.1 Methodological assumptions

In this study, the manner of evaluation of technological groups, that was accepted, results from the methodology described in the Technology Development Program of the Silesian Voivodeship for 2010 – 2020. The survey carried out in this study was related to the uploaded list of technologies in technological areas. The technologies were the subject which underwent expert evaluation carried out as the work of Specialised Observatories.

In the first stage, the experts assessed the technologies to reflect their R&D potential, as well as economic and innovation potential. What is more, they wanted to show its importance in the Silesian Voivodeship with the use of two aspects ''their importance for the Silesian Voivodeship" and "high/low potential".

The result of the works was the classification matrix 2x2, in which positioning of technology according to the sizes was possible. The matrix consists of 4 categories:

- Group A – the group of **potentially developmental and export technologies** – with a high level of technical, organisational and intellectual potential, but of little protechnological importance for the region. In order to make their further development possible (transition into "C" group), actions supporting the growth of product and process innovations are essential. Despite the weak technology procurement potential and low direct function in the technological development in the region, technologies from "A" group can still have a developmental potential. Rebuilding of them, with the use of high intellectual and organisational potential, as well as the support of R&D potential for the region may result in the growth of product innovativeness. Much of the empirical research, carried out in various regions in Poland[49] as well as the research carried out by polish entrepreneurs under SO RIS in EDP in the Silesian Voivodeship shows that a high technological level encourages the entrepreneurs to develop of their business, while a low technological level causes unwillingness and lack of any actions in order to develop the business, including the innovation business.
- Group B – **a group of stagnational or compromised technologies –** technologies with a low intellectual, organisational and technical potential and of little pro-technological importance for the Silesian Voivodeship.
- Group C – **a group of expansive technologies**, technologies with a high intellectual, organisational and technical level, which influence the pro-technological development of the region.
- Group D – **a group of technologies of new possibilities –** rising technologies, with temporary, low level of technological and organisational potential, but of great importance for the pro-technological development of the region. For the technologies classified to "D" group; so called technologies of new possibilities, the evaluation of the state of organisational innovations implementation is very significant. In case of the technology from this group, the development of their organisational and technical potential is an essential step in order to make their general development possible (transition to the technological group of expansive nature). In this regard, it is worth noticing that the percentage of

[49] i.e. Bobyk A., Potencjał technologiczny Lubelszczyzny - ekspertyza naukowa, Wyższa Szkoła Ekonomii i Innowacji w Lublinie, 2013

companies which implement marketing and organisational innovations in the Silesian Voivodeship is lower than of those which implement product and process innovations.

At the second stage of the evaluation, the technologies were analysed in relation to cross-compliance criteria (assignment to the groups: nodal technologies, exogenous technologies) and also in relation to the influence of the region's development (endogenous and exogenous technologies).
At this stage of analysis, a problem of explicit evaluation of technology and technological groups in relation to the criteria of influence on the region's development had been noticed. Due to the inflow and adaptation of new technologies and their influence on the development of the region, thus explicit evaluation of their nature and positioning of them towards one of four orientations:

- Orientation I – "**Leadership and diversification**" orientation – endogenous technologies with a high level of interdependence with other key technologies in the region.
- Orientation II - **"Leadership through perfection**" orientation – endogenous technologies with a low level of interdependence with other key technologies in the region.
- Orientation III - "**Technological acquisition in favour of diversification**" - exogenic technologies with a high level or interdependence with other technologies and the high pressure on the usage of them and the improvement of attractiveness of innovative products in the region.
- Orientation IV - "**Technological acquisition in favour of perfection**" - exogenic technologies with a low level of interdependence with other key technologies, with a high pressure on the usage of them for the improvement of the attractiveness of innovative products in the region at the same time[50].

Due to the various specificity of technological areas, Specialised Observatories used individual technology evaluation methods and techniques in order to position, i.e. quantity and quality analyses.
The evaluation of technology that was carried out on the level of strategical diagnosis became a starting point for the strategical settlements, which aimed to define the technological wallet of the voivodeship.

2.2.3.2 The results of Specialised Observatories' works

The analyses conducted in accordance with the adopted model of evaluation show that the chosen technological groups and technologies are mostly of expansive nature, which gather the desirable features from the point of view of technological development in the Silesian Voivodeship (technologies from C group)[51]. It applies mainly to the area of technologies for medicine as well as nanomaterials and nanotechnologies. In the group of technologies of new possibilities (technologies from group D) the emergence of the technology of design and production in the aviation and space industry group is clearly visible. The table below shows the results of classification of the technology groups to the areas from the point of view of their potential and importance in the Silesian

[50] More in 3.2
[51] Detailed evaluation of individual technologies has been presented in the annex

Voivodeship. In the rest of the analysed technological areas, the coverage of at least two and a half in the evaluation matrix of potential and importance for the Silesian Voivodeship is clearly visible. Such situation is typical for technologies of environment protection, IT and telecommunication technologies in energetics, production and processing of materials. There is only one area in the region, which could be indicated as compromised (technologies from the group B). This group is connected with ceramic materials. However, among the technologies of low importance for the voivodeship and high potential (group A), we can find groups of technologies such as *Production of energy from renewable sources and improvement of the effective need of the acquisition of energy from* RES *and optoelectronics.*

This analysis is, however, only the first stage of the evaluation and it places the technologies and technological groups in terms of technical, organisational and intellectual potential in the region. At the same time, it paves the way for the discussions about its possible reinforcement and indicates the importance of the area from the point of view of the strategical goals realisation in the voivodeship, especially development and innovativeness promotion.

Table 12 Matrix of the evaluation of technological groups

Importance for the Silesian Voivodeship	**Large**	• Prosumer energetics • Technologies of energy storing • Technologies of waste management • Technologies of water and sewage • Technologies of air protection • Technologies of the environmental management • Geoinformation and its use • Modelling and simulations of processes and phenomena • Safety of information • Polymers • Technologies of design and production in the aviation and space industry	• Biotechnologies for medicine • Technologies of medical engineering • Highly efficient energetic technologies • Technologies of fuel cells production • Technologies of intelligent networks and interconnections • Technologies of energy production from the alternative waste and fuels. • Intelligent and energy saving building engineering • Biotechnologies in the protection of environment • Technologies of the improvement of quality of the degraded areas • Telecommunication technologies • IT • IT and telecommunication technologies which support industry 4.0 • Metallic materials • Nanomaterials and composites • Nanoelectronics • Nano-optics • Nanophotonics • Nanobiotechnology • Nanomedicine • Nanomagnetism • Filtration and membranes • Instruments or devices in nanoscale • Catalysis • Software for modulation and simulation
	Small	• Ceramic materials	• Production of renewable energy and the improvement of effectiveness of in acquisition of energy from RES • Optoelectronics
		Low	**High**
		Potential	

Source: SO RIS analyses

The next stage of the analysis was connected with the evaluation of technology and technology on the basis of the criteria connected with interdependence. The experts from the Network of Regional Specialized Observatories conducted an analysis of the relations between the identified key technologies through the prism of knowledge generation and absorption, useful skills and

competence in creating and implementing of technological innovations to the business field. On this basis, they made a distinction of technologies into two groups – nodal and island technologies. The table below presents the results of the conducted analysis and the division into technological groups (detailed division of each technology is shown in the attachment to this document).

Table 13 EvaluationEvaluation of interdependence of technological groups

Groups of nodal technologies	Groups of island technologies
• Biotechnologies for medicine • Technologies of medical engineering • Technologies of fuel cells production • Prosumer energetics • Technologies of intelligent networks and interconnections • Technologies of energy storing • Intelligent and energy saving building engineering • Biotechnologies in the protection of environment • Technologies of the improvement of quality of degraded areas. • Technologies of waste management • Technologies of water and sewage • Technologies of environmental management • Telecommunications technologies • Geoinformation and its use • Modelling and simulation of processes and phenomena • IT and telecommunications technologies which support industry 4.0 • Metallic materials • Polymers • Nanomaterials and composites • Nanoelektronics • Nanooptics • Nanophotonics • Nanobiotechnology • Nanomedicine • Nanomagnetism • Filtration of membrane • Instruments or devices in nanoscale • Catalysis • Software for modelling and simulation	• Highly efficient energetic technologies • Production of renewable energy and the improvement of effectiveness of RES energy acquisition • Technologies of energy production from the alternative waste and fuels. • Technologies of the air protection • IT • Optoelectronics • Safety of information • Ceramic materials • Technologies of design and production in the aviation and space industry

It has been noticed that a particularly large involvement among the identified developmental technologies in the Silesian Voivodeship is on the part of the technologies of nodal nature, thus ones which are strongly dependent on the development of other technologies in the region or which are a

condition of other technologies' development in the region. A high level of the interdependence of technologies shows that their intermingling and mutual interdependencies influence the generation of new solutions which are broadly used in business and science field for the creation of new tenders of products and services. Nodal technologies constitute, however, a different kind of technology, the development of which happens autonomously. For the preservation of balance in the region and the involvement in global chains of values, ensuring the development of both groups is essential. Both, nodal and island technologies provide solutions through the involvement in global chains of values. These solutions are used by entrepreneurs from the Silesian Voivodeship, including big entities with an international operating radius.

The next stage was connected with separation of two groups of technology according to criterion of influence on the development of the region, some of which – endogenous - may be the basis for creating new products and services, thanks to which, the region is recognizable and can be competitive on global markets, and some other - exogenous -which come from outside of the region but their application will affect the region's development. The expert evaluation SO RIS for technology groups is presented in the table below. Details of the evaluation concerning individual technologies are enclosed in the attachment.

Table 2 Evaluation of the influence technology groups on the development of the region

Endogenous technology groups	Exogenous technology groups
• Biotechnologies for medicine • Medical engineering technologies • High-efficient energy technologies, Technologies of smart networks and interconnections, Technologies of production of energy from waste and alternative fuels, Smart and energy-saving construction • Technologies to improve the quality of degraded areas • Water and sewage technologies • Information technologies • Geo-information and its use • Modelling and simulation of the processes and phenomena of Optoelectronic • Telecommunications and information technologies supporting industry 4.0 • Metallic materials • Nano-materials and composites • Nano-electronic • Nanophotonics • Nanobiotechnology • Nanomedicine • Nanomagnetism • Filtration and membranes • Tools or devices at the nanoscale	• Fuel cell manufacturing technologies • Generation of energy from renewable sources and improving the efficiency of obtaining energy from RES • Pro-consumer power generation • Energy storage technologies • Biotechnologies in environmental protection. Waste management technologies. Air protection technologies • Environmental management technologies • Telecommunication technologies • Information safety • Polymer materials • Ceramic materials • Design and production technologies in the aircraft industry • Nanophotonics

• Catalysis • Modelling and simulation software	

Source: SO RIS analyses

Separation of these groups is strongly connected with the expert evaluation of technical and intellectual potential, which in the course of already implemented projects has been significantly renovated and modernized, although it still requires expenditures and more intensive internationalization due to the progress of knowledge. In the case of exogenous technologies, actions are required to create experimental infrastructure to ensure their development in the region and to link with technologies already occurring in the region. It will result in further strengthening of the region's competitiveness and innovation.

The analysis and evaluation of technological areas, technology and technology groups carried out by SO RIS experts indicated the blurred boundaries between the separated groups, which justifies the dominant concept of open innovation[52]. The growth of innovativeness is also influenced by the progressing globalization of the economy and the development of transnational corporations using local potential. These enterprises play a dominant role in creating and diffusing innovations.

The concept of open innovations [53] is a starting point for intensifying cooperation between entrepreneurs and other entities, indicating as a way to growth and innovation, acquiring the necessary knowledge and innovations within the network of contacts being built (e.g. with R&D sector entities, suppliers, product users, clients, as well as competitors). At the same time entrepreneurs should also share their solutions which they do not use in business activity, other entities on the basis of license sale, create consortia or spin-off companies[54].

In many technological areas, the process of changing from a closed, traditional innovation model to an open innovation system is visible. This applies especially to the following areas: information and telecommunications technologies, as well as nanomaterials and nanotechnologies, which in the Silesian Voivodship have the form of horizontal areas - complementing and supporting the remaining ones. In other technological areas, the process of applying open innovations takes place with different dynamics and requires systemic support, in particular creating methods and tools that increase trust between actors of the innovation ecosystem and support for the commercialization of new technological solutions based on the open innovation paradigm.

[52]According to the concept of open innovation, enterprises should not rely solely on the results of their own research and, but use external sources of innovation through cooperation with other entities.

[53] Chesbrough H. W., Open Innovation: *The New Imperative for Creating and Profiting from Technology*, Harvard Business School Press, Boston Mass 2003.

[54] Bailom F., Matzler K., Tschemernak D.: *How to solidify success* What distinguishes the best enterprises. Warsaw: Wolters Kluwer Poland, 2013, p. 91-93

2.3 SWOT analysis

SWOT analysis showed, that there is a large number of research and development units in the Silesian Voivodeship, creating a highly developed base for implementing innovative solutions. The R&D sector employs highly qualified scientific and technical staff, which guarantees high quality of scientific research conducted in the voivodship and creates an opportunity for commercialization of solutions. The threat to further development of technology in the region is the low level of expenditure on the R&D sphere, both from budgetary and extra-budget funds, as well as the lack of effective mechanisms for knowledge transfer to the industry. The reason for this is the lack of sufficient legal regulations in the field of transfer of science to industry. In addition, the lack of financial resources will result in the outflow of academic staff outside the region and a decrease in the interest of young people in pursuing studies focused on exact sciences. An opportunity for technology development in the Silesian Voivodship is a growing public awareness and a high level of acceptance for new ecological solutions.

Strengths of the **Technologies for Medicine (healthcare) (MED)** are high innovativeness of enterprises in the industry, resulting from favourable EU policy and availability of structural funds. The development of the industry and the search for innovative solutions result from the growing public health awareness, trust in new technologies and rapidly increasing standardization requirements regarding the quality and safety of medical devices. Weakness of the technological are is still insufficient number of laboratories accredited and low level of integrity within producers. The technologies developed in the Silesian Voivodeship have expansive features, but there is still an innovation gap between Poland and highly developed countries, which is intensified by strong international competition on the medical devices market.

The development of **Technologies for energy and mining (ENER)** results from the high demand for energy and the potential of local energy resources. Additionally, the conditions of the Silesian Voivodeship show great potential for the development of RES. A hope for the technology area is high demand for interdisciplinary solutions i.e. smart home and smart energy applications) as well as increasing public acceptance for a dispersed and green energy mix. All these features can allow for the transformation of power generation into low-carbon. The condition for this, however, is the legislative support in the area of energy, which currently, under the pressure of interest groups, resulting from the high installed capacity in coal-fired power plants, is focused on maintaining the status quo in the energy sector. The threat is the global competition of the renewable energy market and the difficulty in obtaining foreign investors in the field of RES in the context of the assets of other regions.

Technologies for environmental protection (TFEP) have nodal features, which are manifested by the increase in the activity of entrepreneurs in taking actions related with environmental protection and the targeting of production and services to ecological and smart solutions. Investments in research infrastructure have contributed to strengthening the research and manufacturing potential of the Silesian Voivodeship. The strength of the region is also the existing supply area, including the production of energy from renewable and "waste" sources. Investments in the field of environmental protection are also caused by pressure on "zero-emission" economic activities. The growing ecological awareness of society and the level of education in this area is an opportunity for rapid

development. A certain threat is the need to quickly adapt the regional economy to zero-emission standards, which may favour the purchase of ready-made solutions, including foreign competitors. It is necessary to build new business models, intensify network cooperation and increase internal expenditure on R&D received from institutions allocating public funds, including B, C, D, E sections.

The strong side of the **Information and Telecommunications Technologies (ICT)** area is the constantly growing share of ICT enterprises among all companies in the Silesian Voivodeship and their high ability to adapt to global trends in the outsourcing and IT solutions market. The development of the industry is due to from the progressive transformation towards large system solutions, i.e. industry 4.0, the progress of works on advanced artificial intelligence algorithms, the development of 5th generation high speed networks and subsequent ones, and increased expenditure on R&D. The offer of ICT companies is based on existing solutions. The voivodeship is lacking of entities which create new and unique technologies. The activities of ICT companies are concentrated in large urban centres, i.e. in Katowice, Gliwice and Bielsko-Biała. The vulnerability of ICT systems to cybercrime and cyberterrorism, tightening public control over data exchange in cyberspace and the use of ICT in a manner contrary to commonly recognized value systems is a great threat to the industry. Another threat is the dependence of countries and national economies on large ICT corporations.

In the technological area of **Production and processing of materials (MAT),** many years of experience and tradition, good relations with clients and knowledge of their needs and expectations are the advantages. Restrictions in development are capital intensity and energy intensity of production, high fixed costs, the need for high-volume investments and a low degree of utilization of external innovations. This is related to the fluctuation of qualified staff and the deficit of human resources. An opportunity for development is still growing demand for innovative materials, robotization and automation of processes as well as financial support for development from the local capital groups. The high demand for pro-environmental solutions increases the chances of obtaining EU funds and the development of multi-directional cooperation. The threat is growing competition, including from Asian countries and unstable prices of components and raw materials.

The strong side of the technological area of **Design and manufacturing technologies in the aviation industry and the aviation industry (MASZ)** is a long tradition, specialization in the production of selected products such as light aircraft, composites, components for satellites, international competence level and developed network of sub-suppliers. The creation of an aviation cluster and the improvement of manufacturing techniques generate process and organizational innovations. The weakness is the lack of leading R&D centres in the field of aerospace specialization, which limits the number of product and marketing innovations. An opportunity for the rapid development of the space sector in Europe and Poland (Poland's accession to ESA), industry cooperation and development of the domestic supply chain by foreign companies and export sales. The uncertain situation on the global market, the development of intellectual potential in countries with lower labour costs, being at the same time large recipients of this industry's products, is a threat to the further development of the industry. Development may also be limited by poor financial condition of SMEs in the aviation and space sector as well as difficult access to public funds due to the change of criteria for their allocation.

In the technological area of **Nanomaterials and nanotechnologies (NANO),** a large number of business entities, including those with international reach, investing in research and development as well as strong science-business cooperation networks, including the Silesian Cluster Nano cluster, are

a major advantage. This translates into a growing number of experts in scientific research units and industry and high quality services, including advisory services. The weakness of the area is poor research facilities of business entities and the lack of own technological solutions or exclusive rights to purchased licenses. On the other hand, the number of companies interested in the Nano area is constantly growing, resulting in an increase in the number of projects, patents, publications, including international ones. Increasing the financial outlays for research and development in the Nano area will be conducive to the development of cooperation between research and development centres and business entities.

A synthetic approach to the SWOT analysis for the updated range of technological areas is presented in the table below.

Table3 SWOT analysis for the Silesian Voivodeship and individual technological areas

	Strengths	Weakness	Chances	Threats
S V	• Number of R&D institutions • Human capital level - Qualifications and experience of scientific and technical staff • Quality of scientific research results • Technical education • Location and communication of the region with Europe and the world • Quality of services, including consulting ones	• Number of high-tech enterprises • Low level of enterprises' expenditures on innovative activity • Low share of financing R&D from private funds • Low / low interest of entrepreneurs in the solutions of the scientific sector	• Educational potential of creating professional stuff • Availability of public funds, including subsidies for the development of innovation and science • Increase in GPD • Commercialization of solutions • Access to foreign markets (economic union) • The efficiency of using information and communication technology tools • Demand for new and effective technologies	• The level of expenditure on the R&D sphere • Costs of research and commercialization of solutions • Lack of effective knowledge transfer mechanisms to industry • Demographic decline • Brain drain • Decreasing interest of young people in exact sciences • Legal regulations in the area of science stimulating implementation activities • The costs of buying patents and licenses
MED	• The costs of buying patents and licenses • Cooperation with centres in the country and abroad • Innovation of enterprises	• Insufficient level of integration processes among producers • A small number of accredited laboratories • A small number of entrepreneurs / companies cooperating with R&D units, resulting from too low co-financing of innovation / implementation activities	• Focusing education on education in the field of medicine and biomedical engineering • A favourable EU policy regarding the industry and the availability of structural funds • Technological development in related industries • Technologies with expansive features, including the European / global market • Increased public health awareness,	• Growth dynamics of standardization requirements regarding the quality and safety of medical devices • Healthcare financing system • International competition on the market of medical devices • Innovation gap between Poland and highly developed countries

	Strengths	Weakness	Chances	Threats
			trust and demand in the context of improving the quality of life and lifestyle diseases	
ENER	• Big demand for energy • The potential of local renewable energy resources for the development of energy based on dispersed and renewable energy sources	• Transaction cost • Lack of infrastructure adapted to distributed energy sources • Number of implemented projects • The power of functioning renewable energy installations • There is no integrated data collection and management system	• Mechanisms of financial support for the industry • EC pressure on the liberalization of the wholesale electricity market • The voivodeship's potential for generating a priority pension for renewable energy in the country • Increasing acceptance for the scattered and green energy mix • The observed drop in prices of RES technologies • Voivodeship potential for RES development - use of existing infrastructure, e.g. for building energy storage • Building energy clusters • Initiation of technological changes in the direction of non-emission energy	• Legislative variability in the area of energy • Global competition on the RES market • Social awareness about the benefits of RES development • Difficulties in obtaining foreign investors in the field of RES • The need to attract and maintain high-class specialists
ŚROD	• Environmental technologies of endogenous and nodal nature • Investments in research infrastructure strengthening research	• Awareness of society and entrepreneurs in the field of environmental protection • Insufficient financial resources for undertaking an increased risk of eco-innovation implementation	• Pressure on "zero-emission" economic activities. • The use and development of strong sectors for building the advantages of areas concentrated in new value chains • Growth of social environmental	• Necessity to adapt the regional economy to zero-emission standards, which favours the purchase of ready-made solutions • High international competition in the area of technology

	Strengths	Weakness	Chances	Threats
	and productive potential • Increased activity of entrepreneurs in the field of R&D • The raw material base, including for the production of energy from renewable and "waste" sources	• Deceasing internal expenditure on R&D received from institutions allocating public funds, including B, C, D, E sections.	awareness and level of education • Trends towards smart and green solutions • New business models and intensification of network cooperation	• Drastic reduction of expenditure on R&D by institutions allocating public funds
ICT	• High position in the country in terms of the number of active business entities included in the ICT sector • The growing share of ICT enterprises among all companies in the voivodeship • High ability of ICT from voivodeship to adapt to global trends in the outsourcing and IT solutions. • Large domain diversification of ICT companies in the voivodeship	• Relatively low share of IT companies from the region in the domestic IT market in terms of revenue • Technology development in the voivodship based on existing solutions, • The voivodeship is lacking of entities which create new basic and unique technologies. • The offer of ICT companies from the region to attract experienced engineers and programmers • Decrease in the number of students and graduates of ICT-related fields of study • Limited access to broadband Internet	• Fashion for consumer and social solutions based on ICT: the Internet of Things, Smart City, sharing • Progressive transformation towards large system solutions, e.g. industry 4.0 or autonomous vehicles • Progress of works on advanced artificial intelligence algorithms • Increasing expenditures on R&D activities including the development or use of ICT • Technological demand for the ICT sector from other sectors (ICT horizons) • Development of high-speed networks, 5th generation and subsequent ones • The growing ability to collect and process mass data	• High probability that the current state of the ICT sector is another “speculation bubble" • The susceptibility of integrating ICT systems to cybercrime and cyberterrorism, tightening public control over data exchange in cyberspace • The growing costs of maintaining the ICT infrastructure • Dependence of states and national economies on large ICT corporations • The use of ICT in a way that is contrary to universally acknowledged systems • Social retreat from ICT in connection with privacy violations

	Strengths	Weakness	Chances	Threats
		• Focusing the activities of companies in large urban centres: Katowice, Gliwice, Bielsko-Biała	• development of geolocation technologies • Small scale technology development of sensors scattered in the atmosphere, waters and on land	• Progressive consolidation on the global ICT market, changing the balance of power towards giants and a dispersed network of small subcontractors • The possibility of a regional lock-in effect in the sector (preventing employees from leaving the workplace)
MAT	• Many years of experience and tradition in the production and processing of materials • Good relations with customers - knowledge of their needs and expectations • Great importance for the labour market • Many years of experience in cooperation with scientific units • A wide range of products and global recognition of Silesian brands	• Insufficient own resources for development, in particular for technological investments • A relatively low degree of utilization of external innovations • Capital intensity and energy intensity of production • Lack of pro-ecological solutions, application of many technologies which threaten the environment • The need for high-volume investments • High fixed costs • Exhausted qualified human resources and personnel fluctuation • Small research facilities	• Demand for innovative materials in many market segments • Financial support for development from the local capital groups. • Fast return on investment (especially in the area of processing) • Acquiring EU funds for pro-ecological and energy-saving investments • Robotization and automation of processes • Development of multicultural cooperation	• Growing competition, including from Asian countries • Unstable prices of components and raw materials • Introducing cheaper substitutes at the expense of quality, durability and ecology • Insufficient activity of the business environment to support the implementation of innovation • Unattractive external financing instruments • Weakening of the economic situation in Poland and in the world • The deteriorating situation on the labour market

	Strengths	Weakness	Chances	Threats
MASZ*	• Long tradition • Specialization in the production of selected products such as light planes, composites, components for satellites • International level of competence • Developed network of sub-suppliers • Aircraft cluster • Aircraft infrastructure • Improvement of manufacturing techniques - process and organizational innovations	• Lower financial potential of the regional aviation industry in comparison with other countries • Number of product and marketing innovations • Relatively low cooperation at the national level • A narrow database of scientific units specializing in aviation and space • No leading R&D centres in the field of specialization	• Fast development of the aviation market in the world • Rapid development of the space sector in Europe and Poland (Poland's accession to ESA) • Growing cooperation between small and large companies • Further development of the domestic supply chain by foreign companies and a large share of export sales • The development of aircraft engines • Construction of new gliders, light aircraft, including unmanned aircraft • Opportunity to participate in EU research programs, including ECO.	• Uncertain situation on the global market that may have an impact on reducing the pace of development of the industry in the region • The development of intellectual potential in countries with lower labour costs, which are also large recipients of this industry's products • Poor financial condition of SMEs in the aerospace sector • Difficult access to public funds due to the change of criteria for their allocation • Lack of strategic autonomy, mainly in the area of creating new products
NANO	• Big number of companies • Business entities investing in research and development • Strong science-business cooperation networks, including the Silesian Nano Cluster • High quality of services,	• Non-integrated programs and level of teaching in fields related to nanotechnology between universities • Lack of didactic programs, including dual directions in the nano area • Research facilities of business entities • Lack of support programs,	• The growing number of companies dealing with • Increasing number of projects, patents, publications, including international ones • Increasing the competitiveness of companies from the region on the Polish and global nanotechnology market • The growing number of	• Ambiguous legal regulations regarding the area • No increase in funding for the development of the area • Social concerns related to the use of nanomaterials and nanotechnologies • Formal and legal difficulties related to running business in the nano area

	Strengths	Weakness	Chances	Threats
	including consulting ones • A large number of experts in scientific research units and industry • Business entities with international reach	especially for small entrepreneurs • Lack of own technological solutions or exclusive rights to purchased licenses • Lack of own technological solutions or exclusive rights to purchased licenses	technological areas using nanotechnology achievements • Increasing financial outlays for research and development in the area • Growing cooperation between science and research centres and business entities • Increasing support for local and government authorities to develop the industry • Development of a knowledge-based economy and information society	• Shortening the life of innovation • Rising research costs • Limiting the development of the area through growing competition • Low awareness of intellectual property protection • Component prices increase

*Design and manufacturing technologies in the aviation industry and aviation industry

Source: SO RIS analyses

3 Strategic arrangements

3.1 Program Objective

The Technology Development Program of the Silesian Voivodeship for 2010-2020 is a strategic plan for the technological development of the region, the hitherto general objective of which is to identify the potential of the region, taking into account the future programming period.[55] Thus, TDP is part of a wide range of activities implemented under the Regional Innovation Strategy.
Taking into account the previous experience related to the implementation of the Program, diagnostic work carried out by the Network of Regional Specialized Observatories allowing its update and objectives included in the Communication of the European Commission Europe 2020 - Strategy for smart and sustainable development supporting social inclusion of March 3, 2010 and documents related to the definition of a new financial perspective[56] and national and regional strategic documents, in particular the *Silesian 2020+ Development Strategy for the Silesian Voivodeship and the Regional Innovation Strategy of the Silesian Voivodeship for 2013-2020*, three main values were identified as pillars of the Technology Development Program update:

1. Integrity
2. Cooperation
3. Innovation

The integrity of TDP manifests itself in the technological field and expresses the interpenetration and interconnection between technological areas, technology groups and technologies. The conducted analytical work indicates that the development of the region is conditioned by the generation, connection and adaptation of technologies having a source in various technological areas, which is an important source of advantage for competition The integrity of technology also occurs at the socio-economic level, where it is read as a factor influencing the improvement of the quality of life, including the state of the environment. In this dimension, integrity can also be read by coherence of the Program with regional, national and international policies. Integrity also exists in the spatial plane, where it manifests itself through participation in global value chains.
Cooperation in TDP is the result of many years of building the Network as part of the regional eco-innovation system. Cooperation between actors of the ecosystem of innovation in the economic spheres (entrepreneurs), research and development (scientists) and administration is additionally strengthened by the developed institutions of the business environment. A special solution is the Network of Regional Specialized Observatories created in the region, whose main task is to monitor the technological development of the region and provide information about its condition and the latest technological trends. Cooperation is a key value shaping the region's innovative development.
Innovation is the fundamental value of the regional ecosystem. The TDP identified technologies with the highest development potential, which form the basis for the implementation of social, economic and environmental challenges included in the RIS. These technologies present now and in the future

[55]Technology Development Program of the Silesian Voivodeship for the years 2010 - 2020, p. 23
[56] Draft Regulations of cohesion policy for the years 2021-27, http://www.miir.gov.pl/strony/zadania/fundusze-europejskie/fundusze-ue-2021-27/, 28.09.2018

about the directions of actions taken to strengthen and develop economic and R&D potential as well as to create the necessary knowledge infrastructure.

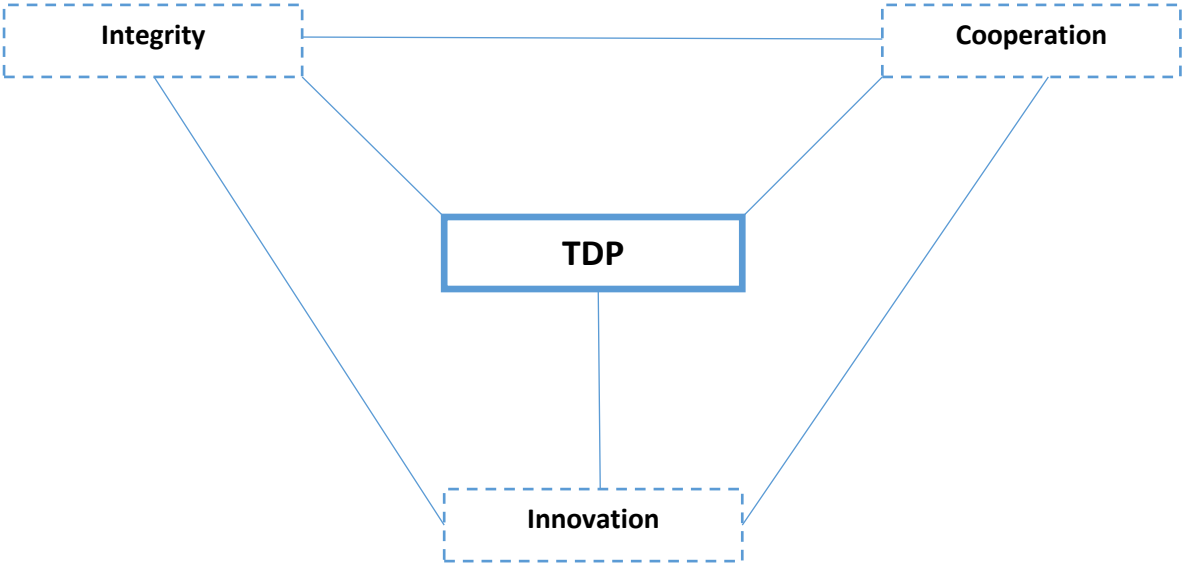

Figure 1 Pillars of the Technology Development Program
Source: SO RIS own elaboration

The identified values have become the basis for discussions with experts and entrepreneurs as part of the ongoing EDP to formulate the Program's objective:

Identification of the region's potential to strengthen its technological advantage

and operational objectives:

Operational objective 1 A unique resource of knowledge and skills
Operations:
1.1. The development of a unique research infrastructure for the development of knowledge economy
1.2. Intensification of participation in the global R&D network
1.3. Diffusion of knowledge and technology in industry and services
The result: application of new technologies / solutions in industry and services

Operational objective 2 Open cooperation
Operations:
2.1. The development of specialized cooperation and knowledge exchange networks
2.2. Professionalization of BSI services
The result: increased business interactions for the development of technology

Operational objective 3 Flexible strategic orientation
Operations:
3.1. Identification of challenges, needs and areas of technology application
3.2. Feedback and interaction with the business sector

3.3. Public support mechanisms
3.4 Actions for the internationalization and promotion of technologies
The result: an effective system of support and monitoring the needs of enterprises

The group of objectives formulated in this way (main and detailed) of the updated Program is, on the one hand, a continuation of the objective adopted in TDP 2010 - 2020, on the other, it corresponds to the changing conditions related to the dynamic process of innovation ecosystem formation and implementation of intelligent development of the Silesian Voivodeship. This objective also refers to the industrial character of the Silesian Voivodship, where the technological potential, including research and development facilities and the presence of enterprises investing and developing modern technologies is a key source of advantages. The transformation of the region from the group of highly energy intensive regions based on traditional industries (e.g. mining, metallurgy, etc.) into regions where modern, smart technologies are being developed, which respond to new emerging, is not without significance. Civilization challenges, including Industry 4.0, a circular economy or the implementation of activities for a smarter Europe. Technologies generation and implementation in the region find a demand not only on local markets but also at home and abroad, which confirms a gradual increase in the internationalization of entrepreneurial activities, including their share in global value chains and the export and import of technological solutions. Thus, the updated Technology Development Program is to contribute to:

- implementation of a continuous process of identifying the needs of entrepreneurs and the sphere of science based on the mechanisms of the Entrepreneurial Discovery Process and analysing the directions of development of the global and national economy,
- setting new directions for the development of the potential of the region, including the directions of education and supporting key research infrastructure,
- adaptation of personnel education system to the needs of dynamically changing labour market demand,
- defining the criteria for the selection of innovative projects in the current and future financial perspective,
- development of new instruments for supporting entrepreneurs, including those based on returnable financing mechanisms,
- increasing the share of entrepreneurs in global value chains by supporting international cooperation and positioning regional brands on foreign markets,
- implementation of the social pillar for the development of technologies in the Silesian Voivodeship.

Implementation of the Technology Development Program of the Silesian Voivodeship 2020+ and its results in the form of:

- updated areas of technology applications,
- new innovative technological directions,
- indication of directions requiring further research,
- formulating guidelines for the regional development plan,
- recommendations regarding system and operational changes for the innovation ecosystem,

are a starting point for popularizing the Entrepreneurial Discovery Process and intensifying the dialogue between actors of the regional innovation ecosystem for smart development and economic transformation of the Silesian Voivodeship.

3.2 Evaluation of technological groups and strategic orientations

The work of expert teams focused on SO RIS during the implementation of the project and conducted according to the methodology designed in the TDP document for 2010-2020, works connected with the evaluation of the technological potential of the Silesian Voivodeship, allowed to carry the positioning of technologies and technology groups of the Silesian Voivodeship in relation to strategic initiatives that define the policy of supporting their development[57]. Strategic orientations have been collected in the matrix below.

Table 4 Evaluation of technological groups and strategic orientations

Exogenous	**(IV) Technological acquisition for excellence** ▪ Generation of energy from renewable sources and improvement of the efficiency of obtaining energy from RES ▪ Water and wastewater technologies ▪ Information security ▪ Ceramic materials ▪ Design and manufacturing technologies in the aerospace industry	**(III) Technological acquisition for diversification** ▪ Fuel cell manufacturing technologies ▪ Prosumer energy ▪ Energy storage technologies ▪ Biotechnologies in environmental protection ▪ Waste management technologies ▪ Air protection Technologies ▪ Environmental management technologies ▪ Telecommunication technologies ▪ Polymer materials ▪ Nano-optics
Endogenous	**(II) Leadership through excellence** ▪ Nanomaterials and composites ▪ Nanoelectronics ▪ Nanophotonics ▪ Nanobiotechnology ▪ Nanomedicine ▪ Nanomagnetism ▪ Filtration and membranes ▪ Tools or devices at the nanoscale ▪ Catalysis ▪ Modelling and simulation software ▪ Information technologies ▪ Optoelectronics	**(I) Leadership through diversification** ▪ Biotechnologies for medicine ▪ Medical engineering technologies ▪ Intelligent networks and interconnections technologies ▪ Intelligent and energy-saving construction ▪ The quality of degraded areas improvement technologies ▪ Geoinformation and its application ▪ Modelling and simulation of processes and phenomena ▪ Telecommunication and information technologies supporting industry 4.0 ▪ High-efficiency energy technologies ▪ Energy generation technologies from waste and alternative fuels ▪ Metallic materials
	Island	**Nodal**

Source: Own elaboration of Specialized Observatories

[57] Klasik A., Kuźnik F.et al, *Rekomendacje strategiczne do polityki rozwoju technologicznego województwa śląskiego* Katowice University of Economics, Katowice, March 2008

Strategic initiatives arising from the strategic orientations defined for particular groups of technologies in the area of supporting the development of key technologies of the Silesian Voivodeship indicate:

- **Technology groups in the orientation of "Leadership through diversification",** due to technologies characterized simultaneously by a high level of interdependence with other key technologies of the region and usefulness for building a new technological position of the region on the external markets. In their case, there appears a strong need for conversion of solutions generated in the existing R&D sector in the Silesian Voivodeship. This means the necessity of generating connections between R&D sphere and entrepreneurs through, among others, supporting the development of centres, laboratories, research and development parks of a high quality, where it may be possible to conduct research in interdisciplinary teams of specialists in cooperation with enterprise sector, further development of cluster initiatives, scientific and industrial consortia, and support for the formation of the spin-off companies (i.e. *spin-off, spin-out*), initiating and supporting patent, seed and grant funds, support for the practical implementation of technology transfer tools.
- **Technology groups in the orientation of "Leadership through excellence",** due to technologies characterized simultaneously by a low level of interdependence with other key technologies of the region and a high level of usefulness for building a new technological position of the region on the global markets. For this group, the key activities are related with strengthening creative capital in the region and creating and promoting advanced high-risk technologies, launching networking mechanism in the systems of personnel education, creating a widely available for entrepreneurs' infrastructural facilities.
- **Technology groups in the orientation of "Technological acquisition for diversification",** due to technologies characterized simultaneously by a high level of interdependence with other key technologies of the region and an increasing pressure on their use to improve the growth of attractiveness of innovative products in the region. Acquisition of the medium-term technology used for the regional needs in order to increase the attractiveness of the Silesian Voivodeship is carried out in this group. In this case, activities focus on the support of the purchase of apparatus and equipment, incentives for investors, internationalization and promotion on foreign markets.
- **Technology groups in the orientation of "Technological acquisition for excellence",** due to technologies characterized simultaneously by a low level of interdependence with other key technologies of the region and a high increasing pressure on their use to improve the growth of attractiveness of innovative products in the region. It includes technologies, for which it is necessary to strengthen creative capital in the voivodeship and to raise the investment attractiveness for current and future entrepreneurs.

The abovementioned four strategic orientations are the starting point for carrying out strategic decisions in relation to identified groups in the evaluation of technology included in the matrix.

3.3 Scope of technological areas

The diagnostics works and prospective studies carried out in the project SO RIS in EDP, supplemented with opinions from industry experts on the updating of the technological areas, have demonstrated a reasonable division of maintaining the current technological areas, while the names of some technological areas have changed as well as their internal structure of technology and technology groups. The changes are the result of the diagnosis for technological areas carried out by SO RIS, the

synthetic results of which were presented in the first part of the document. The purpose of the changes was the updating of existing knowledge about innovative technologies in the region and adjusting it to the changed conditions arising from the environment. Additionally, in the course of analytical work, experts pointed out the necessity to distinguish a new technological area that is **"Technologies for the raw materials industry".** The distinguishing of this technological area is related above all to the identified strong scientific-research and economic potential of the Silesian Voivodeship. This region is the centre of the traditional industry based on natural raw materials due to occurring there resources of hard coal, zinc and lead deposits, iron ore, deposits of methane, natural gas, limestone and natural aggregate, as well as mineral, healing and thermal water deposits[58]. For years, these resources have influenced the dynamic development of dedicated and innovative technologies connected with the extraction, processing, effective use of deposits and utilization of waste generated, which arise in the strong scientific-research centres in the region. In the area of natural resources management, there are many enterprises, of which the employers are the significant part for thousands of residents of the Silesian Voivodeship. Technologies for the raw material industry occurring in the Silesian Voivodeship are recognizable not only in the country, but also abroad and are one of the key export products of the region. It is worth paying attention to the fact, that the re-industrialization of the economy, which is now one of the trends in the global economy and the region transformation connected with the reduction of energy consumption, will be the driving force of technological development related to raw materials sourcing and their effective use and management of generated waste, which will affect the development of power and environmental protection technology as well as machine industry[59]. The distinguishing this technological area corresponds with the existing National Intelligent Specializations, especially KIS 7. *Modern sourcing, processing and use of natural resources technologies as well as manufacturing their substitutes[60] and the policy of economic development of the Silesian Voivodeship. Strengthening the role of the Silesian Voivodeship economy in international value chains* [61]. The new technological area includes, among others, such technology groups as: recognition, extraction and protection of raw materials technologies, processing technologies and use of natural resources, raw materials recovery technologies, or underground storage of CO2 technologies. The detailed scope of the technological area "Technologies for the raw materials industry" should be an element of further work within the framework of evaluation studies or the gathering of a dedicated Specialist Observatory.

During the discussion with experts, there appeared the issue of extending the scope of the technological area "Transport and transport infrastructure" to incorporate logistics, which is currently a greatly developing element of the region's economic and scientific potential. Logistics activities are significant for the industry and trade, in particular in the ecommerce sector[62]. The Silesian Voivodeship is the second warehouse market in Poland[63], and the central geographical location with high availability of industrial lands, and modern road infrastructure (A1 and A4

[58] Szuflicki M., Malon A., Tymiński M. (red.), Bilans zasobów złóż kopalin w Polsce wg stanu na 31 XII 2017r., Państwowy Instytut Geologiczny Państwowy Instytut Badawczy, Warsaw 2018 (annually updated publication).

[59] Raw Material National Policy – project, Ministry of Environment Protection, http://psp.mos.gov.pl/images/pdf/politykasurowcowapanstwa.pdf, 29.09.2018

[60] http://www.miir.gov.pl/media/48960/opis.pdf, 29.09.2018

[61] https://archiwum-bip.slaskie.pl/dokumenty/2017/02/07/1486459606.pdf, 29.09.2018

[62] Ibid.

[63] Poland MARKET INSIGHTS Annual Report 2018, http://docs.colliers.pl/reports/Colliers_Raport-Market-Insights-2018.pdf, 29.08.2018

motorways, expressways, ring roads, etc.) and existing and built transhipment terminals with access to almost all branches of transport are the region's competitive advantage. In the region there are cooperation networks such as: Southern Railway Cluster; Silesian Urban Transport Cluster; Silesian Logistics Cluster as well as the Silesian Logistics Centre CO. and Euroterminal Sławków, which is located farthest to the west section connecting the sections of wide and narrow gauge railway lines. There are also logistics operators who, along with standard solutions and technologies, offer specialized logistics services that require modern technologies. Logistics and transport development is strictly connected with information and telecommunication technologies development, and the machine industry, and in this respect it may be a source of competitive advantages due to the relevance of logistics processes in global value chains. Field experts suggested the introduction of the following names for the technological area **"Logistics and transport"** and pointed out technology[64] groups:

- Technologies for freight transport, including intermodal transport
- Technologies for passenger transport
- Information technologies for logistics and transport
- Warehouse technologies

During analytical and diagnostic works, SO RIS experts also concluded that the technological area pointed out in the TDP for 2010-2020, i.e. "Machine, car, aviation and mining industries" was introduced very broadly, which restrained clear recognition of technologies characterized by actual innovative potential, and thus impeding the programming of their development for the 2020 perspective. In connection with the above, special attention was paid to the need of distinguishing the new technological area **"Aviation technologies and aerospace industry**", which is justified by the high innovative potential of solutions arising in this area, and the similarities occurring in technologies that may have common application in the aviation as well as aerospace sector. The recognition of the technological area " Aviation technologies and aerospace industry" is a result of the observation of economic phenomena and technological trends, which is connected with the development of aircraft and aerospace manufacturing technologies, which on the one hand are based on the rich traditions of the aviation industry in the region (especially the production of light aircraft) functioning on the Podbeskidzie region, and on the other hand, they are able to make use of the opportunities offered by the openness of global markets and multi-level cooperation in terms of geographic as well as technological aspects. There are business cooperation networks in the region, which advance research and development cooperation with crucial scientific units of the region in terms of development of modern materials for aviation, construction of light aircraft and unmanned platforms. The recognition of the new technological area also corresponds to the appearing of a new era in the development of the aerospace industry - the so-called "Space 4.0", which is mainly identified with the aerospace commercialization and the appearing of new actors in the aerospace sector, i.e. independent and private enterprises that generate a new type of personalized products and services based on satellite data obtained thanks to the technology of miniaturization of satellites. The new era of the development of the space industry is a special chance for companies in the region to appear in the aerospace market and use the established market niches. In this aspect,

[64] Expert opinions prepared by industry experts involved in the project.

what is in particular important is the interdependence of aviation technologies and the space industry with regional ICT technologies, which will undoubtedly contribute to gain an additional competitive advantage of the region. Not meaningless for the recognition of the new technological area is the necessity to combine the regional Technology Development Program with national and international plans in this respect - first of all, Poland's accession to the European Space Agency (ESA)[65] and the adoption in 2017 of the Polish Space Strategy, which includes the time horizon for 2017-2030.

Taking into account the relationship between aviation and aerospace technologies as well as the specificity and character of entities functioning in the region, within area of "Aviation technologies and space industry", the following technology groups have been determined:

- Design and manufacturing technologies in the aerospace industry
- Technologies related to avionics of aircraft and space
- Technologies of aerial and satellite imaging of the Earth and related services.

The common features of manufacturing in the aerospace industry are design methods and methods of numerical analysis, requirements of manufactured elements, acceptable manufacturing methods, surface engineering methods and the use of modern materials, non-destructive testing methods and requirements for special processes. In the context of avionics, the convergence of the aviation sector is no longer so unambiguous, because the differences arise from the purpose of these objects and their work environment. There are a lot of similarities though, because precise position control systems based on satellite data are always necessary. The similarities also cover used languages and programming procedures, the necessity to use real-time systems[66], etc. A separate identified group are services built on the basis of parallel developing Earth imaging technologies, both at the aerial level (airplanes and unmanned aerial vehicles) as well as space (satellites) as well as navigation and satellite communications. Services based on these technologies are now applied in practically all aspects of economic life, and barriers to enter this market for Polish entities are significantly lower than in traditional technologies. In this group of aviation technology and satellite imaging of the Earth and related services, entities functioning in the Silesian Voivodeship in competition with other domestic enterprises may use their strengths in the form of, among others, developed ICT, electronics, automation and robotics.

Finally, the new shape of the technological areas suggested in the update of the Technology Development Program involves:

- Technologies for medicine,

[65] At the time of Poland's accession to ESA, there were less than 50 Polish entities (mainly scientific institutions) interested in ECO. tenders on the Agency's dedicated website. Currently, it is over 300 entities, and most of them are SMEs - including those from Silesian Voivodeship (source: *Polish Space Strategy*, Warsaw, February 2017).

[66] Wachowicz M.E. (edit) *Polski Sektor kosmiczny, Struktura podmiotowa, możliwości rozwoju, pozyskiwanie środków,* Polish Space Agency, Warsaw 2017, 58 -64

- Technologies for the power industry,
- Technologies for environmental protection,
- Information and telecommunications technologies,
- Production and processing of materials,
- Logistics and transport,
- Machine and automobile industry,
- Aviation technologies and the space industry,
- Nanomaterials and nanotechnologies,
- Technologies for the raw materials industry.

Specified on the basis of diagnosis and panels as well as expert opinions, the technological groups in individual technological areas are presented as included in the table below.

Table 5 Areas and technology groups

Technological area: **TECHNOLOGIES FOR MEDICINE**	
1.1	Biotechnologies for medicine
1.2	Medical engineering Technologies
Technological area: **TECHNOLOGIES FOR POWER ENGINEERING**	
2.1	High-efficiency power technologies
2.2	Fuel cell manufacturing technologies
2.3	Generation of power from renewable sources and improvement of the efficiency of obtaining energy from RES
2.4	Prosumer energy
2.5	Technologies of intelligent networks and interconnections
2.6	Power/Energy storage technologies
2.7	Technologies of power production from waste and alternative fuels
2.8	Intelligent and power-saving construction
Technological area: **TECHNOLOGIES FOR ENVIRONMENT PROTECTION**	
3.1	Biotechnologies in environmental protection
3.2	Technologies to improve the quality of degraded areas
3.3	Waste management technologies
3.4	Water and wastewater technologies
3.5	Air protection technologies
3.6	Environmental management technologies
Technological area: **INFORMATION AND TELECOMMUNICATION TECHNOLOGIES**	
4.1	Telecommunications technologies
4.2	Information technologies
4.3	Geoinformation and its application
4.4	Modelling and simulations of processes and phenomena
4.5	Optoelectronics

4.6	Information security
4.7	Telecommunications and information technologies supporting Industry 4.0
Technological area: **PRODUCTION AND PROCESSING OF MATERIALS**	
5.1	Metallic materials
5.2	Polymer materials
5.3	Ceramic materials
Technological area: **LOGISTICS AND TRANSPORT**	
6.1	Technologies for freight transport, including intermodal transport
6.2	Technologies for passenger transport
6.3	Information technologies for logistics and transport
6.4	Warehouse technologies
Technological area: **MACHINE AND MOTORIZED INDUSTRY**	
7.1	Industrial automation, automated production lines
7.2	Sensors and robots
7.3	Design and manufacturing technologies in the automotive industry
7.4	Technologies for designing and manufacturing machine tools and workshop aids
7.5	Design and manufacturing technologies for power transmission, machinery and special equipment
7.6	Defence and arms industry
Technological area: **NANOMATERIALS AND NANOTECHNOLOGY**	
8.1	Nanomaterials and composites
8.2	Nanoelectronics
8.3	Nanooptics
8.4	Nanophotonics
8.5	Nanobiotechnology
8.6	Nanomedicine
8.7	Nanomagnetism
8.8	Filtration and membranes
8.9	Tools or devices at the nanoscale
8.10	Catalysis
8.11	Modelling and simulation software
Technological area: **AVIATION TECHNOLOGY AND SPACE INDUSTRY**	
9.1	Design and manufacturing technologies in the aerospace industry
9.2	Technologies related to aircraft and space avionics
9.3	Aerial and satellite Earth imaging technologies and related services
Technological area: **TECHNOLOGIES FOR RAW MATERIAL INDUSTRY**	
10.1	Technologies for the recognition, acquisition and protection of raw materials
10.2	Technologies of processing and use of natural resources
10.3	Raw material recovery technologies
10.4	Technologies for underground CO2 storage
10.5	Design and production technologies of mining and power machinery and equipment

Source: Own elaboration of Specialist Observatories

4. Recommendations

The program recommendations determined in the TDP for 2010-2020 document had the impact on the generation of permanent connections in the chain- the region - the entrepreneurs - the science and research sector - business support institutions and in a consequence the innovation ecosystem development.

However, global trends related with, among others, economy digitalization, energy-saving and resource-efficient management as well as dynamically changing business models on the globalized markets, causes the change in the revision of existing strategic arrangements and the formulation of new recommendations for the development of system support technology in the Silesian Voivodeship.

When determining the TDP program recommendations, the results of Entrepreneurial Discovery Process conducted by Specialized Observatories were taken into account, in particular:

1) Diagnosis of the condition, in-depth examination of the needs of innovations systems actors (entrepreneurs, scientific units)
2) Cataloguing of the R&D and BSI offers,
3) Review of strategic arrangements included in the level of international, national and regional documents,
4) Prospective studies with the cooperation of industry experts.

Created on this basis recommendations should provide coordinated and supportive measures for the development of technological predominance in the Silesian Voivodeship.

Continuing the TDP's taken plans for 2010-2020 towards building "innovation business effective environment", the TDP update in the perspective of 2020 is concentrated on improving the cooperation efficiency within existing networks in the region in the field of strengthening the region's technological predominance. The crucial is also the improvement of competence and awareness and culture of innovations of the innovation ecosystem actors.

The realization of the recommendation is to professionalize efforts to create secure and lasting foundations for prosperity and the quality of life in the region with the wide involvement of communities and local resources.

Support system should, in optics, have the whole value creation chain starting with basic examination on products development and ending on business.

Monitoring and evaluation of the TDP in the 2020 perspective is an important element of regional innovations system for targeted and directional development of the most prospective technological areas of the region.

Considering the above, the recommendations have been formulated that focused on the three main areas:

- technological predominance,
- the entrepreneurial discovery process,
- system solutions.

4.1 Technological advantage

Context

Obtaining a permanent technological predominance in the face of progressing changes and quickly changing rules of competitive battle is a great challenge nowadays. The conception of a permanent technological predominance loses its significance, and the reaction for the fundamental changes is the temporary approach, which does not include building a competition predominance[67].
Silesian Voivodeship, according to the *Innovation Scoreboard*, has been positioned in the group of moderate innovators (with a negative tendency). In particular, i.e. low values, below 0,2 have been adopted by the indicators[68] describing:

- business sector expenses on research and development,
- product or process innovators,
- marketing or organizational innovators,
- SMEs introducing innovations on their own,
- Innovative SMEs cooperating with others,
- Public- private co-publications,
- EPO patent conclusions,

Non-limited resources and skills are a crucial element of building a technological predominance in the era of aggressive competition, and their protection against copying has become a condition for maintaining a competitive position.
Innovation policy of the Silesian Voivodeship plays a crucial role, because it is the engine of changes, catalysing, modelling and improving processes of technology development, particularly in terms of the improvement of the quality of life in the voivodeship. TDP, elaborated together by SO RIS with the participation of representative of industry, science and administration, identifies 10 mostly important technological predominance areas for the region, as part of which key technologies determined as a contribution to the growth of region's innovativeness due to favourable environment and initiatives resulting from business, science and society, with the possible support of public institutions. The prospective technological areas for the Silesian Voivodeship are part of the global challenges connected with sustainable development, perspective technological trends[69] indicate as well the thematic convergence with KET[70]:

I. Production technologies:

1) Advanced production technologies
2) Advanced materials and nanotechnology
3) Technologies in the field of life sciences - interdisciplinary areas that combine biological, biochemical and medical sciences

[67] Sołoducho-Pelc L., *Competitive Advantage –key research trends*, Scientific Works of the Wrocław University of Economics, No. 444, 2016

[68] *Regional Innovation Scoreboard 2017* - Database

[69] *The future of industry in Europe*, European Union, 2017

[70] *Re-Finding Industry. Defining Innovation Report of the independent High Level Group on industrial technologies, European Commission, Directorate-General for Research and Innovation, Key Enabling Technologies, 2018*

II. Digital technologies

1) Micro-nanoelectronics and photonics

2) Artificial intelligence

III. Cybernetic technologies

1) Security and connectivity.

As a result of the diagnosis carried out in the entrepreneurial discovery process, barriers and needs have been determined in key areas affecting the current state of technological development of the voivodeship and its competitive position on the national and international arena.

In the TDP optics in the perspective of 2020, it is especially important to activate entrepreneurship in the scientific community, creativity in the enterprise sector, strengthen cooperation and stimulate private investments for research and innovations.

Recommendations:

1) Developing competences and specialist knowledge

In the region, the most frequent innovation activity is implemented in the easiest way, i.e. through the purchase of machinery, equipment, software. One of the causes are restrictions in the availability of qualified human capital. However, human capital in the form of knowledge, competence and skills is the accelerator of the development of innovation activity.

The development of knowledge and its direction may be the fundament for the creation of innovations in the region. Universities and other research institutions according to the Act of 20 July 2018 Law on Higher Education and Science[71] (Act 2.0) are to make a key contribution to the innovation of the country's economy, whereas public authorities are oblige to create optimal conditions for freedom of scientific research. Consequently, multiplication of specialist knowledge and competences should be carried out in a multi-directional manner, as well as in terms of conditions, method and subject.

It is necessary to continue activities in the field professional personnel development, and the priorities in the perspective of 2020 should be the development of specialist knowledge, development of key competence in the field of mobility, creativity, entrepreneurship and improvement of educational programs at both the secondary and higher level.

a. The development of unique specialist knowledge

The constant creation and extension of pioneer scientific achievements is the basis for creating innovative processes and participation in international cooperation networks.

Providing talented expert teams with attractive conditions is the opportunity for the development in the promising science fields and reduces the risk of outflow of highly qualified research staff. Activities should include both the development of scientific research (basic and application) as well as development works, in the fields related to the identified predominance[72] areas, in particular: natural, engineering-technical, medical and health sciences as well as agricultural sciences.

[71] Act of 20 July 2018 Law on higher education and science (Journal of Laws 2018 item 1668, as amended)

[72] According to the list of fields of science and techniques classification determined by the OECD

What is particularly crucial for the region's innovation growth are application research, which aim at gaining new knowledge oriented towards new products, processes, services as well as development works in the field of development and integration of technologies.

b. Multiplying the skills of using intangible resources (knowledge and intellectual capital)

The implementation and management of a new product does not require any specific competences and skills. The development of skills in the field of entrepreneurship and innovativeness in the scientific units is favourable to increase business contacts with industry.
The key factor in building a competitive predominance in the area of innovation is the protection of unique intellectual property, on the basis of which it is possible to develop intellectual capital and compete on the international area. For the sake of minimizing the risk of taking over innovations by the competitors, it is necessary to provide information security which have economic value. Both, scientific units and the entrepreneurs must take actions consciously to keep their confidentiality. Both formal and informal instruments of intellectual property protection should be implemented, for the sake of prevention. It is important to build the consciousness and strategy to protect intellectual property at every stage of its implementation and commercialization.
On the other hand, the development of entrepreneurship of scientific teams should focus on increasing the involvement in the market process of knowledge commercialization both in the form of business scientists' activity as well as scientific unit orientation towards entrepreneurship and economic results related with the commercialization of solutions. The obligatory condition connected with the growth of entrepreneurship of scientific units are:

- managerial competences in scientific teams for the sake of orientation of research and scientific papers works towards commercial applications,
- active mobility of scientific teams serving effective economic contacts and closer cooperation.

c. Diffusion of knowledge:

An important role the shaping the ecosystem of innovative entrepreneurship plays an education, which provides the foundations and shapes the competences for the development of new solutions.
The participation of enterprises in the process of education yet from its lowest levels enables to adjust education programs to the needs of the market.
It is also significant to implement proprietary curricula in key for the region areas of knowledge to build intellectual capital and to develop the professional personnel necessary in the processes of commercialization of knowledge as intermediary in the transfer of intellectual properties (technology), so called technology broker or its management (manager).

2) Developing of the R&D **unique infrastructure**

Building strong and lasting connections with enterprises and carrying out research projects at the global level requires continuous professionalization of scientific units offers and the development of the research infrastructure. Modern infrastructure is the obligatory condition for undertaking innovative solutions and research important for the region's technological areas. The development of R&D infrastructure should correspond to the demands of particular

technological areas and be at the global level. Along with the development of the unique R&D infrastructure, the possible access of it should be also provided it should also be provided the, thanks to which its potential may be increased in the field of scientific progress support (use in a different context/area, research stimulations) and its positioning on the European map of open education.

3) Building and developing technological regional brands

The brand is a marketing category contributing to the creation of a good image of the product, and, what follows- to the growth of its popularity. A strong and recognizable brand is a determinant of reputation and authority.[73]

The value of export from the Silesian Voivodeship is about 8 % of the total value of Polish export, while the value of intra-community supplies from the Silesian Voivodeship is 14% of the value of Poland's intra-community supplies. Net income from sales of new products or significantly improved products abroad in the industrial enterprises in the Silesian Voivodeship by the end of 2016 were 6,8 % of net incomes from total sales.[74]

Increasing the activity of companies on international markets and taking advantage of the investment attractiveness is an important support area for the enterprises and was indicated in the Silesian Voivodeship Development Strategy "The Silesian 2020+" (Operational objective: D.1. Cooperation with partners in the environment). The progressing globalization of markets and conditions related to the economic growth generates greater cooperation and international exchange. The presence of international corporations in Poland, including the Silesian Voivodeship is an opportunity to access new customers and their technologies as well as cooperation by local suppliers and companies offering specialized products, services.

Additionally, according to the analyses of the group of 1000 innovator on a global scale, it is assumed that in the coming years, the process of transition from incremental innovations to breakthrough innovations to stimulate the economic[75] growth will take place in transnational companies.
The issue of international cooperation and internationalization of the economy of the region on the eve of the next industrial revolution is consequently an important element of the new perspective in the development of innovation and should be a key component of the support system for the creation of new solutions.
Intensification should include activities related to the entry of regional enterprises of advanced technologies into foreign markets and building alliances for the sake of the development of technology.

4) Professionalization of public services

The progressive change of the proportion in the structure of goods created in favour of service activities and the penetration of information and communication technologies into even bigger

[73] https://slaskie.trade.gov.pl/pl/marka-regionalna/252689,marka-slaskie-konkurs-promocji-wojewodztwa-slaskiego.html
[74] Regional Operational Program for the Silesian Voivodeship for the years 2014-2020 - second version, adopted by the Voivodship Board on August 16, 2018, by virtue of Resolution No. 1878/278 / V / 2018
[75] Annual Research „Global Innovation 1000" (source: https://www.strategyand.pwc.com/innovation1000)

social-economic areas of life are an impulse for the generation of new solutions and directing science and industry projects towards social needs that build the future balanced welfare of the voivodeship.

Complex Urban structures, progressing metropolisations processes and the more broadly promoted and implemented concept of smart urban and local economy (smart city) are the essential factors of accelerating the metropolisation and technological development of public services in the Silesian Voivodeship to overcome issues, among others, environmental, infrastructural, logistics.

The Upper Silesian Metropolitan Area is a space requiring the implementation of bold future solutions that open development opportunities in the perspective of generations taking into account radical changes in the region's[76] economy.

The implementation should cover the fields of metropolitan services: transport, health, cultural and environmental in the areas of application: systems, equipment and management.[77]

5) Rational resource management

The current economic development based on linear model and the mass acquisition of goods and services not related directly to the demands has consequences in the form of irreversible changes in the natural ecosystems and the depletion of natural resources that constitute the foundations of the economy development.

The demand to minimize the impact on the environment of created goods and service is a global challenge and priority direction for the united Europe activities for the future.[78]
In accordance with the circular economy, the value of products should be kept as long as it is possible, and the amount of waste is limited to a minimum, as well as the use of resources. Waste products, materials constitute resources for re-use and creating additional value.
The implementation the circular economy concept requires integration of various technological areas (industry sector) and creating industrial symbiosis with the participation of public authorities and the involvement of civil society. The thematic areas especially relevant for the new economic model are:

- catalysis for eliminating pollution and transforming carbon dioxide,
- industrial biotechnology,
- balanced processing industry,
- waste and resources management,
- production systems,
- water,
- bioeconomy.[79]

[76] *Technological Foresight on the development of the Public Service Sector in the Upper Silesian Metropolitan Area – Summary Report from realization of task IV, Strategic Recommendations, Main Mining Institute*, 2011

[77] Ibidem

[78] http://ec.europa.eu/environment/circular-economy/index_en.htm

[79] *Circular economy research and innovation - Connecting economic & environmental gains*, European Union, 2017

The support systems for technological areas should take into account the questions of the development of a new economic model and develop interdisciplinary new and pre-environmental technologies.

6) Providing security and system stability

The progressing digitalization causing the technological revolution (industry 4.0) make it possible to establish economy that introduces new economic models and solutions, for example, personalized products, the common use of paid sharing, intelligent devices supported by artificial intelligence.[80]
Implemented technological, business, social innovations need to be controlled and it is necessary to generate mechanisms in order to the regulations could follow changes and the innovations could develop legally and were not the source of overuse.
Providing cybersecurity, understood as technological and strategic challenge is a significant challenge in the economy 4.0. The changing digital reality influences the functioning of the economy and national security state. Important are therefore coordinated and complex activities for the sake of the public cybersecurity and public services system.

[80] Global trends 2030, National Intelligence Council, 2012,

Method of realization of recommendations

- International research projects in key region's areas of knowledge
- Launching the processes of commercialization in scientific entities
- Pro-market educational programmes
- Implementation of strategic instruments of intellectual protection
- Development of competence centres
- Marketization of the offer of R&D sector
- Effective support mechanisms
- Support and promotion of projects of navel nature (flagship) and support for enterprises in their image actions
- Development of the network structures and partnerships towards technological strengthening of the metropolisation and technological development of public services and security systems

Effects

- Development of intellectual capital
- Strengthening the pro-market orientation of scientific communities
- Increased knowledge transfer and transfer of innovative technological solutions
- Recognition country and worldwide of products and services
- Increase of internationalization of enterprises with innovative products, services and technologies
- Increases of the number of enterprises carrying out expert activities on extra-EU markets
- Technological development of public services in the region, high level of cooperation
- Improvement of the quality of life of region’s inhabitants
- Strengthening a positive image of regional economy

4.2 The Entrepreneurial Discovery Process

Context

The entrepreneurial discovery process is a set of actions of permanent nature for identification of regional advantages, including those of technological nature. It was initiated in the Silesian Voivodeship through realization of venture called "Priority technologies towards sustainable development of the Silesian Voivodeship", which became the basis for elaborating TDP for 2010-2020. Within TDP for 2010-2020 for the realization of the entrepreneurial discovery process, instruments allowing to implement, among others, technological-innovation audit have been elaborated, whilst the created in the region The Network of Regional Specialized Observatories constitutes an institutional support for its continuation. The key components of the ecosystem of innovations are the entrepreneurs and representatives of scientific institutions as well as business support institutions, whilst their needs shape the regional policy for support of research, development and innovation.

Applying the bottom-up approach enables targeting the system of support of the real needs (actions and initiatives) leading to the intellectual and sustainable region's growth, where the main premise is the development of endogenous regional resources and effective engagement of the private sector within research and innovation. At present the entrepreneurial discovery process constitute a component of the process of indicating smart specializations which are the fields that distinguish a given region on the local and international markets. Its continuation and professionalization are a natural necessity in a situation of a dynamically changing social, political, environmental and economic conditions while integration of the gathered information will allow for a fast and effective undertaking of decisions of strategic nature. Thus, the key actions which ought to be taken in the nearest future are targeted at continuing the progress of local integration and supra-regional database systems, ensuring validity of information contained there and development of the previous ones as well as improving new instruments of identification and evaluation of the areas of advantage.

Recommendations:

1. **Integration of the dispersed and non-structured data on technological areas**

Data obtained by SO RIS, related to the world trends, latest research and innovative implementations and concerning local stakeholders of the ecosystem of innovation constitute at present a dispersed set of precious information which play a significant role in the entrepreneurial discovery process in the region and implementation of the policy called *evidence-based policy*. In addition, the integration of specialist data on projects, offer of scientific and research entities and business support institutions as well as needs of entrepreneurs may be used as a source of new ideas and concepts for the market products and technologies the realization of which will be possible upon the use of regional resources and cooperation of different entities. Therefore, expanding the already functioning portal INNOBSERVATOR SILESIA by subsequent functionalities and its integration with the functioning databases which are used for realization of tasks stemming from the understanding is necessary. Such a solution meets the requirements of new challenges in the scope of digitalization

and computerisation of science and economy, decreasing the barriers in cooperation between the science-research environment and business, as well as offering a higher efficiency of marketing-promotional actions targeted at promotion of undertaking actions under individual technological areas and at the verge of them.

2. Ensuring a mechanism of providing detailed statistical data

Public statistics continues to constitute a significant source of information on technological areas in the Silesian Voivodeship, despite a number of limitations related to its availability and the level of detail of data. Hindered access to data, among others due to high costs, for the Observers at the level of sections and classes according to NACE Rev. 2 classification makes the realized by them statutory obligation of monitoring the trends and identifying the leading technological directions incomplete. Launching a free mechanism of provision of non-public data by GUS for the purposes of SO RIS constitutes a desired action which would equip the Network in a tool that initiates a thorough discussion on the perspective directions of technological growth of the region. Statistical information combined with the opinions of experts may be the source of recommendations in the scope of directing the streams of funds towards the key ventures in the region.

3. Intensifying and increasing the quality of process of researching needs

Initiated in TDP for 2010-2020 process of identifying needs, which was a technological-innovation audit evaluated and transformed into the research of needs, covering both entrepreneurs and entities from R&D sector. The research of needs is the main instrument of realization of the Entrepreneurial Discovery Process as well as of obtaining reliable information on the effectiveness of the implemented solutions in the scope of support of innovation. Intensity of the process of researching needs is however diverse and requires a constant improvement of competencies by the Observer who carries it out. The development of the process of researching needs and its promotion, supported by an increase of competencies of personnel of the observers and the mechanism of promotion would allow to obtain, in constant time intervals the supplementary but very important for the decision process information towards the regular evaluation and evaluation of TDP and RIS. The service of researching needs would also impact the development of dedicated services of support of commercial nature.

4. Update of offer of scientific units

The changing needs of entrepreneurs in individual technological areas could be on multiple occasions fulfilled by research resources made available in the region as well as by the regional scientific personnel. Entrepreneurs, especially from SMEs sector, cannot be fully engaged in the time-consuming processing of searching for a dispersed offer of R&D entities and they decide to select random solutions quite often, including also reaching for the R&D potential from outside of the region on a frequent basis. Coherent and available in one place offer regarding the ongoing and completed research projects, offered infrastructure and services, constitute a significant facilitation of the access to professional R&D services. Information in this regard ought to be updated and supplemented on an ongoing basis by SO RIS on the websites of INNOBSERVATOR SILESIA. Strengthening competencies of personnel of the Observers and research and development entities with the knowledge in the scope of managing technology and negotiation skills would also increase the chances for a permanent inventory of R&D offer in the region and reaching a wider group of recipients with dedicated solutions, tightening the bonds between the stakeholders within the ecosystem of innovation.

5. Developing the methods of identification and evaluation of the areas of technological advantages

Experience stemming from the carried out the Entrepreneurial Discovery Process in the Silesian Voivodeship proves that efficiency of the process of identification and evaluation of the areas of technological advantages depends on a wide use of different methods and tools. Those which ensure direct engagement of stakeholders from different technological areas or researching of needs, researches with the use of smart lab, interviews, forecasts and foresight methods are of particular importance here. Further continuation and intensification of the entrepreneurial discovery process requires not only developing and professionalization of the already available solutions, but also creating new ones which might constitute an element of commercial services provided by the Observer, such as: interview and technological consulting, technological scouting, elaboration of business models, identification of value chains etc. Apart from the dedicated solution, panels of smart specialization may be created in the region, which would engage the representatives of different technological areas in discussion on identification and update of smart specializations.

Method of realization of recommendations:

- Conceptual elaboration and expansion of INNOBSERVATOR SILESIA portal - adjusting the new functionalities and integration with the current activity of the observers
- Elaboration of the models of provision of services by observatories
- Commercialization of the selected services realized by the Observatories
- Undertaking a dialogue with GUS, targeted at making certain information, necessary for performing a description of technological areas, available
- Elaborating procedures of information exchange, including statistical one in the framework of the network
- Increasing the qualifications of personnel of the observers through dedicated forms of education

Results:

- facilitating the process of information exchange in the Network
- New packages of services offered by the Observatories according to commercial principles
- Continuation of the process of overcoming barriers and deepening of cooperation between the stakeholders of the ecosystem of innovation
- Increase of the number of research-implementation projects adequate for the needs of the market
- Increase of the number of implemented, innovative technological solutions and products within the regional economy
- Increase in the number of professional personnel related to identification and evaluation of technological areas
- Increased interest of the entrepreneurs in the offer of regional scientific and research entities
- Inclusion of the university innovation centres and project management into scientific entities under EDP.

4.3 Recommendations for system solutions

Context

Complexity of challenges standing before the regions, stemming from the development of economy and a strive for improvement of the quality of life, justifies a multi-directional technological development in the areas characterized by intellectual, technological and economic potential as well as advantages on a country scale. Appropriately directed process of changes requires a systemic approach, especially due to the limited public funds for research and development as well as for innovation. Therefore the models elaborated within the Silesian Voivodeship and instruments of impact on pro-innovation attitudes and readiness of the entrepreneurs require a constant development and improvement. Bearing in mind the key significant of the level of awareness of entrepreneurs and the sphere of science on the necessity to implement innovation, it is necessary to ensure all actions directed at an increase of this factor. In addition, attention must be paid also to the constantly insufficient awareness in this area among the representatives of SMEs [81]. Due to the above, it is required to maintain a systemic nature of actions undertaken at the regional level, the effect of which is elimination of ineffective traditional forms of impact and support in favour of the new, internationally focused ones, as well as on professionalization and open access.

The Silesian Voivodeship is one of the most attractive economically region but with a low level of introduction of process or product new or improved innovation on the market outside of the companies. This stems, among others, from a small interest among the entrepreneurs in the solutions offered by the scientific sector (compare: SWOT analysis)[82] which indicates the necessity to continue actions accelerating the process of innovation transfer from R&D sphere to economy and development of effective and efficient business models based on the permanent cooperation between the stakeholders in the region.

Recommendations:

1. **Continuation of the processing of improving the services of support for innovation**
   Business support institutions and innovation centres in particular are the components of the structure which supports entrepreneurship, indicated in all strategic documents as key for strengthening the development of region's economy[83]. The support institutions which function within the region are characterized by large diversity in the scope of number and quality of the provided services. Development of specialized general business services and the networking with research entities is the desired direction of improvement in this sector. Specialist, pro-innovation BSI services, desired for the development of technological advantages of the region include: legal intermediation, financial intermediation, evaluation of the value of technology and counselling in the scope of internationalization of products and services. Ensuring that professional personnel has the conditions necessary to maintain the so far and obtain the new competencies for their constant improvement of the provided services is the condition for maintaining relations between R&D sector and the entrepreneurs as well as the development of entrepreneurship in the region.
2. **Development of SO RIS Network**

[81] Report „Entrepreneurship in Poland", Ministry of Entrepreneurship and Technology, Warsaw 2018
[82] SO RIS Reports for the needs of diagnosing technological areas in the Silesian Voivodeship
[83] Expert report „ Evaluation of the system of support for business support institutions in the regional operational programmes for 2014-2020", Ministry of Development, Warsaw, 2016

Proper understanding of the process of managing innovative development of the region and active participation in it through monitoring and assessing the world and national trends in technological areas constitutes one of the purposes of SO RIS operations which places the Observatories permanently within the regional system of innovation. The advantage of the Observers is their direct access to specialized knowledge of a wide range of industry experts and the data. Observatories which are the animators of cooperation within the region combine the key stakeholders of the ecosystem of innovation and provide recommendations in the scope of actions, allowing for improvement of effectiveness and efficiency of the support mechanisms. Development of the Network of Observatories ought to be of evaluation nature and enable its flexibility with regards to the content and scope of the observed technological areas. Promising functioning of the network must however be based on an understanding which clearly defines the rights and obligations of individual partners. The growth of such network requires a review of the so far understanding and its adjustment to the changing needs of the region as well as the possibility of Network members. The review of provisions of such understanding would open the road ahead of commercialization of services realized by the Observatories on the basis of the elaborated by them models and ensure consistency of the Entrepreneurial Discovery Process.

3. **Internationalization and promotion of regional technologies**

Liberalization of world economy, appearance of the new, large markets and development of ICT technologies as well as participation in the global value chains have become the factors contributing to internationalization of economic and R&D activities. Actions related to creating and managing regional "exported technologies" have become critical (among others support and promotion of projects of innovative nature (flagship) and support for enterprises in image areas). Entrepreneurs however in many cases do not have at their disposal the sufficient potential for promoting their solutions on international markets. HR and financial shortages are indicated as an obstacle in undertaking such actions, further to organizational and information shortages. Strengthening the competencies of SMEs personnel would be a solution to this, especially in terms of languages and organizations supporting the participation in ventures the objective of which is internationalization of solutions from the Silesian Voivodeship, organization and participation in economic missions, further realization of fairs and exhibitions promoting technological solutions in the region and other.

4. **Adjusting support mechanisms to the market needs**

In recent years, one might observe a drop in expenditure of enterprises for innovative activity in relation to GDP. The risk related to generating and implementing innovation is the key factor which hinders this form of activity among the enterprises. Limited public funds, offered level of co-financing and difficult in the evaluation of the entrepreneurs' access and conditions of applying make the entrepreneurs resign from this form of aid. On the other hand, the policy of innovative growth assumes support of specialized group of ventures which realize social, economic and environmental goals of the region. Due to the specificity of innovation, it is also necessary to secure the funds for realization of pioneer ventures with a higher degree of risk, which carry out ground-breaking innovations and which do not directly result from the accepted development priorities. Pioneer financial ventures with the use of venture capital funds would be a stimulant of development of new technologies. Elaboration of an effective system of support

on the basis of an open portfolio of projects for technologies located on various levels of technological readiness (TRL).

Method of realization of recommendations:

- Financing the networking processes, generating new knowledge and organizing the network of dialogue and project consortia around the key development themes
- Making the co-funding mechanism for projects dependent on the level of technological readiness
- Introducing new mechanisms of support, including health-related
- Support for internationalization of technologies appearing in the region through organizing economic missions for SMEs and R&D sector, organizing industry fairs etc.
- Increasing qualifications of personnel of the Observatories and SMEs through dedicated forms of education
- Updating the understanding on the basis of which SO RIS operates

Results:

- Improvement of effectiveness and efficiency of the functioning of SO RIS
- Improvement of the conditions of cooperation of the sphere of science and business
- Increase of the number of new technological solutions, responding to the market needs
- Development of young companies and increase in the tendency to take investment risks among the entrepreneurs
- Including SMEs in global value chains
- Increasing interest of entrepreneurs in technological offer of R&D entities
- Development of partnership and cooperation between support units, research centres, entrepreneurs and self-governments.

5. PROGRAM MONITORING

6. PROGRAM IMPLEMENTATION

Update of the Technology Development Program ***of the Silesian Voivodeship*** constitutes an operational document which supplements the Regional Strategy for Innovation of the Silesian Voivodeship. It provides current knowledge on the directions of technological development of the region and the potential for building competitive advantage on the basis of the existing economic and scientific-research potential. From the point of view of realization of targets of the Program one must consider ensuring the tools and system solutions that guarantee implementation and many-years functioning of TDP along with the mechanism of recurring evaluation and verification of development targets stemming from the economic growth dynamics of the region and the country as well as the ongoing globalization processes enforcing reorientation of development policies as key. The main premise for system recommendations is the support for the Entrepreneurial Discovery Process within the ecosystem of innovation as a permanent component of a dialogue among the various stakeholders and the shaping of SO RIS. This action ought to be supported by an improvement of the quality of services provided by the Observatories and business support institutions. Facilitation of actions in this scope may be a gradual creation of the models of services offered by BSI and their commercialization. It is very important, from the point of view of anticipating technological development of the region, to increase availability of public data which currently, due to the degree of aggregation, support the entrepreneurial discovery process to an insignificant degree.

The entrepreneurial discovery process, implemented within TDP, is targeted at directing the undertaken actions in the future, related to the elaboration and implementation of the strategy of support for technological areas. It is also supposed to provide policymakers and the experts' reliable data on the dynamics of growth of technology with regards to economic indicators and the evaluation of the competitive position of the region.

Update of TDP constituted the first practical application of the elaborated model of evaluation of the areas and technological groups, providing information on the potential and the efficiency of the model of evaluation itself. In the course of works, changes occurred on each plain of the description of technology in the region. A new area emerged *Technologies for raw material industry*, and additionally, the scope of area *Transport and transport infrastructure* was expanded, once significance of logistics was identified. At the stage of analytical works and discussion with experts, the area of *Aviation Technologies and Space Industry* has also been identified as requiring special observation. These changes, dictated by an observed dynamics of technological development of the region, imply the necessity to carry out analytical-research works devoted to each of the technological regions.

Detailed approach to the necessary ventures being the result of formulated system recommendations has been described within the Implementation Model of TDP. These ventures are connected with:

- Further development of tools supporting realization of the targets of the Technology Development Program of the Silesian Voivodeship.
- Creating new and maintaining the existing Specialist Observatories along with maintaining the network of cooperation on the regional level as well as on the supra-regional one, including an update of provisions of the concluded understanding constituting the Network and specifying the conditions of partner cooperation.
- Intensifying the works on modification and expansion of the regional statistics gathering data which allow for quantifying and a reliable evaluation of technological potential and innovative potential of the region.
- Expansion of the offer and the functionality of INNOBSERVATOR SILESIA platform - Regional Platform of Innovation Development through integration of databases and an update of offers of institutions which support entrepreneurship as well as research in the region.
- Further elaboration of annual reports concerning the state of technological areas by individual Observatories with the results of the carried out the Entrepreneurial Discovery Process, combined with the structuring of the scope and method of presenting the results.
- Support for decision making processes of RIS Steering Committee on the basis of the results of recurring evaluation of technological potential of the region and the effects of realization of pro-technological policy of the region.
- Implementation under operational programmes of the Silesian Voivodeship of arrangements of an Update of the Technology Development Program of the Silesian Voivodeship and the indicated areas of technological specializations as a criterion of granting funding under actions specified in the operational programmes, targeted at realization of a broad spectrum of ventures of innovative character.
- Monitoring and forecasting of technological development on the basis of the ongoing Entrepreneurial Discovery Process and realization of foresight, targeted at establishing the factors conditioning strategic directions of development and the scenarios of conditions for the development of priority technologies in accordance with the principles of voivodeship growth.
- Implementation of recommendations of system nature as well as ventures address to the sector of enterprises, units of entrepreneurship support and innovation, R&D as well as region's authorities.

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SUMMARY

The Technology Development Program ***of the Silesian Voivodeship for 2010-2020 (***TDP 2010-2020***)***, approved in 2011, constituted the first of its type document on a country level in which both the directions of pro-technological development of the region within the perspective up to 2020 and the methods and tools for their evaluation and monitoring were specified.

Dynamic changes in the economy of the region, caused by an ongoing region's transformation, blurring of the borders between the sectors of industry as a result of diffusion and transfer of innovation, designating new directions of growth in the European and global economy and changes in the social-economic environment triggered the necessity to carry out a review and an update of the Technology Development Program for 2010-2020, so that it reflected the new challenges and became the basis for programming the region's development in 2020+ perspective. In fairness, the technological areas marked out within the TDP document for the years 2010-2020 are still represented in the Silesian Voivodeship, but the structural changes which are taking place inside them, caused by global trends and national and regional conditionings as well as endogenic factors have triggered the necessity to revise their scope and undertake an attempt to identify the new development niches.

Update of Technology Development of the Silesian Voivodeship constitutes an operational document which supplements the Regional Strategy of Innovation of the Silesian Voivodeship. It provides current knowledge on the directions of technological development of the region and the potential for building competitive advantage on the basis of the existing economic and scientific-research potential. The main objective of the Program was formulated as follows: **Identification of the region's potential in terms of strengthening its technological advantage** and its operational targets which has been presented on the below scheme:

Such formulated target group (main and detailed) of the updated Program constitutes on the one hand a continuation of the target accepted in TDP 2010-2020, while on the other hand, constituting a response to the changing conditionings related to the dynamic process of shaping of ecosystem of innovation and the realization of postulates of intelligent growth of the Silesian Voivodeship. This objective corresponds to the industrial nature of the Silesian Voivodeship, where the technological potential, including the research and development backup and the presence of enterprises investing in and developing modern technologies is the key source of advantages. The ongoing transformation of the region from the group of strongly energy-intensive and based on traditional industries (such as mining, metallurgy etc.) towards regions with developing modern, smart technologies which reply to the new, appearing civilizational challenges, including Industry 4.0, closed-circuit economy or realization of actions towards more intelligent Europe is of significance for the acceptance of such Program goal. Technologies which are generated and implemented in the region find their use not only on the local markets, but also in the country and abroad, which is confirmed by an increase in internationalization of the actions carried out by the entrepreneurs, including their participation in the global value chains and export and import of technological solutions.
Through this, the updated Technology Development Program is designated to contribute to:

- realization of an ongoing process of identification of the needs of entrepreneurs and the area of science based on the mechanisms of the Entrepreneurial Discovery Process and the analysis of directions of global and national economy growth,
- indication of new directions of growth of the region's potential, including the directions of education and support for the key research infrastructure,
- adopting the system of educating personnel for the needs of the dynamically shifting demand on the labour market,
- defining the criteria of selection of innovative projects in the current and future financial perspective,
- development of new instruments of supporting entrepreneurships, including those based on returnable financial mechanisms,
- increasing the participation of entrepreneurs in global value chains through supporting international cooperation and positioning of regional brands on foreign markets,
- Implementing the social pillar for the development of technology in the Silesian Voivodeship.

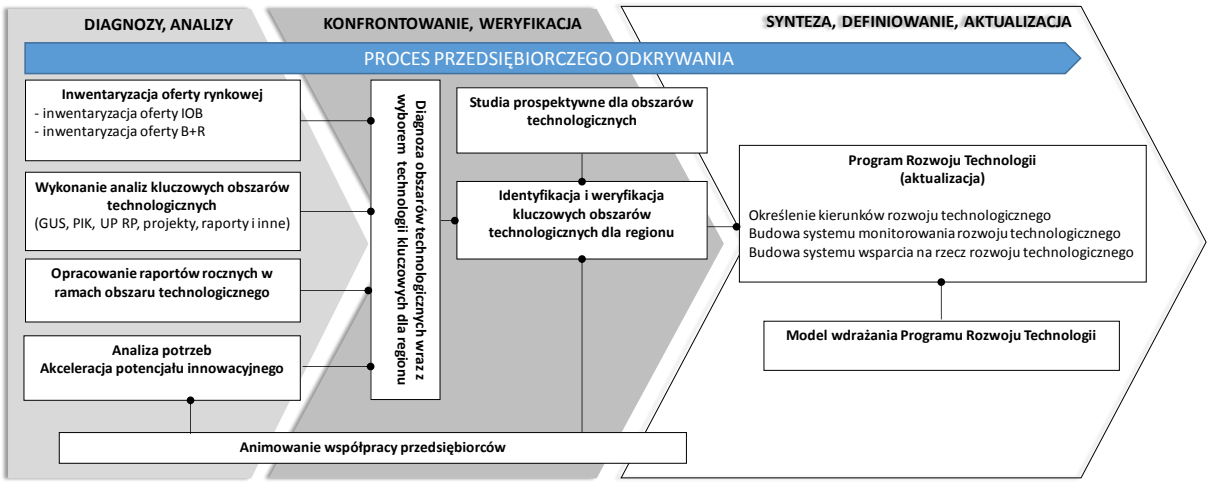
From the perspective of realizing the Program targets, one must consider ensuring the tools and system solutions which guarantee implementation and long-term functioning of TDP as well as the mechanism of recurring evaluation and verification of development targets stemming from the dynamics of economic growth of the region and the country as well as the continuous globalization processes enforcing reorientation of development policies as critical.

Realization of the Technology Development Program of the Silesian Voivodeship 2020+ and its results in the form of:

- updated areas of technology use,
- new innovative technological directions,
- Indications of directions requiring further research,
- Formulating guidelines for an innovative plan of region development,
- Recommendations concerning system changes and operational changes for the ecosystem of innovation,

Constitute an exit point for promoting the Entrepreneurial Discovery Process and intensification of dialogue between the stakeholders of the regional ecosystem of innovation towards intelligent development and economic transformation of the Silesian Voivodeship.

The subject of TDP's update has been carried out in consideration of a new approach to programming and innovative management of region's development, that is the entrepreneurial discovery process, with the use of the existing Network of Regional Specialized Observatories in the region, the partners of which are the Marshal Office of the Silesian Voivodeship and the leading R&D institutions of the voivodeship, on the basis of the so far strategic settlements of the Technology Development Program of the Silesian Voivodeship for 2010-2020 and the carried out strategic diagnosis by each Observatory with the use of individual methods and research techniques and extensive actions for a dialogue between the stakeholders and parties in the ecosystem of innovation from the sector of enterprises.
The logic of works on the update of the Technology Development Program has been presented in the below scheme.



The Silesian Voivodeship is one of the biggest investment areas in Poland and one of the strongest ones in terms of economic potential. The high urbanization and industry level related to the above makes the Silesian Voivodeship the region subjected to constant transformations. The diagnosis carried out under the Networks of Observatories confirmed large importance of technological areas for innovative development of the Silesian Voivodeship, while at the same time indicating the necessity of updating the groups of technology and the technology in each of the technological areas which includes their development, innovative nature and the changing state of knowledge. The outcome of these works were the changes of structural nature - expansion or narrowing of the groups of technology occurred. A detailed scope of technological areas has been shown in attachment to the updated TDP document. Simultaneously, it is important to note that the structure of technological areas constitutes an open catalogue which, due to the carried out the Entrepreneurial Discovery Process, may be subject to changes.

At the initial stage of works on the updated TDP document, the experts carried out an evaluation of technology in order to reflect R&D, economic, innovative potential of technology and its significance

for the Silesian Voivodeship with the use of two dimensions “importance for the voivodeship growth” and “low/high potential”.

Potential	high	**Group A** group **potentially developmental and export-oriented technologies** - with high level of technical, organizational and intellectual potential, but with a low pro-technological importance for the region	**Group C** **group of expansive technologies**, technologies with high level of intellectual, organizational and technical development, the existence of which on the market impacts the pro-technological development of the region
	low	**Group B** Group of stagnation technologies or threatened with collapse - technologies with low intellectual, organizational and technical potential and a low pro-technological importance for the Silesian Voivodeship	**Group D** Group of technologies of new possibilities - rising technologies with a temporarily low level of technical and organizational potential, but with a large significance for pro-technological development of the region
		low	**high**
		Significance for the development of voivodeship	

At the second stage of evaluation, the technologies were subjected to analysis with regards to the criteria of interdependence (assignment to groups: node technologies - with high degree of interdependence and island technologies -autonomous) and impact on region's development (endogenic and exogenic technologies). As a result of the analyses, the technologies were positioned in terms of the strategic initiatives which define the policy of support of their development, specifying one of their four orientations:

- Orientation I - orientation towards **“Leadership through diversification”** - endogenic technologies with high level of interdependence with other key regional technologies.
- Orientation II - orientation towards **“Leadership through perfection”** - endogenic technologies with low level of interdependence with other key regional technologies.
- Orientation III - orientation towards **“Technological activation towards diversification”** - exogenic technologies with high level of interdependence with other technologies and of high pressure towards their application for improvement of an increase of attractiveness of innovative products in the region.
- Orientation IV - orientation towards **“Technological activation towards perfection”** - exogenic technologies with low level of interdependence with other key technologies upon simultaneous high pressure for their application for improvement of the increase of attractiveness of innovative products in the region.

Exogenic	**(IV) Technological activation towards perfection** ▪ Creating energy from renewable energy sources and improvement of efficiency of obtaining energy from RES ▪ Technologies of water and sewage ▪ Information security ▪ Ceramic materials ▪ Technologies of designing and creating in air and space industry	**(III) Technological activation towards diversification** ▪ Technologies of creating fuel cells ▪ Prosumer energy ▪ Technologies of energy storage ▪ Biotechnologies in environment protection ▪ Technologies of waste management ▪ Technologies of air protection ▪ Technologies of environment protection ▪ Telecommunications Technologies ▪ Polymers ▪ Nano-optics
Endogenic	**(II) Leadership through perfection** ▪ Nano-materials and composites ▪ Nanoelectronics, ▪ Nanophotonics, ▪ Nanobiotechnology, ▪ Nanomedicine, ▪ Nanomagnetism ▪ Filtration and membranes ▪ Tools or devices in nanoscale ▪ Catalysis ▪ Software for modelling and simulations ▪ Information Technologies ▪ Optoelectronics	**(I) Leadership through diversification** ▪ Biotechnologies for medicine ▪ Technologies of medical engineering ▪ Technologies of smart networks and interconnections ▪ Smart and energy-efficient construction ▪ Technologies of quality improvement in degraded areas ▪ Geoinformation and its application ▪ Modelling and simulations of the processes and phenomena ▪ Telecommunications and information technologies supporting industry 4.0 ▪ High efficiency energy technologies ▪ Technologies of energy production from waste and alternative fuels ▪ Information Technologies ▪ Optoelectronics ▪ Metallic materials
	Island	Node

Diagnostic works carried out within the project SO RIS in EDP as well as prospective studies, supplemented by opinions on the side of industry experts regarding an update of the scope of technological areas indicated that maintenance of the so far divisions of technological areas was justified, whilst names of some technological areas as well as the internal structure of groups of technology and the technologies changed. These changes stem from the conducted diagnosis for technological areas the synthetic results of which have been signalled above and which have been presented in details in the first part of the document - TDP Update.

The objective of changes was an update of the so far knowledge regarding technological innovations in the region and its adjustment to the changing conditions stemming from the environment. In addition, in the course of the carried out analytical works, the experts indicated the necessity to distinguish a new technological area, namely **"Technologies for raw material industry".** Distinguishing of this technological areas is related above all to the identified strong scientific-research potential and an economic one of the Silesian Voivodeship. The region has at its disposal not only the resources of black coal, zinc and lead, iron ores, methane deposits, natural gas deposits, deposits of limestones and natural aggregate, but also deposits of healing waters, mineral and thermal waters, but these resources have for years been impacting the dynamic growth of

specialized and often innovative technologies related to the process of extraction, processing, effective use and utilization of the created waste, which occur in strong scientific-research centres of the region. Technologies for raw material industry which are created in the Silesian Voivodeship are recognized not only on the country scale but also outside of its borders, constituting one of the key export products of the region. Distinguishing of this technological areas corresponds to the existing National Smart Specialization and, in particular, NSS 7. Modern technologies of obtaining, processing and using natural raw materials and creation of their substitutes. The new technological area covers, among others, such groups of technology as: detection technology, obtaining and protection of raw materials technology, technology of processing and use of natural raw materials, technologies of raw material recycling, as well as underground storage of CO_2. Detailed scope of technological area "Technologies for raw material industry" ought to constitute an element of further works in the framework of evaluation studies or creation of a dedicated Specialist Observatory.
An issue of expanding the scope of technological area "Transport and transport infrastructure" to incorporate logistics, which at present constitutes a strongly developing component of the economic and scientific potential of the region was also discussed. Development of logistics and transport are strictly related to the development of information and telecommunication technologies and machine industry and within this aspect, it may constitute a source of competitive advantage, especially due to the existence of logistics processes in global value chains. Industry experts proposed introducing the following name for technological area **"Logistics and transport"** and indicated the below components of the group of technologies: technologies for cargo transport, including intermodal transport, information technologies for logistics and transport and storage technologies.

In the course of analytical and diagnostic works SO RIS experts came to a conclusion that the technological area identified in TDP 2010-2020, that is "Machine, automobile, air and mining industry" was covered very broadly, which hindered a division of technologies characterized by an actual innovative potential. Therefore, distinguishing of a new technological area was suggested: **"Air technologies and space industry",** which is justified by high innovative potential of the solutions created in this area, as well as due to the similarity in technologies which might have a common application in the aviation sector as well as in the space sector. Under the area "Air technologies and space industry" the following groups of technology were distinguished: design and production technologies in aviation and space industry, technologies related to avionics of aircrafts and spacecraft and technologies of air and satellite imaging of Earth and the related services.

The new shape of areas and technological groups proposed within the Technology Development Program covers the below presented

Technological area: **TECHNOLOGIES FOR MEDICINE**	
1.1	Biotechnologies for medicine
1.2	Technologies of medical engineering
Technological area: **TECHNOLOGIES FOR ENERGY SECTOR**	
2.1	High efficiency energy technologies
2.2	Technologies of creating fuel cells
2.3	Creating energy from renewable energy sources and improvement of efficiency of obtaining energy from RES
2.4	Prosumer energy

2.5	Technologies of smart networks and interconnections
2.6	Technologies of energy storage
2.7	Technologies of energy production from waste and alternative fuels
2.8	Smart and energy-efficient construction
Technological area: **TECHNOLOGIES FOR ENVIRONMENT PROTECTION**	
3.1	Biotechnologies in environment protection
3.2	Technologies of quality improvement in degraded areas
3.3	Technologies of waste management
3.4	Technologies of water and sewage
3.5	Technologies of air protection
3.6	Technologies of environment protection
Technological area: **INFORMATION AND TELECOMMUNICATIONS TECHNOLOGIES**	
4.1	Telecommunications Technologies
4.2	Information Technologies
4.3	Geoinformation and its application
4.4	Modelling and simulations of the processes and phenomena
4.5	Optoelectronics
4.6	Information security
4.7	Telecommunication and information technologies supporting Industry 4.0
Technological area: **PRODUCTION AND PROCESSING OF MATERIALS**	
5.1	Metallic materials
5.2	Polymers
5.3	Ceramic materials
Technological area: **LOGISTICS AND TRANSPORT**	
6.1	Technologies for cargo transport, including intermodal transport
6.2	Technologies for passenger transport
6.3	Information technologies for logistics and transport
6.4	Storage technologies
Technological area: **MACHINE AND AUTOMOTIVE INDUSTRY**	
7.1	Industrial automatics, automation of production lines
7.2	Sensors and robots
7.3	Technologies of designing and production in automotive industry
7.4	Technologies of designing and creation of moulders and workshop tools
7.5	Technologies of designing and production of measures of drive, machine and special device translocations
7.6	Defence and army industry
Technological area: **NANOMATERIALS AND NANOTECHNOLOGIES**	
8.1	Nano-materials and composites
8.2	Nanoelectronics,
8.3	Nano-optics
8.4	Nanophotonics,
8.5	Nanobiotechnology,
8.6	Nanomedicine,
8.7	Nanomagnetism
8.8	Filtration and membranes
8.9	Tools or devices in nanoscale

8.10	Catalysis
8.11	Software for modelling and simulations
Technological area: **AIR AND SPACE INDUSTRY TECHNOLOGIES**	
9.1	Technologies of designing and creating in air and space industry
9.2	Technologies related to avionics of air and spacecraft
9.3	Technologies of air and satellite imaging of Earth and the related services
Technological area: **TECHNOLOGIES FOR RAW MATERIAL INDUSTRY**	
10.1	Detection, obtaining and raw material protection technologies
10.2	Technologies of processing and use of natural raw materials
10.3	Technologies of raw material recycling
10.4	Technologies of underground storage of CO_2
10.5	Technologies of designing and creating mining and power machines and devices

Within the document, also program recommendations concentrated on three basic areas have been drawn up.

Area	Recommendations
Technological advantage	1) Developing competencies and specialist knowledge, including: a. Development of unique specialist knowledge B. Multiplying skills of using non-material resources (knowledge and intellectual capital) c, Knowledge diffusion 2) Developing unique R&D infrastructure 3) Building and developing technological regional brands 4) Professionalization of public services 5) Reasonable resource management 6) Ensuring safety and stability of systems
Entrepreneurial Discovery Process	1. Integration of the dispersed and non-structured data on technological areas 2. Ensuring a mechanism of providing detailed statistical data 3. Intensifying and increasing the quality of process of researching needs 4. Update of offer of scientific units 5. Developing the methods of identification and evaluation of the areas of technological advantages
System solutions	1. Continuation of the processing of improving the services of support for innovation 2. Development of SO RIS Network 3. Internationalization and promotion of regional technologies 4. Adjusting support mechanisms to the market needs

The system of monitoring updated TDP is based on the so far structures of management system and implementation of RIS in the Silesian Voivodeship and, in particular, on the functioning network SO RIS which is directed at gathering information and data necessary for the regional authorities to diagnose the potential in a given technological areas through the use of uniform set of indicators.

Monitoring and evaluation of TDP is carried out by Implementation Coordinating Unit of RIS, appointed by the Marshal Office of the Silesian Voivodeship, functioning by the Regional Development Department. Individual Observatories which function within SO RIS Network on the basis of provisions of the understanding monitor and assess the impact of public interventions on the development of a given technological area in accordance with their specialization.

Evaluation of the Program ought to be carried out at least once every 3 years, upon considering the results of the Entrepreneurial Discovery Process carried out by SO RIS. Monitoring of TDP ought to be carried out by an annual analysis of indicators referring to the technological development of the Silesian Voivodeship.