Summary Report of the EDP to the Strategy

SK RIS3 2021+

MINISTERSTVO
INVESTÍCIÍ, REGIONÁLNEHO ROZVOJA
A INFORMATIZÁCIE
SLOVENSKEJ REPUBLIKY

CONTENTS

List of abbreviations

5G	The 5th generation mobile network
AKIS	Agricultural Knowledge and Innovation System
AI	Artificial Intelligence
AIA SR	Automotive Industry Association of the Slovak Republic
AIUT SR	Association of Industrial Unions and Transport of the Slovak Republic
BA	Bratislava
BB	Banská Bystrica
CAVs	Connected and autonomous vehicles
CCAM	Connected, Cooperative and Automated Mobility
CNC	Computer Numerical Control
CO_2	Carbon dioxide
CT	Clinical trials
CZ	Czech Republic
DIH	Digital Innovation Hub
EC	European Commission
ECRIN	European Clinical Research Infrastructure Network
EDP	Entrepreneurial discovery process
EIP AGRI	European Innovation Partnership – Agricultural Productivity and Sustainability
EIS	European Innovation Scoreboard
EIT	Institute of Innovation & Technology
ES	Electricity system
ESFRI	European Strategy Forum on Research Infrastructures
ESIF	European Structural and Investment Funds
EU	European Union
EU-27	EU Member States after the withdrawal of the UK from the EU
FTE	Full-time Equivalent
GDP	Gross domestic product
GIS	Geographic Information System
GR	Government Resolution
H2020	Horizon 2020
HC	Healthcare
HE	Horizon Europe
HiAP	Health in All Policies
HPC	High-performance Computing
HU	Hungary
HW	Hardware
ICT	Information and communication technologies
IoT	Internet of Things
IPCEI	Important Projects of Common European Interest
IPO SR	Industrial Property Office of the Slovak Republic
KE	Košice

KET	Key Enabling Technologies
KPI	Key Performance Indicator
LTSR	Long-term strategic research
MaaS	Mobility as a Service
MARD SR	Ministry of Agriculture and Rural Development of the Slovak Republic
ME SR	Ministry of Economy of the Slovak Republic
MESRS SR	Ministry of Education, Science, Research and Sport of the Slovak Republic
MF SR	Ministry of Finance of the Slovak Republic
MH SR	Ministry of Health of the Slovak Republic
MIRDI SR	Ministry of Investments, Regional Development and Informatization of the Slovak Republic
MoE SR	Ministry of the Environment of the Slovak Republic
MTC SR	Ministry of Transport and Construction of the Slovak Republic
NFC	Non-refundable financial contribution
NGS	Next Generation Sequencing
NIRD	National Institute of Rheumatic Diseases
NOI	National Oncology Institute
NOP	National Oncology Programme
OECD	Organisation for Economic Co-operation and Development
OEM	Original Equipment Manufacturer
OP SK	Operational programme Slovakia
PL	Poland
PO	Prešov
R&D	Research and Development
RDI	Research, Development and Innovation
RES	Renewable energy sources
RIS3	Research and Innovation Smart Specialisation Strategy
RIS3 2014-2020	Through Knowledge towards Prosperity - Research and Innovation Smart Specialisation Strategy of the Slovak Republic 2014-2020
RPHA	Regional Public Health Authority
RRF	Recovery and Resilience Facility
RWE	Real World Evidence Data Generation
SAA	Skills Assessment and Anticipation
SAS	Slovak Academy of Sciences
SCSTI	Slovak Centre of Scientific and Technical Information
SGCSTI	Slovak Government Council for Science, Technology and Innovation
SK RIS3 2021+	Research and Innovation Smart Specialisation Strategy of the Slovak Republic 2021-2027
SK VI Roadmap 2021 - 2030	Roadmap of research infrastructures
SMEs	Small and medium-sized enterprises
SR	Slovak Republic
SRDA	Slovak Research and Development Agency
STEM	Science, Technology, Engineering and Mathematics

STU	Slovak University of Technology in Bratislava
SW	Software
TNUAD	Alexander Dubček University of Trenčín
TRC	Technology Research Centre
TRL	Technology Readiness Level
TUKE	Technical University of Košice
UK	Comenius University in Bratislava
UN	United Nations – intergovernmental organisation
UNIZA	University of Žilina in Žilina
UPJŠ	Pavol Jozef Šafárik University in Košice
V4	Visegrad Group (Czech Republic, Hungary, Poland and Slovak Republic)
VEGA	Scientific Grant Agency of the MESRS SR and SAS
ZMOS	Association of Towns and Communities of Slovakia

Executive Summary – SK RIS3 2021+

The Summary Report of the Entrepreneurial Discovery Process (hereinafter referred to as the "Summary Report") is part of the update and implementation of the Research and Innovation Strategy for Smart Specialisation of the Slovak Republic 2021-2027 (hereinafter referred to as "SK RIS3 2021+"), which are needed to meet the criteria of the enabling condition "Good governance of the strategy for smart specialisation at national or regional level" (hereinafter referred to as "enabling condition"). The fulfilment of the enabling condition is a prerequisite for the disbursement of funds and the implementation of the activities of Policy Objective 1 "A smarter Europe through innovation, digitalisation, economic transformation and support to SMEs" under the Operational Programme Slovakia (hereinafter referred to as "OP SK") in the programming period 2021-2027.

The summary report has been developed in a participatory way in cooperation with domain coordinators, visionaries and members of the domain platforms. The aim of the Summary Report is to present in more detail the Entrepreneurial Discovery Process (hereinafter referred to as "EDP") within the framework of the Smart Specialisation domains update, i.e. to present in more detail the individual domains, the justification for their selection taking into account the specificities of the Slovak Republic and global megatrends and a detailed description of the process of defining the priority areas, transformation goals, transformation maps, including mapping of available research capacities and potential customers.

The Summary Report is a living document and a direct follow-up to the SK RIS3 2021+, which will be updated at regular yearly or two-yearly intervals based on available data and outcomes of the previous period. This set-up will ensure the possibility to react in a more flexible way to any change in developments within the individual priority areas of the smart specialisation domains.

The Summary Report has three main parts, within which the methodology of selection and updating of the smart specialisation domains is defined, as well as domain-specific information and general measures to ensure the successful implementation of SK RIS3 2021+.

The introductory part of the Summary Report explains the methodology and process of updating the smart specialisation domains and describes the EDP in detail. The chapters specifically focused on the smart specialisation domains describe the justification for their selection, the goal, the priority areas and the desired cooperation and synergies with other domains. The final chapter brings a summary of general actions that need to be implemented to successfully achieve the transformation goals and the implementation of the domains. These measures will also be reflected in the Action Plan for the implementation of SK RIS3 2021+.

Introduction

The summary report, which is part of the updated RIS3, has been developed in collaboration with domain coordinators, visionaries and members of the domain platforms. It is a living document and a direct follow-up to the SK RIS3 2021+, which aims to summarise in detail the EDP within the RIS3 smart specialisation domain update.

The identification of the smart specialisation domains of the SR is directly related to the implementation of the project entitled "Supporting the transformation of the Slovak economy by enhancing its innovation performance", which was prepared in collaboration with the international consortium of *VVA Economics & Policy, BAK Economic Intelligence, KPMG* (hereinafter referred to as "Consortium") and national stakeholders, and was directly funded by the European Commission (hereinafter referred to as "EC") and linked to the preparation of SK RIS3 2021+.

The Ministry of Investment, Regional Development and Informatization of the Slovak Republic (hereinafter referred to as "MIRDI SR") used communication with domain coordinators, visionaries and members of domain platforms to define the structure of the Summary Report, which was then divided in three chapters.

The chapter "Methodology for defining and updating the domains" describes the methodology and process for updating domains of smart specialization and describes the EDP in detail.

The chapter "Smart specialisation domains" was drafted by the domain coordinators and visionaries. It contains information on the justification for the domain selection, domain goals, priority areas, transformation goals and foreseen collaboration and synergies with other domains. The domain justification briefly describes the domain definition, the strategic and policy materials of the SR relevant to the domain area, the justification and process of the domain selection, and the priority areas. The domain summarises desired outcomes of the domain across all priority areas, with more detail in the description of its transformation goals. The priority domains include information regarding the justification for the selection of the priority domain, the transformation goal, indicative measures for its achieving, examples of research capabilities, an estimate of potential customers, and a transformation map. The desired collaboration and synergies with other domains then define potential partners and inter-domain linkages that can help to meet the goals of the priority areas in order to achieve a more effective transformation.

The chapter "Horizontal conditions for a successful transformation" summarises the general actions that need to be implemented for successful achievement of the transformation goals and implementation of the domains. These measures will also be reflected in the Action Plan for the implementation of SK RIS3 2021+.

1 Methodology for defining and updating the domains

Entrepreneurial Discovery Process (hereinafter referred to as "EDP") is an essential element of the smart specialisation strategy concept that helps to address one of the key problems of vertically focused specific policy – the so-called information gap.

Information and data on individual areas and their transformation potential are essential for shaping innovation policy. These data are not available in any central location and cannot be extracted from statistical and other publicly available sources, or at best are only partially available. The necessary information is rather dispersed among the various actors in the innovation system. To a large extent, they can only be derived interactively and are often only identifiable after a long period of time. For these reasons, the one-off use of tools (such as questionnaires or formal stakeholder seminars/workshops) at the beginning of the strategy formulation or update process is insufficient to obtain all the necessary information. The EDP aims at making this knowledge available for strategic decision-making. For these reasons, the EDP represents an essential process for setting strategic goals and achieving them. The preparation of a smart specialisation strategy is a highly interactive process and involves various stakeholders and their interactions. Elements of the EDP should guide the development of the strategy and the setting of priorities and transformation goals from the outset. Moreover, the EDP is not a one-off process, as it should continuously accompany the implementation of the SK RIS3 2021+ and continuously contribute to its completion/updating. The EDP is not just one step in the strategy development process, but a tool used in the various activities needed to gather information.

The EDP is a collaborative discovery process with the business sector. Given this premise, the EDP is not bound by a methodology with strict rules and predefined procedures. The EDP is influenced by participation, the activity of the business environment, the actual performance of research, development and innovation (hereinafter referred to as "RDI") and also depends on the circumstances and framework conditions in the regions.

The aim of the EDP is to identify specific interlinked themes and actors for their implementation, which are intertwined and jointly contribute to the same transformation in a priority area and reinforce each other.

The expected outcome of the EDP is a **transformation map**: a collection of concrete, deliverable and strategically complementary thematic headings for defining challenges and actions. The transformation map shows the possible path to be followed to achieve the strategic objectives set out by the defined priority areas and transformation goals, while identifying the necessary actions to achieve it.

The transformation map aims to **identify the key links between the themes and the related projects, activities, measures and actors, aimed at the same direction of structural change and oriented towards the same transformation goal.** The identified projects are complementary and synergies between them should be promoted. If properly managed, strategic complementarity between projects will trigger a sustained transformation process and, over time, allow other complementary projects to emerge.

The EDP needs to be implemented across all stakeholders and can take different forms, ranging from spontaneous interdisciplinary brainstorming to more formalised workshops setting.

Prerequisites for setting/updating priority areas and transformation goals[1]

- Priority areas must be well defined and appropriate for the region;
- They must provide a framework for the economic added value resulting from the strategy and structural improvements;
- Transformation goals must be clearly defined and appropriately calibrated:
  - Not too "general" but specific and detailed sufficiently (more like megatrends or improvements);
  - Measurable – it is important to identify SMART indicators for the transformation goals;
  - Ambitious, but achievable and realistic.
- Available capacities must be known; possible data sources and available data and results need to be evaluated.
- Priority areas and transformation goals must be accepted by stakeholders.

The process of updating smart specialisation domains in the SR

The process of updating smart specialisation domains started in 2019 within the European Commission project "*Supporting the transformation of the Slovak economy by improving its innovation performance*". During 2020, several activities were carried out to define and update the smart specialisation domains of the SR for the new programming period 2021-2027. The main role in updating the five smart specialisation domains was played by the **domain platforms**, which are composed of representatives of the business sector, the science and research base, the academia, and the state or public administration (hereinafter referred to as "stakeholders").

In July 2020, an **initial domain definition workshop** was held with the participation of stakeholders and the consortium to discuss the update of the smart specialisation domains, priority areas and transformation goals. The next step was taken under the responsibility of MIRDI SR and the domain coordinators, a survey was carried out within the public and private sectors to map in more detail the areas of the Slovak economy with high transformation potential. In the case of the Ministry of Health (hereinafter referred to as "MH SR"), a special detailed questionnaire was prepared and implemented by the respective domain platforms. A survey on the update of SK RIS3 2021+ was also carried out in the form of a questionnaire under the responsibility of the Ministry of Economy (hereinafter referred to as "ME SR") and the coordinators and visionaries of Domain 1 – Innovative industry for the 21st Century. The results of the surveys mentioned above serve as a basis for the continuous EDP.

In late September/early October 2020, **five methodological workshops were held** within the framework of the EDP to define the priority areas more precisely, to present the methodology of the continuous EDP and the basic pillars of the transformation maps to the stakeholders. Due to the COVID-19 pandemic, the workshops were conducted both in a face-to-face and virtual/online format, as well as through additional consultations with stakeholders in each domain. Through the workshops, the EDP itself was launched to identify transformation maps through which transformation goals will be achieved.

Based on the data available for each domain as well as the results from the five EDP methodological workshops, domain coordinators, domain visionaries and stakeholders defined priority areas and transformation goals by the end of October 2020 and prepared a short document on the results of each workshop in the required structure by 15 November 2020.

[1] These assumptions will be applied in workshops, seminars, conferences and dissemination activities related to the EDP.

A validation workshop of the EDP outcomes was held in November 2020 with the participation of stakeholders. In this event, which was coordinated by the consortium, the EDP outputs were presented across all five updated domains:

Domain 1: Innovative industry for the 21st Century

Domain 2: Mobility for the 21st Century

Domain 3: Digital transformation of Slovakia

Domain 4: Healthy society

Domain 5: Healthy food and environment

The specific priority areas of each domain were presented with the identification of the transformation goals to be achieved in each area. The approach taken by each domain to define the priority areas, the data on which they were based and the needs identified by each domain were discussed during the workshop.

2 Horizontal conditions for a successful transformation

The success of the transformation as well as the associated development of the ecosystem are directly dependent on the functioning of their individual components. Within the framework of SK RIS3 2021+, the following areas have been identified as the main areas for the development and building of the national RDI system:

- **Horizontal challenges and a set of measures** that represent the necessary reform changes, support and incentives to the RDI system and national priorities in this area in order to address the horizontal issues that hinder the research and innovation potential of the SR;
- **Strategic goals**, which will be achieved by systematic measures and public policies while responding to the main challenges of the RDI ecosystem;
- **Smart specialisation domains** as the EDP outputs to be developed through specific projects focused on technology and product development, infrastructure development or building collaborative platforms;
- **Domain-specific goals** at the level of individual domains, where these are achieved through more specifically defined transformation goals at the level of priority areas, which will be implemented through the transformation maps that are part of this Summary Report;
- **Smart specialisation domain priority areas** identified as part of the EDP to further specify and narrow the specialisation focus of the five domains, with the prospect of significant potential and high added value.

During the EDP process, key requirements were identified for the transformation and its implementation, reflecting the specificities of the smart specialisation domains, their priority areas, as well as the cross-cutting challenges of the RDI ecosystem. These specificities have a direct impact on the possibility and success of the implementation of activities and projects in the SK RIS3 2021+ and in the Summary Report, so that their subsequent implementation is in line with the EDP, while at the same time leading to the initiation of the search for new significant prospective areas of development.

To ensure the achievement of the transformation goals of the priority areas as well as further development and transformation in the individual domains, it is necessary to focus also on horizontal activities and measures that reflect the needs within all priority areas of the individual domains.

The measures represent the basic prerequisites for further development of the domains as well as deepening of specialisation within the individual domains, which are linked to the systemic and legislative measures defined in the SK RIS3 2021+[2] and specify them at the level of the domains. These measures should be considered when planning specific activities and drafting Action Plans for the implementation of SK RIS3 2021+ for the relevant years.

The horizontal challenges can be broken down into the following thematic sub-domains:

Quality of human resources

A suitable educational structure of the population is an important prerequisite for the RDI development. Since the 1950s, the educational structure of the Slovak population has changed significantly. In 2020,

[2] Chapter 3 – Research and innovation strategy for smart specialisation of the SR 2021-2027 (SK RIS3 2021+)

Slovakia ranked third among EU countries with the lowest educational attainment level in the age group 15-64[3]. As with other education statistics, regional disparities are particularly problematic also for this indicator (3.5 % in BA; 10 % in BB, PO and KE).[4] Even today, the assumed low quality of higher education in the SR is a critical issue. The ranking of Slovak universities in international comparison is significantly lower than in other EU countries; in 2021, Slovakia had only 1 university in the top 1000, while, when compared with the V4 countries, CZ had 7, HU 4, and PL had 10 universities in the top 1000[5]. The structure of fields of study is also perceived as problematic, with lower representation of natural sciences, mathematics, and engineering fields of study, which are precisely the fields that are expected to have the greatest innovation potential. The link between the education system and practice, the relevance of the fields of study for practice, education as the precursor for the emergence of a new economy, and the quality of lifelong learning are also considered to be relatively weak (with reference to the evaluation in the European Innovation Scoreboard). The way out of this situation can be the preparation of educational programmes in cooperation with the business sector, recognition of other forms of education – other than exclusively formal education, international cooperation in education (especially internships for top foreign experts at Slovak universities). One of the keys to the transformation of the Slovak economy is also the stabilisation of quality human resources and the effective use of the existing intellectual potential in Slovakia in both the public and private sectors. The EDP stressed the need to also significantly and continuously strengthen the staffing at the appropriate level (including increasing the share of PhD students, research and administrative staff of universities/colleges on academic mobility, researchers/experts from Slovakia and abroad who want to pursue their research/expert career in Slovakia, and to develop cooperation with scientific and research institutions in the EU), together with creating appropriate incentives and conditions for their employment in the field of R&D in Slovakia.

Brain drain

Indirectly related to education is **the so-called brain drain**, a phenomenon, which Slovakia is strongly affected by in international comparison. Based on the Human flight and brain drain index, Slovakia ranked 19th among all EU countries in 2021. This ranking has been confirmed by another international statistic from the OECD, which assesses the proportion of students going abroad to study at university. According to this statistic, the SR is ranked 2nd (behind Luxembourg) with a share of 19.2 %.[6] Long-term or permanent emigration, as opposed to short-term stays abroad, is a financial burden and an obstacle to the development of RDI for the country of origin of the migrant human capital. The Czech Republic, on the other hand, is attractive as a destination country for highly educated migrants, not only at the level of its Capital city, but also within other regions, while also attracting to some extent the inflow of highly qualified people from Slovakia. Also, for these reasons, the SR must clearly encourage the return of key professionals by means of financial instruments, the building and development of research centres, the optimisation of the working environment and career conditions as well as through the promotion of attractive areas for future development linked to the smart specialisation domains. The implementation of the SK RIS3 2021+ strategy and the smart specialisation domains must create the conditions, in particular, for increasing the share of GDP generated from own research, development and innovation and for making Slovakia more attractive in the international context and promote its

[3] Eurostat: *Population by educational attainment level, sex and age (%) - main indicators*. Available at: https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=edat_lfse_03&lang=en
[4] To dá rozum: *Analýza zistení o stave školstva na Slovensku.* Available at: https://analyza.todarozum.sk/analyza-zisteni-o-stave-skolstva-na-slovensku.pdf
[5] Shanghai Ranking: *2021 Academic Ranking of World Universities.* Available at: https://www.shanghairanking.com/rankings/arwu/2021
[6] The UNESCO institute for statistics: *Education*. Available at: http://data.Uis.Unesco.Org/#

perception as an attractive workplace for knowledge-based professions with high added value, which will increase the country's modern productivity and its competitiveness in the international context.

Supporting innovation in SMEs

For the development of human resources in Slovakia, the environment of small and medium-sized enterprises (hereinafter referred to as "SMEs") is also important. In spite of the undersized systematic support, the EDP has seen an increasing number of start-ups and SMEs emerging also in the areas focused on RDI. It confirms the interest and ambitions of Slovak innovators in this segment, which needs to be further developed. A small country like Slovakia clearly needs innovation to generate revenue from the knowledge economy. Denmark is a good example of a small innovative country and one of the innovation leaders in the EU and in the world.[7] Despite its potential, Slovakia generates overall little innovative output compared with other countries. In the SR, based on the recent report on innovation performance of enterprises for 2016-2018, the share of SMEs with innovation activity was only 24.1-27.8 % (innovation in services/industry). The structure of enterprises with innovation activity by type of innovation in 2016-2018 was distributed in the following categories: 13.5 % product innovation and 37.1 % process innovation.[8] Compared with the V4 and EU countries in 2018, Slovak SMEs lagged behind mainly in product innovation (EU-27: 33.8 %, CZ: 33.0 %, HU: 18.0 %). The overall participation of Slovak SMEs in Horizon 2020 (hereinafter referred to as "H2020") projects was also very low. In November 2020, SMEs accounted for 229 participations (with an EU contribution of EUR 51.7 million),[9] which represents one of the lowest participation rates in the EU, also due to insufficient national co-financing of European partnerships. An essential part of the domain transformation is also the development of start-ups and SMEs operating in Slovakia in industries and sectors linked to the smart specialisation domains with the help of grant schemes aimed at excellent projects evaluated in the European framework schemes, which at the same time have not been financially supported by these programmes. Setting up various financial incentives (including vouchers), providing a quality expert/mentor platform, networking, etc. can be highly effective particularly for start-ups.

Internationalisation

In the case of the H2020 programme, which focuses on linking science and innovation, the SR received a total of €138.9 million, which is only 0.44 % of the total EU funding (the SR is ranked 24th out of all 28 Member States at that time). A problematic aspect is the very low number of projects submitted, as well as their low success rate. Based on the findings of the mid-term evaluation of R&D cooperation of Slovak institutions,[10] this problem is mainly related to the highly complex administrative procedures for the project submission and complex administration processes, the insufficient level of skills, experience and motivation of persons responsible for the preparation of international projects and low awareness of the existence and possibilities of support for international cooperation in the field of RDI (in the area of increasing awareness, the MESRS SR together with the CVTI has established a professional office of national contact points for H2020 – currently for Horizon Europe (hereinafter referred to as "HE"), which

[7] European Commission (2021): European Innovation Scoreboard: Innovation performance keeps improving in the EU Member States and regions. Available at: https://ec.europa.eu/commission/presscorner/detail/en/IP_21_3048
[8] Statistical Office of the SR: *Inovačná aktivita podnikov v SR 2016-2018.* Available at: https://lnk.sk/txcx
[9] European Commission (2021): *Horizon 2020 Country profiles.* Available at: https://ec.europa.eu/info/research-and-innovation/statistics/framework-programme-facts-and-figures/horizon-2020- country-profiles_en
[10] OP II 2014-2020: *Priebežné hodnotenie medzinárodnej výskumnej a vývojovej spolupráce slovenských inštitúcií.* Available at: https://www.opvai.sk/media/102134/priebe%C5%BEn%C3%A9-hodnotenie-medzin%C3%A1rodnej-v%C3%BDskumnej-a-v%C3%BDvojovej-spolupr%C3%A1ce-slovensk%C3%BDch-in%C5%A1tit%C3%BAci%C3%AD.pdf

organises regular information days throughout the SR, provides consultations to those interested in the HE programme as well as mentoring programmes.[11]

The solution is to increase participation in research programmes and provide continuous administrative assistance to institutions with project management (from application through project implementation). A key challenge in the field of internationalisation will therefore be to increase the interest in the schemes of the new HE programme and to provide systematic assistance to public institutions in the application process, where the size of the documentation to be submitted is a significant problem not only for research institutions and public universities, but mainly for enterprises. It is also important to adapt models for the creation of consortia (e.g. the 'hop-on model') and for linking actors and partners in the creation of comprehensive projects (using multi-source funding) with a societal relevance and a high potential for commercial exploitation.

Harnessing the great potential for implementation in each of the three pillars of implementation (1 – Excellent Science; 2 – Global Challenges and European Industrial Competitiveness; 3 – Innovative Europe)[12] and the participation of the SR in the European Research and Innovation Partnerships and missions of the HE programme. Under Pillar Two, there is the possibility to participate directly in calls at the level of smart specialisation domains in the clusters Health; Civil Security for Society; Digitalisation, Industry and Space; Climate, Energy and Mobility; and Food, Bioeconomy, Natural Resources, Agriculture and Environment. All of these clusters cover each of the five smart specialisation domains and, combined with multi-source funding, represent an excellent opportunity for the SR to increase its participation through projects in this programme.

A key priority will be to launch as soon as possible support schemes to increase the participation of Slovak researchers in Horizon Europe, in particular through the SRDA programme "Strengthening the participation of the SR in European cooperation in research and development" and from the EU Structural Funds under Objective 1 Smarter Europe.

Support should focus mainly on:

- Preparation of Horizon Europe projects;
- Projects focused on priority area: Increased participation and promotion of excellence – ERA Chair, Teaming;
- Complementary funding for Horizon Europe projects;
- Projects that have been awarded the Seal of Excellence (EIC, ERC, Marie Sklodowska Curie),
- Co-funding of participation of Slovak organisations in European research and innovation partnerships.

Completion, maintenance and development of infrastructure

Despite the financial support received in the previous programming period, we have seen serious infrastructure gaps under the new EDP. Slovak universities and institutes of the Slovak Academy of Sciences had the opportunity to build science parks and centres but, due to the incorrect setting of

[11] In 2021, 37 information days were organized in relation to the Programme calls with more than 2000 participants; 1270 individual consultations were provided, plus 3 mentoring programmes. The information is provided through the national portal for the Horizon Europe. SLORD Brussels also plays an important role providing Slovak community with the topical information in the area of the European support for R&D and creating and promoting liaison between Slovak researchers and their partners from the EU and associated countries.
[12] Horizon Europe: *For a green, healthy, digital and inclusive Europe*. Available at: https://op.europa.eu/en/publication-detail/-/publication/eef524e8-509e-11eb-b59f-01aa75ed71a1/

rules, many of them remain unused due to the lack of possibilities for continuous funding. The impossibility of sharing instrumental infrastructure has led to a significant reduction in opportunities for the creation of so-called "core facilities", the implementation of contract research or effective cooperation with the business sector, based on the erroneous or inadequate identification of state aid rules. Thanks to funding from the ESIF we have 14[13] university science parks and research centres in Slovakia. As for digital innovation centres that help companies with digital transformation, Slovakia only has two of them.[14] In the case of research infrastructures, it is important to have systematic, continuous and long-term funding even for existing infrastructures, so that they do not have to restrict their operations after the end of the sustainability period, but instead continue to develop. As a result, the founders had to allocate part of their budgets to supporting the work of the parks and centres, without increasing their budgets by these resources. For these reasons, the new parks and centres have, in most cases, placed a financial burden on the budgets of virtually all the organisations involved in building them. Ensuring their further functioning and development is therefore also based on supporting the implementation of their commercial exploitation, whether in the field of service provision and contract research, the implementation of basic or translational/applied research projects, in the framework of national or international strategic projects, in particular in cooperation with the business community. An important element for streamlining the system of infrastructure use and development is also the functional Roadmap of Research Infrastructures in the SR and Action Plans for its implementation.

Protection of intellectual property rights

Innovation is the driving force of the economy. In order for the innovative efforts of Slovak companies to achieve their full potential, they must go hand-in-hand with the protection of intellectual property rights (hereinafter referred to as "IPR") – that is, if our country is to fully benefit from its R&D, the relevant actors need to know how to protect, manage and enforce their intellectual property effectively, as well as how to avoid damages caused by infringements of the IPR of other entities. SMEs make up 99.9 % of business entities operating in Slovakia, but the frequent claim that intellectual property protection applies only to large companies is a myth.[15] As every single business has the ambition to grow and strengthen its position in the market, ignorance about IPR protection in the early stages of a business can bring unexpected obstacles and jeopardise its sustainability and future development.
In addition to the aforementioned lack of a "culture of IP awareness", the amount of administrative and maintenance fees and the financial intensity of patent attorneys' services have a significant impact on the poor performance of Slovak companies and academia in the area of IPR protection and enforceability. There is a lack of sufficient financial and educational support as well as expertise in this area in Slovakia. However, it cannot be said that no support is implemented – there are, for example, PATLIB Patent Information Centres initiatives in the CVTI SR[16] related to IP searches, training and consulting services, several mentoring/networking platforms (e.g. CIVITTA, BIOHUB SK) also focused on education and support in generating a quality portfolio in the area of IPRs. Within the EU, however, the level of systematic support is at a higher level[17] and it is therefore essential to significantly strengthen

[13] Balog, M.: *Vedecké parky a výskumné centrá na Slovensku*. Available at: http://www.prog.sav.sk/sites/default/files/2019-07/Miroslav%20Balog%20-%20Vedeck%C3%A9%20parky%20a%20v%C3%BDskumn%C3%A9%20centr%C3%A1%20na%20Slovensku.pdf
[14] European Commision: *Online Digital Innovation Hubs catalogue:* Available at: https://ec.europa.eu/eip/agriculture/en/find-connect/online-resources/online-digital-innovation-hubs-catalogue
[15] Wipo Magazine: *IP protection: building value and growth for small businesses*. Available at: https://www.wipo.int/wipo_magazine/en/2021/01/article_0003.html
[16] Patlib: *Stredisko patentových informácií PATLIB v CVTI SR.* Available at: https://patlib.cvtisr.sk/sk/nase-sluzby.html?page_id=285
[17] European IP Helpdesk: *Our Services*. Available at: https://www.iprhelpdesk.eu/home

awareness and information about such European platforms among Slovak business as well as other research entities focused on the commercialisation of applied research.

Another problem which figured until recently was that the IPRs (relevant in particular for patents) of the Slovak Academy of Sciences (hereinafter referred to as "SAV") – the largest public research institution in Slovakia – were owned by the state, which significantly limited the legal certainty of its ability to act.[18] This area needs to be stimulated in order to increase capacity and efficiency also in attracting investment and licensing in the upcoming programming period. In line with the current requirements of the European Structural and Investment Funds (ESIF) procedures, the obligation to disclose sensitive company research information in project applications not only risks the disclosure of patentable information to the applicant's competitors, but also renders patent protection impossible given the extent of the disclosed data.

The legal framework needs to be revised in order to establish clear and binding rules in relation to all forms of IPR protection, with an emphasis on transparency and ownership. The new rules must ensure that sensitive information is effectively protected as it comes into the public domain by being made public. As part of the transformation of the Slovak innovation space into an environment with a developed awareness of intellectual property, it is also necessary to support activities leading to an increase in the use of intellectual property protection, streamlining its management and improving the overall awareness of its effects on business and other research entities, with the aim of facilitating informed decision-making about the opportunities and risks associated with innovation. The topic of IPR protection is currently being discussed on an ad-hoc level in the framework of the preparation of various strategic documents in relevant areas where addressing the issue of IPR is desirable and warranted. Another option for the future is the development of a more comprehensive national IPR protection strategy (such as that used by countries such as the UK,[19] Canada[20] or Singapore[21]) which has the potential to strengthen Slovakia's ability to generate economically valuable capital in this area in a planned, efficient and sustainable manner.[22]

Funding

In the area of funding in the current period, the Slovak Republic suffers from a lack of interest on the part of the state as well as the private sector to support the funding of topics related to RDI. In an international comparison, Slovakia ranks an unflattering 24th in this indicator, on the tail of the EU countries. The problem is not only the low share of total R&D funding (0.9 % of GDP-2020), but also the low interest in funding R&D activities by private enterprises (43.7 % of total R&D expenditure-2020).[23] A significant limitation of the system of financing RDI activities at the national level is also the provision of a continuous link of resource allocation for areas that are key for the SR in the long term and also have a societal and economic impact. The current SK RIS3 2021+ strategy foresees the preparation of a draft and update of the Action Plan for the implementation of the strategy's activities every two years so that the document becomes more alive and adaptable to the current conditions, requirements and needs of the national economy, while ensuring compliance with the EDP methodology. Another solution to current problems in the area of funding is its predictability, which is a long-term and key problem

[18] Slov-lex: *Zákon o verejnej výskumnej inštitúcii a o zmene a doplnení niektorých zákonov.* Available at: https://www.slov-lex.sk/pravne-predpisy/SK/ZZ/2017/243/

[19] Gov.UK: *IPO Strategy 2018 to 2021*. Available at: https://www.gov.uk/government/publications/ipo-strategy-2018-to-2021

[20] Managing IP: *Canada develops its National Intellectual Property Strategy*. Available at: https://www.managingip.com/article/b1kbm159gzp9bv/canada-develops-its-national-intellectual-property-strategy

[21] IPOS: *Singapore IP Strategy (SIPS) 2030 Report*. Available at: https://www.ipos.gov.sg/media-resources/media/events/singapore-ip-strategy-2030

[22] WIPO: *National IP Strategies*. Available at: https://www.wipo.int/ipstrategies/en/

[23] Štatistický úrad Slovenskej republiky: *Ročenka vedy a techniky v SR 2021*. Available at: https://lnk.sk/iotp

hindering the development and direction of RDI activities at the national level. In the coming period, the principle of defining the scope of allocations for the calls for proposals and the financing of activities from the Action Plan will be implemented for the SK RIS3 2021+ and the Summary Report (the scope of allocations will be defined beyond the activities of the Action Plan, so that the stakeholders who will implement the calls can prepare their project plans in sufficient time and with high quality). However, in addition to a significant strengthening of systemic and continuous funding, duplication and fragmentation of support must also be avoided in order to ensure the transformation of domains, which is one of the basic conditions for the efficiency of R&D spending. It is also essential to pursue a bottom-up strategy based on R&D opportunities in line with European and Slovak strategies, goals and mission in the areas of smart specialisation.

Legislation

Horizontally, within the framework of SK RIS3 2021+, the need for legislative adjustments or methodological elaboration of the legislative framework has already been identified, especially in areas such as state aid,[24] public procurement,[25] protection of intellectual property rights[26] etc. For the development of the priority areas identified in the EDP, the legislative framework needs to be adapted in some areas in order to remove barriers to thematic support. The need for domain-specific legislative adaptations is indicated for the relevant domains.

Implementation of EU funds

Considering the volume of funds coming from European sources to support RDI and the poor performance of the SR so far in terms of their efficient and targeted use, it is essential to focus in the 2021-2027 programming period on the set-up and implementation of processes to remove barriers[27] that cause delays and to contribute to simplification of the whole system. In setting up these processes, it is necessary to draw inspiration from best practice from abroad, as well as from the management and processes of the HE programme, or the predecessor H2020 programme. In relation to addressing this area, systemic measures and their implementation are also planned in the framework of the SK RIS3 2021+.[12]

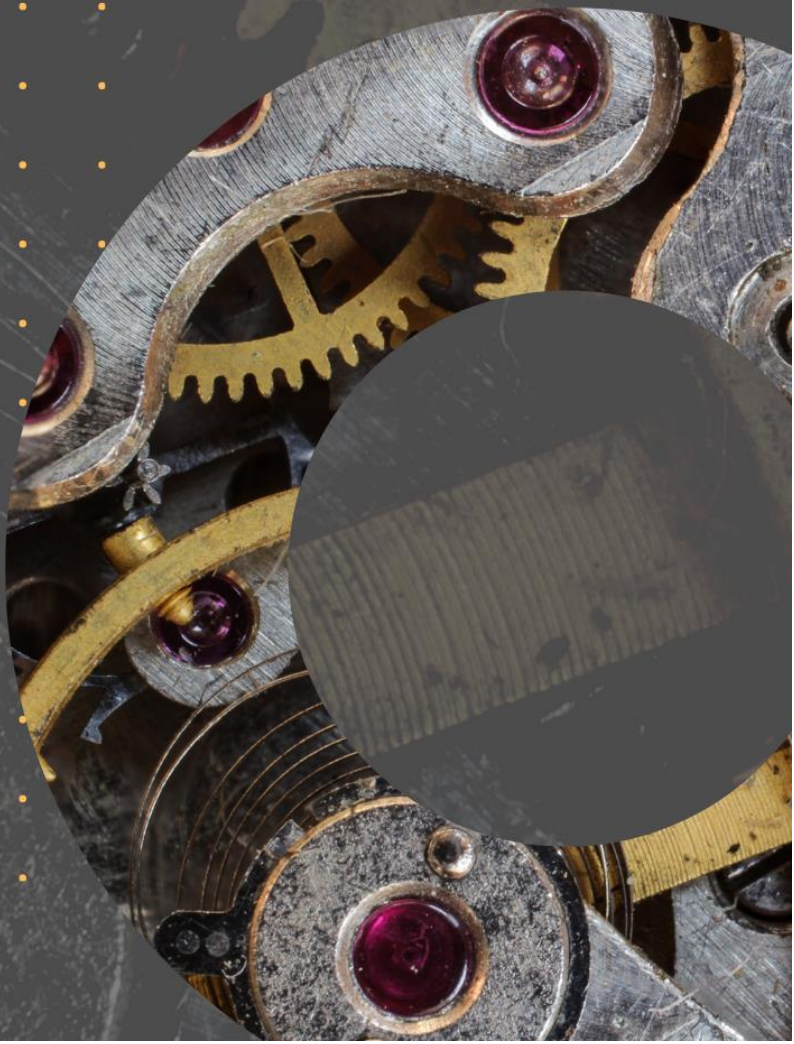
[24] Slov-lex: *Zákon 358/2015 Z. z. o úprave niektorých vzťahov v oblasti štátnej pomoci a minimálnej pomoci a o zmene a doplnení niektorých zákonov (zákon o štátnej pomoci)*. Available at: https://www.slov-lex.sk/pravne-predpisy/SK/ZZ/2015/358/20160101

[25] Slov-lex: *Zákona 343/2015 Z.z. o verejnom obstarávaní a o zmene a doplnení niektorých zákonov.* Available at: https://www.slov-lex.sk/pravne-predpisy/SK/ZZ/2015/343/20210802

[26] Industrial Property Office of the Slovak Republic: *Právne predpisy SR*. Available at: https://www.indprop.gov.sk/legislativa/pravne-predpisy-sr

[27] Stratégia výskumu a inovácií pre inteligentnú špecializáciu SR 2021-2027: *Kapitola 4. Horizontálne výzvy a súbor opatrení a kapitola 3.4 Systémové a legislatívne opatrenia*. Available at: https://www.MIRRI SR.gov.sk/wp-content/uploads/2018/10/Navrh-Strategie-vyskumu-a-inovacii-pre-inteligentnu-specializaciu-Slovenskej-republiky.pdf

Innovative industry for the 21st century



3 Smart specialisation domains[28]

3.1 Innovative industry for the 21st century

3.1.1 Justification for the domain

Definition of the domain

Slovakia is an industrially oriented country, where a substantial part of GDP and employment is provided by industrial production and part of services closely linked to the activities of industry. Industrial production in Slovakia is strongly export-oriented, which implies its high dependence on the development in downstream markets. The model of increasing competitiveness based on modern technologies imported in the past and on the low price of skilled labour has been exhausted, the pace of convergence of the Slovak economy to the most advanced EU countries has slowed down considerably, and Slovakia is currently already at the tail of the euro area countries. The main cause of Slovakia lagging behind is low productivity caused by a low share of value added, due to the absence of its own product or technological innovations as well as the quality of human capital. The lack of an innovative environment in Slovak companies makes skilled young people to go abroad in search of better opportunities, which implicitly has a negative impact on the quality of domestic higher education. The transformation of Slovak industry so that it retains its competitiveness and ability to respond to global challenges is only possible through fundamental reforms and the strengthening of funding of research and development, as well as promoting own original innovations.

Strategic and policy materials of the SR relevant to the domain area

Prosperity through knowledge – Research and Innovation Strategy for Smart Specialisation of the Slovak Republic,[29] Implementation Plan of the Research and Innovation Strategy for Smart Specialisation of the Slovak Republic,[30] Product lines for the Domain Modes of Transport for the 21st Century,* Product lines for the Domain Industry for the 21st Century,* Product lines for the Domain Digital Slovakia and Creative Industry,* Product lines for the Domain Population Health and Health Technologies,* Product lines for the Domain Healthy Food and Environment,[31] Integrated National Energy and Climate Plan for 2021-2030,[32] Strategy of the Economic Policy of the Slovak Republic until 2030,[33] Smart Industry Concept for Slovakia,[34] Smart Industry Action Plan for the SR,[35] Energy Efficiency Action Plan for 2017 - 2019 with a

[28] For each of the domain priority areas that have been defined by the EDP process, it is necessary to verify compliance with Regulation (EU) 2016/679 – protection of natural persons with regard to the processing of personal data and the free movement of such data – when implementing activities that have an impact on the collection, processing and use of personal data. This assessment follows from point 11 of the List of processing operations subject to a Slovak Data Protection Impact Assessment as follows: 11. Processing operations using new or innovative technologies in conjunction with at least one criterion listed in the WP 248 Guidelines.
Available at: https://dataprotection.gov.sk/uoou/sites/default/files/zoznam_spracovatelskych_operacii_ktore_podliehaju_posudeniu_vplyvu.pdf
[29] Ministry of Economy of the Slovak Republic: *Research and innovation strategy for smart specialisation.*
Available at: https://www.MH SR.sk/inovacie/strategie-a-politiky/strategie-vyskumu-a-inovacii-pre-inteligentnu-specializaciu
[30] Eurofunds: *Implementation plan of RIS3 SR.*
Available at: https://www.eurofondy.gov.sk/inteligentna-specializacia/implementacny-plan-ris3-sr/index.html
[31] *European Regional Development Fund OP Integrated Infrastructure 2014-2020: *Important documents.* Available at: https://www.opvai.sk/ris3/dolezite-dokumenty/
[32] Ministry of Economy of the Slovak Republic: *Integrated National Energy and Climate Plan for 2021-2030.* Available at: https://www.economy.gov.sk/energetika/navrh-integrovaneho-narodneho-energetickeho-a-klimatickeho-planu
[33] Ministry of Economy of the Slovak Republic: *Strategies and Policies.* Available at: https://www.MH SR.sk/priemysel/strategie-a-politiky
[34] Ministry of Economy of the Slovak Republic: *Smart Industry Concept for Slovakia.* Available at: https://www.MH SR.sk/inovacie/strategie-a-politiky/smart-industry
[35] Ministry of Economy of the Slovak Republic: *Smart Industry Action Plan for the SR*. Available at: https://www.MH SR.sk/inovacie/strategie-a-politiky/akcny-plan-inteligentneho-priemyslu-sr

view to 2020,[36] Strategy of the Digital Transformation of Slovakia 2030,[37] Digital Transformation Action Plan of Slovakia 2019-2022[38] National Programme for Active Ageing 2014-2020,[39] National Employment Strategy of the Slovak Republic until 2020,[40] Vision and Strategy for the Development of Slovakia until 2030,[41] National Investment Plan of the Slovak Republic for 2018-2030,[42] Energy Policy of the SR,[43] Energy Security Strategy of the SR,[44] National Hydrogen Strategy "Ready for the Future".[45]

Justification for the domain selection

a) Current needs in the SR

Slovakia is a country with a strong industrial tradition, where industry accounts for more than 40 % of GDP (together with related services, even 70 %, accounting for about 90 % of Slovakia total exports). Over 30 % of employees work in industry, which is the second highest share in the EU. Manufacturing is therefore a key strategic area for Slovakia. The share of nominal labour productivity per working person in Slovakia (expressed in purchasing power parity) compared to the EU27 average has fallen to 73 % in 2019 against 2010. The main reason for this is the low value added of output due to the absence of own innovation. The domain is therefore prioritised to target its increase through original product and technological innovations that would ensure the long-term sustainability of the industry and thus sufficient resources to address societal needs. The priorities of the domain are designed so that the supported industrial innovations, in addition to increasing the global competitiveness of the industry itself, also contribute to solving the most serious problems of the Slovak society in the field of environment, efficiency of energy use and raw materials. The domain's task is therefore to transform industrial production in such a way that it comprehensively fulfils several tasks for the state, in particular to ensure the following:

- sufficient revenue to the state budget at the same or lower cost of public funds for operation;
- promoting employment with higher skills and labour costs;
- reducing the negative impacts of society on the environment (efficient use of primary energy and raw materials, including secondary ones in both technologies and products, helping to reduce environmental burdens (waste separation, energy recovery of sorted residues, elimination of brown fields, reduction of emissions).

[36] Ministry of Economy of the Slovak Republic: *Concepts, action plans and progress reports.* Available at: https://www.MH SR.sk/energetika/energeticka-efektivnost/spravy-o-pokroku

[37] Ministry of Investments, Regional Development and Informatization of the Slovak Republic: *Strategy of the Digital Transformation of Slovakia 2030.* Available at: https://www.MIRRI SR.gov.sk/sekcie/informatizacia/digitalna-transformacia/strategia-digitalnej-transformacie-slovenska-2030/index.html

[38] Ministry of Investments, Regional Development and Informatization of the Slovak Republic: *Digital Transformation Action Plan of Slovakia 2019-2022.* Available at: https://www.MIRRI SR.gov.sk/sekcie/informatizacia/digitalna-transformacia/akcny-plan-digitalnej-transformacie-slovenska-na-roky-2019-2022/index.html

[39] Ministry of Labour, Social Affairs and the Family of the Slovak Republic: *National Programme for Active Ageing 2014-2020.* Available at: https://www.employment.gov.sk/sk/ministerstvo/rada-vlady-sr-prava-seniorov/narodny-program-aktivneho-starnutia-roky-2014-2020.html

[40] Ministry of Labour, Social Affairs and the Family of the Slovak Republic: *National Employment Strategy of the Slovak Republic until 2020.* Available at: https://www.employment.gov.sk/sk/praca-zamestnanost/podpora-zamestnanosti/narodna-strategia-zamestnanosti/

[41] Ministry of Investments, Regional Development and Informatization of the Slovak Republic: *Vision and Strategy for the Development of Slovakia until 2030.* Available at: https://www.MIRRI SR.gov.sk/sekcie/vizia-a-strategia-rozvoja-slovenska-do-roku-2030/index.html

[42] Ministry of Investments, Regional Development and Informatization of the Slovak Republic: *National Investment Plan.* Available at: https://www.MIRRI SR.gov.sk/sekcie/investicie/narodny-investicny-plan/index.html

[43] Government Office of the Slovak Republic: *Draft Energy Policy of the Slovak Republic - new wording.* Available at: https://rokovania.gov.sk/RVL/Material/11327/1

[44] Government Office of the Slovak Republic: *Draft Energy Security Strategy of the SR - modified new wording.* Available at: https://rokovania.gov.sk/RVL/Material/4819/1

[45] Government Office of the Slovak Republic: *Draft National Hydrogen Strategy "Ready for the Future"* Available at: https://rokovania.gov.sk/RVL/Material/26128/1

b) System needs

Insufficient coordination of the main actors leads to fragmentation of the political leadership and administrative framework for innovation support. Regardless of their harmonisation, it is necessary to eliminate the negative effects of a large number of actors on the formulation of national priorities in the field of research, development and innovation, which are often prepared purposefully and not in relation to long-term growth, but rather as an ad hoc response to the current needs. Priorities must reflect the real needs of the economy and the strategic direction of the SR. Thus, they can contribute to the necessary balance between the support of the dominant sector of the economy and the support of industrial diversification, or between the stimulation of foreign investment and the support of domestic firms and unique industries. This is a long-term problem that leads to an unsystematic distribution of support activities across departments, to inconsistencies in the creation of strategic and political materials that are not built on a complementary principle.

c) Economic needs

In the ranking of the European Innovation Index,[46] the consistently undersized parameters in the past years are precisely those that most affect innovation performance. Slovakia has been one of the fastest growing economies in Europe over the past 20 years. This has been mainly influenced by an industrial orientation that enhanced foreign direct investment, has been positively affected by low labour costs, a pro-export orientation of the economy that has developed hand in hand with the relative proximity of suppliers in key industries. In the conditions of the global economy, low-cost economy strategies using the currently still partially existing comparative competitive advantages on the basis of low costs are proving to be unsustainable for the Slovak Republic in the future as well. In particular, growing competition from countries with cheap labour is rapidly devaluing these temporary comparative advantages. On the basis of the above, it is therefore clear that the SR must move towards the sources of advantages that are represented by the knowledge economy in the long term, i.e. the growing innovation potential of enterprises, the quality of human resources, research and technology, which are considered to be the key factors of competitiveness growth. At the same time, however, current trends are putting pressure on the necessary changes through which the Slovak economy will continue to be able to respond to the growing demands of production and competition, both domestically and abroad.

d) Structural needs

When comparing structural differences, Slovakia exceeds the EU average in the share of employment in manufacturing sectors (especially in "mid and high-tech" sectors) and in the share of value added of multinational companies or companies with foreign ownership. In contrast, behind the average EU, we lag behind in real GDP per capita (2019 SR: €15,890, EU average: €28,690)[47] and the share of employment in "knowledge-intensive" services.

Due to its high industrial dependence, especially on car production, Slovakia suffers from a higher emissions output than the EU average. This high share is not only related to the structure of economic production in Slovakia, but is also the result of outdated technologies. Reducing emissions in industry is necessary to meet Slovakia's long-term environmental commitments, as well as those of the EU.

[46] European Commission: *European Innovation Scoreboard 2020.* Available at: https://ec.europa.eu/growth/industry/policy/innovation/scoreboards_en

[47] Statistical Office of the Slovak Republic: *Real GDP per capita.* Available at: http://datacube.statistics.sk/#!/view/sk/VBD_SK_WIN/eu0003re/v_eu0003re_00_00_00_sk

Efficient waste management is a cornerstone of the circular economy, which saves expenditure on resource inputs. Municipal waste recycling rates (including composting) remain low at 23 %, almost half the EU average (45 %) and well below Slovakia's target of 50 % by 2020.[48] Landfills and contaminated industrial sites are also a problem. Global megatrends and their growing energy needs are also increasing pressure to accelerate development and innovation in the energy sector, in order to prepare energy systems for the changes related to modern challenges, including their security.

e) Global megatrends

The COVID-19 pandemic has interfered with global developments and precipitated many systemic changes that were already evident before its emergence. The impact of the crisis has significantly affected the development of many industries. The outlook for the global economic recovery is favourable in 2021 and 2022, but the hallmark of a strong recovery will be unevenness across countries and business sectors. In the context of global trends, the following are significant for Slovakia in the coming period: progress in robotisation and automation of processes, which, given the nature of Slovak industry, will result in the disappearance of a number of routine jobs and, on the contrary, the creation of jobs for a specially qualified workforce, a marked acceleration of digitalisation trends in all areas of society, climate change and related challenges, unfavourable demographic developments related to reduced birth rates, deteriorating health of the population due to long-standing negative factors and the negative consequences of the ongoing global pandemic, which, together with reduced immigration and impeded labour mobility and increased demands on the skills of the workforce, will challenge the future labour market. Given the structure, orientation and interconnectedness of Slovak industry in the European space, it will be crucial for Slovak industry to respond to European strategies and trends. The main pillars of future developments in European industry, as defined by the European Commission in the New Industrial Policy,[49] will be the consolidation of the global leadership of European industry and the strengthening of its strategic autonomy, an increase in competitiveness and the significant participation of European industry in the implementation of plans and strategies for achieving climate neutrality as well as shaping the digital future of Europe. Europe's ambition to become the world's first climate-neutral continent by 2050, as defined in the European Green Deal,[50] will require a transformation of industry and its value chains. The priority is to significantly modernise and decarbonise the energy-intensive industries that are vital to the European economy and that other sectors rely on. To lead this change, Europe needs new industrial processes and more clean technologies to reduce costs and improve market readiness. The ICT sector will contribute to this goal, both as a source of clean technology solutions but also by reducing its own carbon footprint.[51] The transition to a sustainable economic system, the increased emphasis on expanding the circular economy,[52] the push to create a framework for sustainable products, optimising the management of primary raw materials and responsible waste policy are challenges that require the cooperation of all European countries and are a major opportunity to transform Slovak industry and move the Slovak economy forward.

[48] European Commission: *European Semester: Country Report-Slovakia.* Available at: https://ec.europa.eu/info/publications/2019-european-semester-country-reports_en

[49] European Commission: *New Industrial Strategy for Europe COM (2020) 102 final.* Available at: https://eur-lex.europa.eu/legal-content/SK/TXT/HTML/?uri=CELEX:52020DC0102&from=EN

[50] European Commission: *European Green Deal COM (2019) 640 final.* Available at: https://eur-lex.europa.eu/legal-content/SK/TXT/?uri=CELEX:52019DC0640

[51] European Commission: *European Data Strategy COM (2020) 66 final.* Available at: https://eur-lex.europa.eu/legal-content/SK/TXT/?uri=CELEX:52020DC0066

[52] European Commission: *EU's new Circular Economy Action Plan, For a cleaner and more competitive Europe COM (2020) 98 final.* Available at: https://eur-lex.europa.eu/legal-content/SK/TXT/?uri=CELEX%3A52020DC0098

Domain and priority areas selection process

The first vision for the domain was presented to a wide range of representatives from the academic, private and public sectors at an introductory workshop in July 2020. Based on the discussion, the domain name was defined. The representatives present expressed support for some of the proposed directions and priorities for the industry, with divergent views on some between academic and private sector representatives. Based on the comments, the draft vision and priority areas were modified and distributed to representatives of industry and research associations, the 500 Club and universities. Repeated face-to-face and online meetings and discussions were held during July-September 2020 to consolidate the wording and content of the proposed priority areas and their transformation goals. The resulting proposal reflects the stakeholders' comments and also fully correlates with the focus of the destinations supported under the EU's ninth Framework Programme for Research and Innovation HE for Cluster 4 - Industry, ICT, Space. The priority areas within the proposed domains have been validated through an extensive questionnaire survey coordinated by MIRDI SR and CVTI. In the case of the MH SR, an in-house detailed questionnaire was also carried out, which was developed and implemented by the respective domain platform. The results of the survey confirmed the sufficient potential and capacity of the environment to address RDI projects. Verification of the correctness of the vision and priority areas for the domain was carried out through intensive discussions with representatives of research and industry associations and federations and through numerous face-to-face meetings and online EDP workshops, which resulted in adjustments to the definition and focus of the priority areas and the resulting compromise proposal. A continuous and ongoing entrepreneurial discovery process (EDP) is the main essence of the correct definition of priorities and the setting of actions to lead to their fulfilment. Effective mapping of developments and needs of enterprises has to be ensured and evaluated throughout the 2021-2027 period.

3.1.2 Domain goal

The subject of the domain is the transformation of industrial production in Slovakia while meeting the following transformation goals:

- Changing the manufacturing nature of Slovak industry to one based on production and development with a high share of own original innovations and R&D activities, which would significantly increase the added value of production and related services. Innovations should be original (not only adopted from other countries), so that the future position of Slovak producers and suppliers in the subcontracting chain would be competitive and sustainable also on a European scale.
- Measures will be more focused on promoting industry solutions in areas of public interest, such as in particular improving the quality of life of the population and the security of the functioning of the state in crisis situations. Original solutions leading to a significant reduction of the negative environmental impact of industry and an increase in its energy efficiency will certainly find export applications in Europe and will contribute to increasing the added value of Slovak exports.
- A transformed innovation-oriented industry should create and sustain jobs with a high share of creative (intellectually satisfying) work in the long term, which will help to reduce the outflow of the best quality (young) people/experts abroad (brain drain).

Table 1: Domain transformation goal

Domain priority area	Priority area transformation goal
1-1 Automation and robotisation of industrial production, Industry 4.0, ensuring resistance to external influences	Transforming industrial production to a high degree of automation and robotisation in accordance with the objectives of Industry 4.0, supporting the concept of smart factories in industrial production in Slovakia and creating conditions for the production of HW and SW components for the needs of automation in other sectors.
1-2 Processing of raw materials and semi-finished products into higher value-added products	Increasing the added value of exported raw materials and domestically produced semi-finished products by processing them into finished products.
1-3 Progressive technologies and materials	Enabling research and development of original technologies and materials delivering innovative solutions with a high positive impact on society in key areas necessary for the sustainable development of civilisation, thus at the same time fostering the growth of global opportunities for the applicant.
1-4 Increasing energy efficiency in the economy	Achieving a substantial increase in the efficiency of primary energy use by reducing unused waste heat and surplus electricity through research and development of systems for their efficient storage, transmission and use.
1-5 Efficient waste management	Significantly reducing the production of waste and pollutants from industrial activities and create the technological capacity to remove existing environmental burdens and reduce landfilled municipal waste.
1-6 Energy security of the SR	Transforming the energy system of the SR in order to increase energy security, competitiveness and environmental sustainability of the Slovak economy.

3.1.3 Priority Area 1-1: Automation and robotisation of industrial production, Industry 4.0, ensuring resilience to external influences

Transformation goal 1-1

Transforming industrial production to a high degree of automation and robotisation in accordance with the objectives of Industry 4.0, to support the concept of smart factories in industrial production in Slovakia and to create conditions for the introduction of hardware and software components for the needs of automation

Justification for the choice of priority area

Today's industrial production is undergoing a transformational revolution, characterised by the widespread use of information and communication technologies, increasing automation and robotisation of processes, which will enable a high degree of autonomous control in the future. It is essential to respect these trends, but with a higher share of own innovation, so that the benefits of higher added value remain in Slovakia.

Innovative industrial products in the field of automation and robotics will also find applications in other sectors of the economy (healthcare, agriculture, transport), where the future trend towards digitalisation and automation is significant.

The COVID-19 pandemic has highlighted the importance and need for industrial companies to secure their own capacities in a critical situation where foreign imports and exports are being disrupted. It is therefore necessary to develop and implement protective mechanisms to increase the resilience of industry and thus the economy to negative external influences.

Indicative measures to meet the transformation goal (from the EDP)

Table 2: Enabling measures to meet transformation goal 1-1

Measure	Measure description
Support for the introduction of new technologies promoting digitalisation, automation and robotisation of industry	• Support the purchase and import of necessary components and technologies. • Promoting the services to facilitate the introduction of new technologies supporting the digitalisation, automation and robotisation of industry (creation and promotion of DIH, testing and prototyping centres, support for feasibility studies...). • Promoting cooperation between support service providers at national and international level (Horizon, Interreg, EDIH, ...).
Support for R&D activities targeting own original solutions in the priority area	The launch of thematic calls or the introduction of a system of support incentives aimed at encouraging the development and production of own original products, but also of products for other sectors.
Indirect instruments aimed at motivating the achievement of the objectives in the priority area	Introduction of a system of tax concessions or other forms of benefits subject to the fulfilment of pre-selected specific indicators (KPI's).

3.1.3.1 Transformation map of Priority Area 1-1

Development and implementation of automated control systems and the necessary HW infrastructure, in particular the development of robots and robotic handling systems, the development of sensors, monitoring and control systems for the needs of the industry itself, but also for the automation and robotisation of other sectors such as healthcare, agriculture, transport, etc., robotisation, automation and digitalisation of production processes, logistics and warehousing and maintenance and quality control systems (product/process). Therefore, the focus of projects in this priority will be prepared with other domains, while projects in this domain will be mainly targeted at the development of HW and SW products for automation and robotics needs based on the needs defined by other domains.

Figure 1: Transformation map of Priority Area 1-1

Priority area current state

- In today's industrial production, a transformational revolution is underway, with significant automation and digitalisation of processes (Industry 4.0), which will enable a high degree of autonomous control in the future. The Slovak Republic has one of the highest shares of production in the EU in the transport and electronics industries, which will be most affected by automation and digitalisation in the near future, so it is necessary to prepare responsibly for this.

- On the other hand, this state of affairs creates good conditions for the arrival of innovative subcontractors in this area if the right conditions are created for them. Innovative industrial products in the field of automation and robotics will also find applications in other sectors of the economy (healthcare, agriculture, transport), which will not be spared by digitalisation and automation.

- The COVID-19 pandemic has highlighted the importance and need for industrial enterprises to secure their own capacities in a critical situation where foreign imports and exports are being disrupted. It is therefore necessary to develop and implement protective mechanisms to increase the resilience of industry and thus the economy to negative external influences.

Thematic support to meet the priority area transformation goal

Proposals for thematic areas of support for projects in the field of development of automated systems and related HW and SW infrastructure:

- creation of robotic systems (machining, welding, casting, ...) and accessories, HW production;
- creation of robotic systems (machining, welding, casting, ...) new software solutions;
- development of robotic positioning, handling and storage equipment and accessories (production of HW components);
- development of robotic positioning, handling and storage equipment and accessories (new SW solutions);
- SW development for logistics process solutions (process layout, transport, storage, required flexibility, management...);
- development of sensors and monitoring devices for industry, healthcare, agriculture, transport....(new HW);
- development of innovative CNC control systems (SW with corresponding HW equipment);
- development of integration platforms (solution of internal and external integration requirements in any environment, solution of automation and robotisation.

Funding sources to achieve desired outcomes

RRF/OP SK/HE/State budget/participation of beneficiaries with a certain share of own resources.

Foreseen cooperation to achieve desired outcomes

Given the interlinked needs of several ministries in this area, there is a need for their coordinated cooperation in developing support mechanisms and identifying specific themes for targeted support, avoiding duplication and overlapping of activities of individual support agencies. European Research and Innovation Partnerships, which are implemented within the framework of the HE programme.

Priority area outcomes

1. Transforming a substantial part of current industrial production to a high degree of automation and robotisation in line with the objectives of Industry 4.0 to ensure its sustainability and competitiveness in the long term.

2. Creating the conditions for the emergence of competitive products in the field of digitalisation, robotisation and automation with good export potential in the product portfolio of industry in Slovakia on the basis of its own innovations, so that the benefits of higher added value remain in Slovakia.

3. Creating preconditions for subcontracting from Slovak industry (components, sensors, software, automated systems, ...) to facilitate digitalisation and automation in other sectors (healthcare, agriculture, transport) and to ensure sustainability in case of import limitation/failure from abroad.

3.1.4 Priority Area 1-2: Processing of raw materials and semi-finished products into higher value-added products

Transformation goal 1-2

Increasing the added value of exported raw materials and domestically produced semi-finished products by processing them into final products with higher added value

Justification for the priority area selection

Slovakia has a significant potential in the recovery of raw materials currently exported in their raw state or in semi-finished products into final products, such as wood, aluminium, ore and non-ore raw materials, steel plates, cellulose, etc. (including so-called critical raw materials).

Given its own energy mix, Slovakia is also expected to have an electricity surplus in the future. In this case, it will be appropriate to export products in which electricity is embedded, thus creating synergies with the use of domestic raw materials, which will result in higher added value.

Indicative measures to meet the transformation goal (from the EDP)

Table 3: Enabling measures to meet transformation goal 1-2

Measure	Measure description
Promoting production using raw material or semi-finished products from domestic sources	Launching thematic calls or introducing a system of support incentives aimed at promoting production using raw materials or semi-finished products from domestic sources.
Promoting research and development activities	Promoting activities aimed at: - products increasing the added value of Slovak raw materials or semi-finished products, - products decreasing dependence on imports of raw materials and semi-finished products from abroad (thematic challenges, incentives).
Promoting sub-supply chains	Promoting sub-supplier relations in order to increase the volume of processed domestic raw materials or semi-finished products into products with higher added value in Slovakia (respecting the limits of the state aid scheme and potential price dumping).

3.1.4.1 Transformation map of Priority Area 1-2

Projects should aim to increase the finalisation of raw materials or semi-finished products into higher value-added products. This concerns, for example, aluminium, most of which is exported in ingots, die-castings, complex profiles (in Slovakia, among other things, there is no rolling mill, aluminium sheets have to be imported, while they are used by Slovak car companies for the production of car bodies, etc.), innovative products made of domestic steel and iron (pipes, body sheets, dynamo sheets for e-mobility), final processing of wood raw material (furniture, wooden houses, wood as a construction material – composites), processing of magnesite into products with higher added value (fertilisers, metallic magnesium, additives for non-flammable plastics, pharmaceuticals, etc.) and processing of zeolite. Electricity can also be considered as a low value-added raw material, which, in case of surpluses, could be exported and used for the production of energy-intensive products (chemistry, metallurgy) – at the same time, production should ensure the stability of the transmission system (production would be controlled from the currently available energy).

Figure 2: Transformation map of Priority Area 1-2

Priority area current state

- In the former Czechoslovak Socialist Republic, the industrialisation of Slovakia prioritised the preparation of raw materials and semi-finished products for subsequent finalisation in the Czech Republic. After the break-up of the republic, although many final production technologies were imported with the help of foreign investment, the semi-finished products and raw materials produced in Slovakia are used to a small extent and are therefore still exported with low added value. Paradoxically, the final products produced in Slovakia also have a lower added value for this reason. There is therefore significant potential for more efficient valorisation of currently exported raw materials or semi-finished products into higher value-added products. These are mainly commodities such as wood, aluminium alloys, profiles, semi-finished steel, cellulose, etc.).

- Given its own energy mix, Slovakia is also expected to have an electricity surplus in the future. In this case, it will be advisable to export products in which electricity is embedded and thus create synergies with the use of domestic raw materials, which will be reflected in higher added value.

Thematic support to meet the priority area transformation goal

Proposals for thematic areas of support for projects in the field of the finalisation of raw materials and semi-finished products into higher value-added products:

- supporting innovative technologies for processing aluminium into higher value-added products (high-pressure casting of complex structural parts, pressing of special profiles, innovative methods of joining and heat treatment, new methods of sheet and profile forming, 3D printing, powder metallurgy, new product applications of aluminium alloys;
- innovative products made of domestic steel and iron, material and technological innovations with a view to greater use of domestic semi-finished products in domestic automotive production (body panels, electrical sheets, variable thickness sheets, thin-walled profiles, forged parts, hydroforming, etc.);
- processing wood raw material into higher value-added products (timber houses, structural building material, specific wood-based construction material, specific construction materials, furniture, veneers, parquet and cladding);
- processing pulp into higher value-added products (paper industry, toiletries, eco-packaging, consumer durables);
- processing magnesite into higher value-added products (new refractories, flame retardants, use in polymers, agriculture, pharmaceuticals, production of magnesium metal and magnesium products);

Funding sources to achieve desired outcomes

RRF/OP SK/state budget/private sector investment

Foreseen cooperation to achieve desired outcomes

MIRDI SR, ME SR, MESRS SR, MoE SR, higher education institutions, SAS, departmental research, ZMOS (public regional administration), European Research and Innovation Partnerships, which are implemented within HE.

Priority area outcomes

1. Increasing the added value of currently exported raw materials and semi-finished products of domestic production by processing them into finished products.

2. Increasing the share of domestic raw materials in products manufactured in Slovakia.

3.1.5 Priority Area 1-3: Advanced technologies and materials

Transformation goal 1-3

Enabling the research, development and deployment of innovative technologies and materials, delivering innovative solutions with a high positive impact on society in key areas necessary for the sustainable development of civilisation, thereby simultaneously fostering the growth of global opportunities for the applicant.

Justification for the priority area selection

Every company needs to promote innovative solutions with high added value, preferably original ones, in order to achieve long-term competitiveness and sustainability. The outcome of innovation projects must be in line with predefined qualitative and quantitative measurable indicators (KPIs) that have a demonstrably positive socio-economic impact.

Support for original innovations will create the necessary space not only for industry, applied research and development, innovative start-ups, but also for creative young people who will not be forced to go abroad in search of interesting and intellectually satisfying work.

Indicative measures to meet the transformation goal (from the EDP)

Table 4: Enabling measures to meet transformation goal 1-3

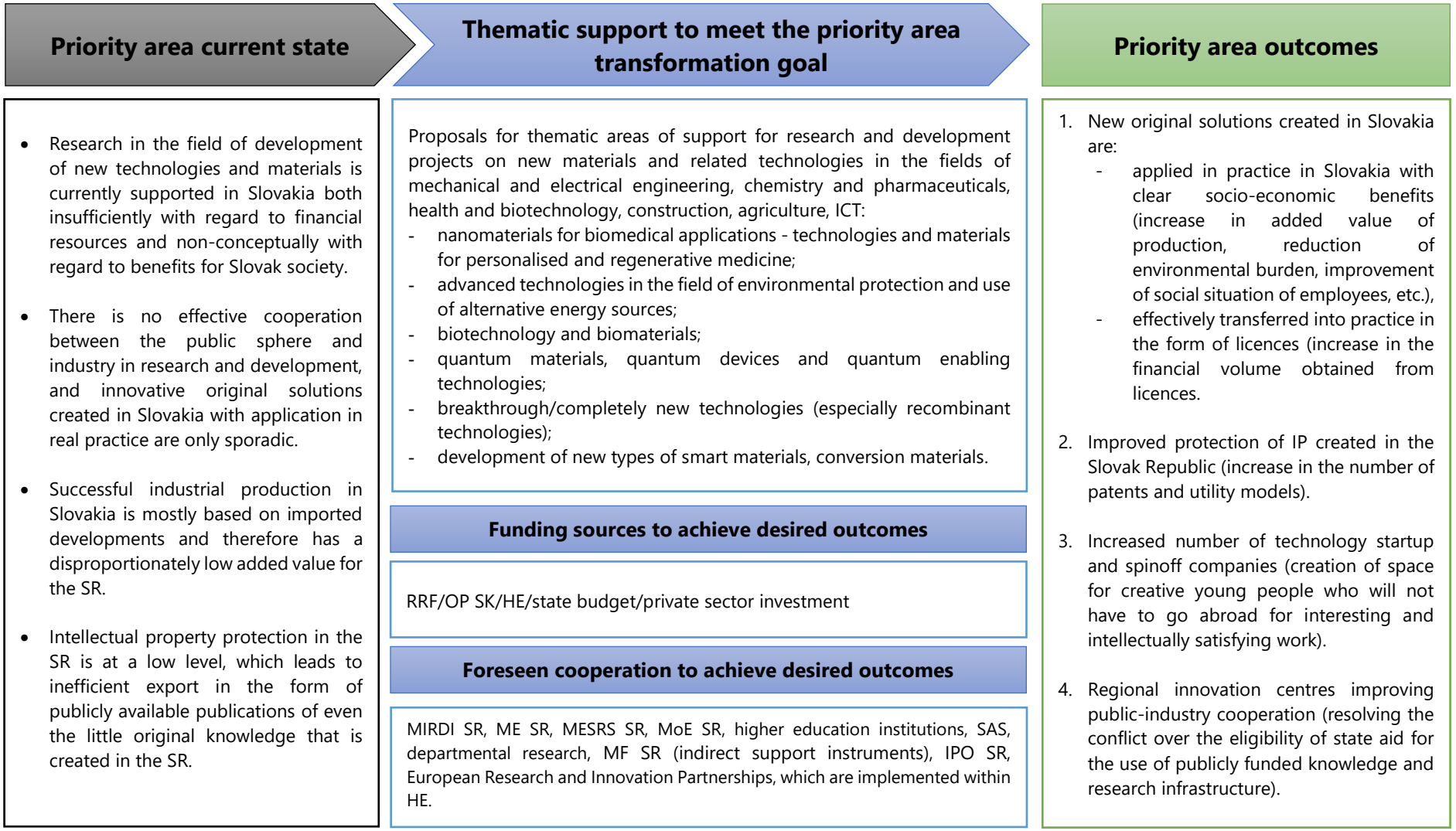
Measure	Measure description
Defining key technologies and materials	Support for activities aimed at identifying key technologies and materials for the development of Slovak society (technology foresight, etc.).
Research and development of original technologies and material solutions in key areas (KETs) declared by the EU	• Launch of thematic calls correlated with the HE calls and focused on KETs • Support tools to strengthen the involvement of Slovak entities in specific HE calls and partnerships
General support for original technological solutions	Support tools for the creation of original solutions that demonstrably deliver predetermined qualitative and quantitative measurable indicators (KPIs) with a clear positive socio-economic impact.
Effective support for intellectual property protection and technology transfer	Licencing support, promoting the development of startup and spinoff companies, creation of regional innovation centres).

3.1.5.1 Transformation map of Priority Area 1-3

Projects should focus on research and development of new materials and technologies that are considered to be key enabling technologies (KETs) for the further sustainable development of civilisation. EU strategic materials can be used as a guide to determine whether or not a technology or material is a key enabling material. Under this priority, projects will address problems in all industrial sectors (mechanical, electrical, chemical, pharmaceutical, biotechnology, construction) but also in sectors outside industry (new materials and technologies for health, agriculture, ICT, etc.), and the terms of reference will be jointly communicated with the relevant domains. In order to improve the opportunities for Slovak entities to engage in international cooperation, it is planned to announce calls at national level parallel to the H2020 calls, which would serve to prepare Slovak entities for competitive

participation in international consortia addressing KETs. Such participation will support the import of the necessary know-how to Slovakia and objectify the real needs of the global market and the current possibilities to meet them.

Figure 3: Transformation map of Priority Area 1-3



3.1.6 Priority Area 1-4: Increasing energy efficiency in the economy

Transformation goal 1-4

Achieving a substantial increase in the efficiency of the use of waste energy in the form of heat and electricity by researching and developing systems for their efficient storage, transmission and use, as well as reducing the total amount of waste energy produced.

Justification for the priority area selection

Energy efficiency can be improved in two ways, firstly by reducing the energy intensity of industrial processes, and secondly by making better use of the available energy through an appropriate energy mix with minimisation of surplus energy that is unnecessarily released into the environment. It is therefore necessary to promote in particular solutions that reduce the overall primary energy demand with a minimum of conversion processes and the use of all available forms, in particular excess heat. Converting buildings to heat using low-potential heat and supplying it from available sources where it is not used would significantly reduce the negative effects of burning low-quality fossil fuels and waste for heating.

Surplus energy needs to be stored in some form for future needs or put into energy-intensive products with a higher added value than the energy itself.

Indicative measures to meet the transformation goal (from the EDP)

Table 5: Enabling measures to meet transformation goal 1-4

Measure	Measure description
Reducing energy consumption in enterprises	Supporting the projects leading to a reduction of the total primary energy demand in enterprises with a minimum of conversion processes and the use of all available forms, in particular surplus heat.
Reducing the energy intensity of processes by using innovative technologies	Supporting the research and development of equipment and technologies to reduce the energy intensity of processes in general in all sectors of society, with an emphasis on technologies to reduce the energy intensity of buildings and technologies for the use of waste heat.
Research and development of efficient ways to store surplus energy	Supporting the projects aimed at storing surplus energy and using it at another time or place, including the development of electric and thermal batteries, the production of alternative fuels, hydrogen, etc.
Promoting research and technological solutions enabling optimal use or storage of surplus energy produced in industry	Promoting the energy interconnection of industrial buildings with the surrounding community environment aimed at the optimal use or storage of surplus energy produced or usable in both sectors.

3.1.6.1 Transformation map of Priority Area 1-4

Research and development of devices capable of capturing heat (including low-potential heat) and storing it in a suitable carrier, development of heat storage using phase change materials, economic heat transfer technologies, technologies and equipment for efficient heating of buildings with low-potential heat, including low-cost retrofitting of low-quality buildings, development of new electric batteries and charging infrastructure, development of efficient hydrogen production and the necessary distribution and pumping infrastructure, development of alternative fuels from CO2 and hydrogen

(methanol and derivatives), development of ammonia from nitrogen and water, development of reversible energy storage based on metallic energy carriers (magnesium, aluminium) and related technologies.

In the area of the development of alternative energy carriers to fossil fuels, there is an overlap with the Mobility for the 21st Century domain, with research and development of technologies and related equipment in this priority, and their use in modern transport systems in the Mobility domain.

Figure 4: Transformation map of Priority Area 1-4

Priority area current state

- The SR is one of the EU countries with the highest share of industrial production in GDP; however, the high share of metallurgical and engineering production creates very high energy demands and associated negative environmental consequences (production of aluminium, steel, ferro-alloys, cement, magnesite processing, cellulose, foundry).
- Older processes often use energy inefficiently with significant losses, mainly through the production of unusable heat that is uselessly released into the atmosphere. There is also a high consumption of fossil fuels, especially gas in the energy mix, which is associated with excessive emissions. Rising energy prices and emission charges may in the future significantly worsen the competitiveness of this type of production, with serious economic and social consequences for Slovakia.
- A serious problem in Slovakia is also the high energy consumption in heating buildings, associated with excessive use of fossil fuels but also low-quality fuels, including waste, while the production of unused heat in industry and electricity generation exceeds the heat demand for heating several times.

Thematic support to meet the priority area transformation goal

Proposals for thematic areas of project support:

- projects aiming at an overall reduction of primary energy demand at company level (optimal energy mix);
- equipment and technologies to capture the waste heat (including low-potential heat) into suitable carriers/tanks for its further use at an appropriate time and place (e.g. thermal batteries with phase change heat storage, etc.);
- technologies and equipment for efficient low-potential heat recovery heating of buildings;
- economical retrofitting/insulation of old buildings (low-energy renovation);
- development of cogeneration systems for electricity production (with low heat rejection);
- new ways of storing unconsumed electricity and related infrastructure:
  - electric batteries, capacitors and charging infrastructure;
  - efficient hydrogen production and the necessary distribution and refuelling infrastructure;
  - production of alternative fuels using surplus energy (methanol, ammonia and derivatives);
  - energy storage for the production of energy-intensive raw materials (use of electrolysis, plasma, etc.);
  - solar energy accumulation.

Funding sources to achieve desired outcomes

RRF/OP SK/HE/state budget/private sector investment/public investment

Foreseen cooperation to achieve desired outcomes

MIRDI SR SR, ME SR, MESRS SR, MoE SR, higher education institutions, SAS, departmental research, MF SR (indirect support instruments), ZMOS (public regional administration), European Research and Innovation Partnerships, which are implemented within HE.

Priority area outcomes

1. Significant reduction of primary energy requirements in the economy coupled with a significant reduction of negative environmental impacts (reduction of CO2 emissions and waste heat)
2. Creation of original competitive product and technological innovations usable in reducing energy requirements (with high added and export value)
3. Better use of available energy through an appropriate energy mix with minimisation of surplus energy that is unnecessarily released into the environment
4. Elimination of the negative effects of burning poor quality fossil fuels and waste in heating buildings by better use of industrially produced waste heat
5. Creation of new opportunities for efficient storage of surpluses for future needs

3.1.7 Priority Area 1-5: Efficient waste management

Transformation goal 1-5

Significant reduction of production of waste and pollutants from industrial activities and create the technological capacity to remove existing environmental burdens and reduce the amount of landfilled municipal waste.

Justification for the priority area selection

The impact of industrial production on the environment relates mainly to emissions of pollutants into the air, water, soil and rock environment, the consequences of accidents and the production of waste, of which industry is the largest producer, as well as the high demands on primary energy. At the same time, industrial production consumes natural resources and takes land.

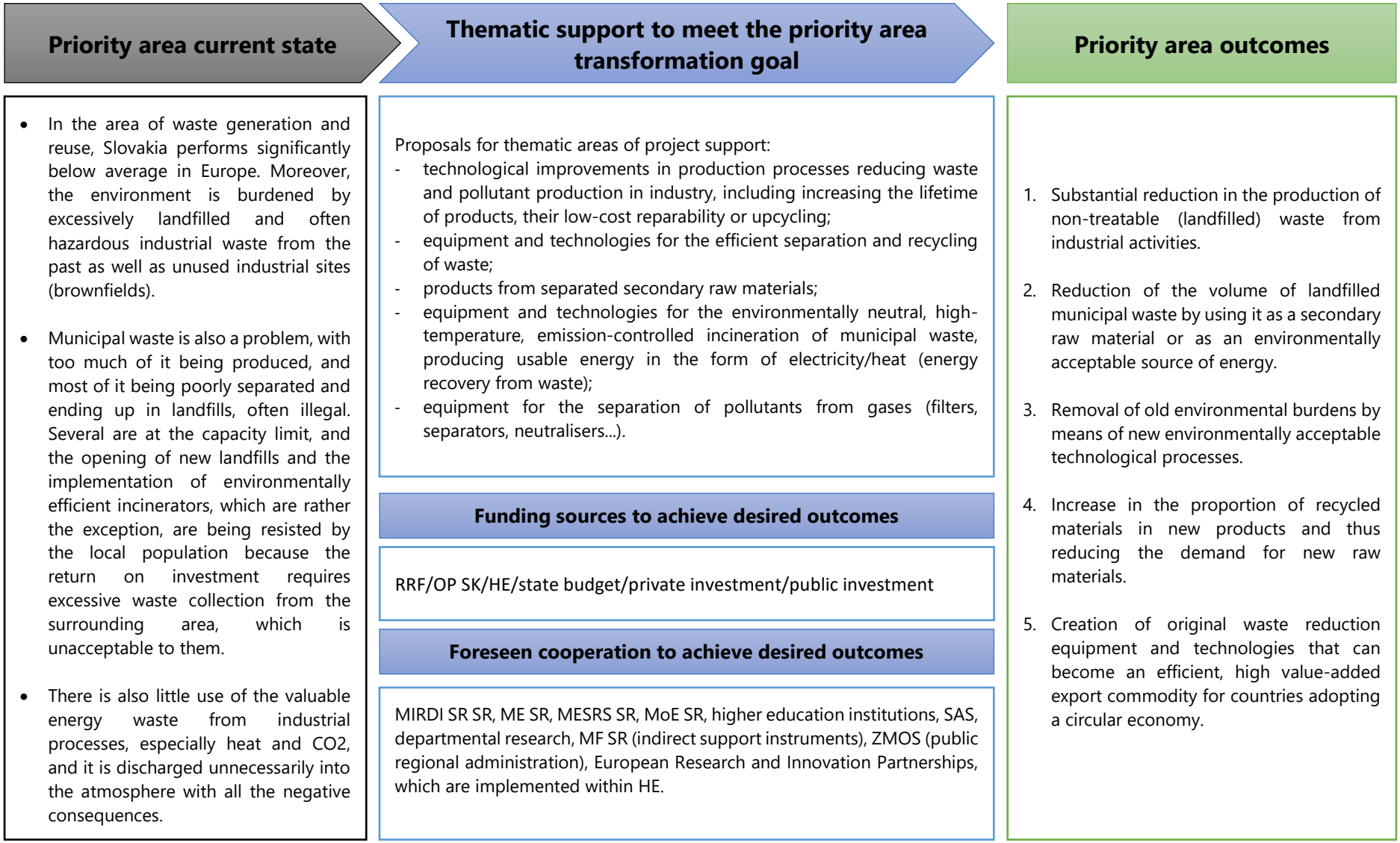
In addition to minimising the environmental impact of industrial production, there is also an opportunity for industry to seek development and technological solutions for, for example, the treatment, recycling or alternative use of various types of waste and secondary raw materials. The development of new technologies for waste separation, recycling of secondary raw materials or new alternative uses of products will, in addition to reducing the negative environmental impacts of non-organic landfilling, also provide an opportunity in the form of a relevant export commodity with high added value, which has the potential for growing demand in countries transforming to a circular economy.

Indicative measures to meet the transformation goal (from the EDP)

Table 6: Enabling measures to meet transformation goal 1-5

Measure	Measure description
Reducing the amount of non-recyclable, landfilled waste	• Supporting the projects leading to the minimisation of non-recyclable waste. • Supporting the research and development of new equipment and technologies enabling the reuse of currently untreatable waste.
Increasing the volume of separated and recycled waste	Supporting the research and development of equipment and technologies for the efficient separation and secondary treatment of waste, including support for the production of products from raw materials derived from waste.
Harnessing energy from environmentally neutral ways of eliminating municipal waste	Supporting the research and development of technologies for environmentally neutral, high-temperature, emission-controlled incineration of municipal waste, producing usable energy in the form of electricity and/or heat, with an emphasis on smaller plants not requiring large investments and volumes of municipal waste to be treated.
Supporting the research and development of equipment for the efficient capture of CO2 for its further use	Supporting the research and development of equipment for the efficient capture of CO2 for its subsequent conversion to alternative fuels.
Supporting the development of energy storage technologies into higher value-added products	Supporting the research and development of technologies for the efficient storage of surplus electricity or heat in energy-intensive products with a higher added value than the energy itself.

Figure 5: Transformation map of Priority Area 1-5



3.1.8 Priority Area 1-6: Energy security of the Slovak Republic

Transformation goal 1-6

Transforming the energy system of the SR in order to increase energy security, competitiveness and environmental sustainability of the Slovak economy.

Justification for the priority area selection

Increasing the share of renewable energy sources and the creation of a single pan-European market are increasing the demands on system management and maintaining a sufficient level of security of the electricity system (hereinafter referred to as "ES").

Under these conditions, it is necessary to carry out research activities leading to the implementation of intelligent systems for efficient management of both consumption and supply of energy to ensure a balanced balance of production and consumption in the ES.

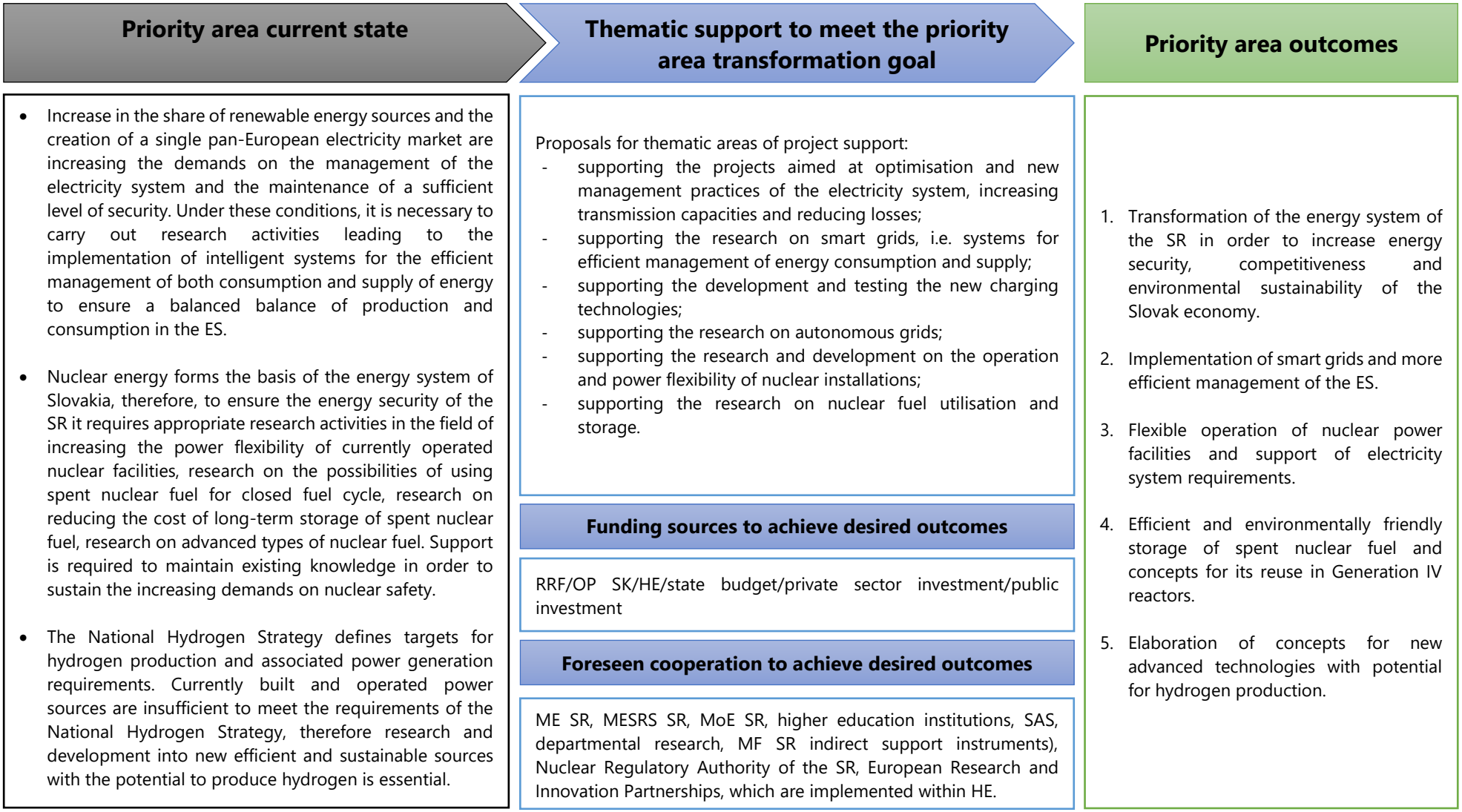
Nuclear energy forms the basis of the energy system of Slovakia; therefore, it requires appropriate research activities in the field of increasing power flexibility in currently operated nuclear facilities, research on the possibilities of using spent nuclear fuel for closed fuel cycle, research in the field of reducing the cost of long-term storage of spent nuclear fuel, research on advanced types of nuclear fuel.

Indicative measures to meet the transformation goal (from the EDP)

Table 7: Enabling measures to meet transformation goal 1-6

Measure	Measure description
Maintaining competence for nuclear safety and decommissioning	The Government should adopt a document setting out a national policy and strategy for security and provisions to ensure that competence for nuclear security is maintained.
Ensuring continued research funding for energy	The energy sector is part of the country's critical infrastructure and the government's role is to support research into low carbon and clean energy technologies.
Human resources in the energy sector	Ensuring continued support for energy education, improving support for higher education in energy, making energy education more attractive.
Completing the infrastructure	Ensuring the completion of infrastructure for research purposes in the field of energy, providing support for the funding of infrastructure included in ESFRI.

Figure 6: Transformation map of Priority Area 1-6



Examples of research capacities available within the domain priority areas

Slovak Academy of Sciences - Institute of Geotechnics, Institute of Materials, Institute of Materials and Machine Mechanics, Institute of Materials Research, Institute of Inorganic Chemistry, Institute of Forest Ecology, Institute of Construction and Architecture, Earth Science Institute, Institute of Inorganic Chemistry, Institute of Physics, Institute of Electrical Engineering, Institute of Experimental Physics, Institute of Informatics, Institute of Measurement Science, Institute of Electrical Engineering, Institute of Mathematics, Biomedical Research Centre, Institute of Chemistry, Polymer Institute, Institute of Construction and Architecture, Institute of Inorganic Chemistry, STU, UK, UPJŠ, TUKE, UNIZA, TNUAD, TU in Zvolen, Technical University of Košice - Faculty of Materials, Metallurgy and Recycling, Faculty of Mining, Ecology, Process Control and Geotechnologies, Faculty of Mechanical Engineering, Medical University Science Park Medipark, University Science Park Technicom, Pavol Jozef Šafárik University in Košice (UPJŠ), Technology and Innovation Park, Slovak University of Technology - Faculty of Mechanical Engineering, Faculty of Chemical and Food Technology, Electrotechnical, Research and Design Institute, Prototyping and Innovation Centre, National Centre of Robotics, Faculty of Materials Science and Technology, Faculty of Chemical and Food Technology, Faculty of Electrical Engineering and Informatics, Faculty of Mechanical Engineering, Technical University in Zvolen - Faculty of Wood Sciences and Technology, University of Žilina in Žilina - Faculty of Mechanical Engineering, Research Centre, CEIT, Alexander Dubček University of Trenčín and other private and public research institutions active in the field that can contribute to the fulfilment of the objectives of the priority area

Estimation of potential customers in application practice for domain priority areas

- Direct users (applicants and project promoters);
- Customers across all sectors of industry and economy;
- Customers in related domains (healthcare, agriculture, mobility, ICT...).[53]

[53] Applicable to all priority areas of the domain.

Mobility for the 21st century

3.2 Mobility for the 21st century

3.2.1 Justification for the domain

Transport is an important sector for the economic development of the country, its regions and municipalities. It enables the movement of goods and people, creates opportunities for trade, services, work and recreation, and enhances the quality of life of people. The mass expansion of the use of motorised means of transport is one of the most important socio-economic transformations of the last century (automobile transition) and has contributed to the development of the socio-technical system. The value chain and production chain of the domain are dynamically developing and undergoing changes. They are responding to the demand for increased performance generated by the deepening globalisation of economic activities, to demographic changes, also to the ongoing digital transformation of society and the increasing use of innovation.

New or Future Mobility integrates innovative technologies, solutions and services from different sectors that will bring significant changes to individual and public mobility (e.g. automated vehicles, peer-to-peer sharing applications, internet of things). They are already delivering and will continue to deliver unique solutions that reflect the changing needs of passenger and freight transport and their relationship to transport assets (smart products), systems (smart services and smart data), assets as well as physical and digital transport infrastructure (connected spaces).

Current R&D and innovation activities around the world focus on environmentally sustainable ("clean"), accessible,[54] inclusive, safe and resilient mobility, mobility based on multi-modal chain interoperability and interconnected intelligent transport systems.

Industry and services in the SR have the opportunity to transform themselves to the production-development or development-supply level through the developed production-technical capacities for the manufacture of road, rail and small air transport vehicles. The sector needs to respond to current trends and improve resilience to factors of increasing uncertainty.

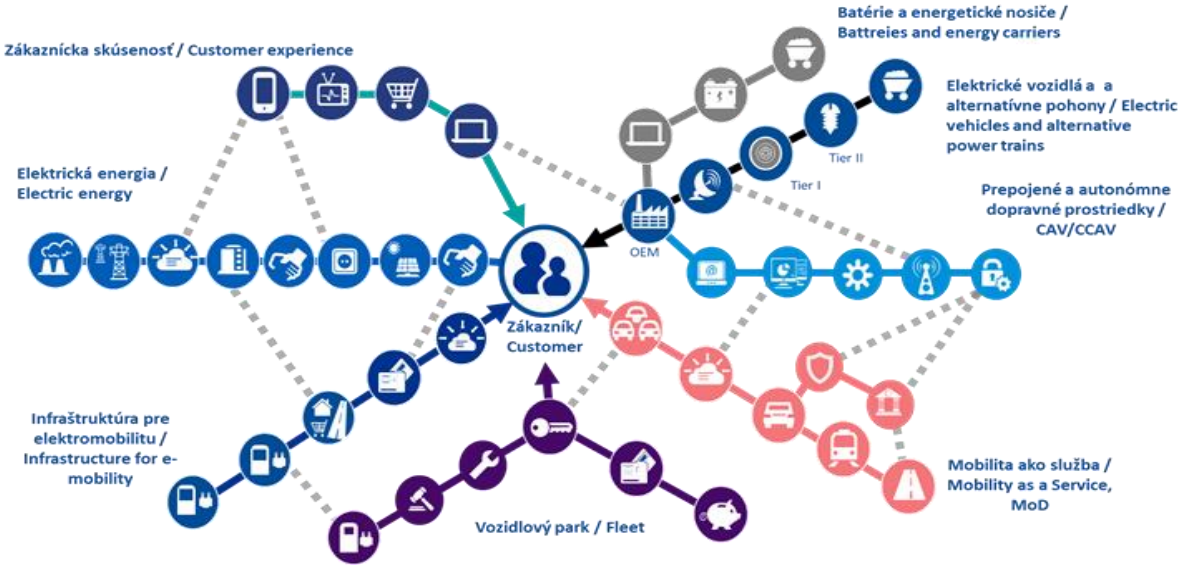
The ambition of the SR is to support the creation of value-added jobs in sectors where it has the potential to grow, thus contributing to its position as a respected player in innovation in smart and new mobility, at least on a Central European scale. The SR also needs to connect to the emerging activities of powerful global players who are setting future trends and prepare for the disruptive changes expected in the period 2030-2050. The SR aims to motivate both domestic and foreign actors to cooperate in the mobility ecosystem, which will increase competitiveness, supply and take-up of products and services in this domain.

Domain definition

We understand mobility as a complex value chain linking transport with industries and services targeted at the user, taking into account the social aspects, needs and requirements of people and organisations. Given the increasing complexity, sectoral interconnection and digital transformation, it is important to develop efficiency in mobility using digital data tools, which can be defined as smart mobility. It has great potential to reduce or mitigate the consequences of accumulating social, economic and environmental problems related to transport (increasing capacity, environmental and social externalities) and to contribute to a functioning transport system with a modern multimodal and safe transport infrastructure.

[54] Introducing greener, cheaper and healthier forms of private and public transport, decarbonising the energy sector (European Green Deal).

Figure 7: Mobility value chain



Source: KPMG

Strategy and policy materials of the SR relevant to the domain area

- Concept of the development of water transport in the Slovak Republic (MTC SR, GR 469/2000);
- Development of public passenger transport before individual transport (MTC SR, GR 675/2008);
- Programme of support for the development of smart transport systems (MTC SR, GR 22/2009);
- Strategy for the Development of Transport in the SR until 2020 (MTC SR, GR 158/2010);
- Strategy for the improvement of road traffic safety in the SR in 2011-2020: National Plan of the Slovak Republic for BECEP 2011-2020 (MTC SR, Government of the SR, GR 798/2011);
- Strategy for the development of tourism until 2020 (MTC SR, GR 379/2013);
- National Strategy for the Development of Cycling Transport and Cycling Tourism in the Slovak Republic (MTC SR, GR-11993/2013);
- Research and Innovation Strategy for Smart Specialisation of the Slovak Republic (RIS3) for the period 2014-2020 and the domains: Industry for the 21st Century, Digital Slovakia and Creative Industry, Means of Transport for the 21st Century (ME SR a MESRS SR, November 2013, GR 665/2013);
- Strategy for the development of public passenger and non-motorised transport in the Slovak Republic until 2020 (MTC SR, GR 311/2014);
- Strategic plan for the development of the transport infrastructure of the SR until 2020 (MTC SR, GR 311/2014);
- Strategy for the development of electromobility in the Slovak Republic and its impact on the national economy of the Slovak Republic (ME SR, GR 504/2015) and Action Plan for the development of electromobility in the Slovak Republic (ME SR, GR 4987/2019);
- National policy framework for the development of the alternative fuels market (ME SR, GR 504/2016);
- Promotion of innovative solutions in Slovak cities – Concept for support of Smart City projects (concept paper ME SR, 2017);
- Smart Industry Concept for Slovakia (ME SR, GR 490/2016) and Smart Industry Action Plan for the SR (ME SR, GR-33624/2018);
- National Action Plan for Green Public Procurement in the Slovak Republic for 2016-2020 (MoE SR SR, GR 590/2016);

- Strategic Plan for the Development of Transport in the SR until 2030 (MTC SR, GR 13/2017);
- Good Mobility Manual (MTC SR, March 2018);
- Greener Slovakia Environmental Strategy (MoE SR SR/IEP, GR 87/2019);
- Measures to remove barriers to the sustainable development of the automotive industry in Slovakia, including the supply network (ME SR, GR 185/2019);
- Integrated National Energy and Climate Plan for 2021-2030 (ME SR, GR 606/2019);
- Operational Programme Integrated Infrastructure 2014-2020 (MTC SR, MIRDI SR and MESRS SR, ME SR, version 9.0, November 2020);
- Evaluation of the traffic safety situation for 2018-2020 according to ISDN data (Presidium of the Police Force of the Slovak Republic, 2019-2021);
- Report on the implementation of priorities and objectives of the Updated National Regional Development Strategy of the Slovak Republic for 2019 (MIRDI SR, informative document, GR 26686/2020);
- Report on the state of research and development in the Slovak Republic and its comparison with foreign countries for 2017-2019 (MESRS SR, informative document, 2018-2020);
- Long-term plan for the development of smart mobility in the Slovak Republic until 2030 and related action plans under preparation (MTC SR, MIRDI SR, in preparation);
- Concept for the development of water transport in the Slovak Republic until 2030 to 2050 (MTC SR, in preparation);
- National Hydrogen Strategy "Ready for the Future" (ME SR, June 2021).[55]

European and international strategic and policy materials relevant to the domain area

- Action Plan on Urban Mobility, COM 2009/490;
- A strategy for smart, sustainable and inclusive growth (2010);
- Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system COM/2011/0144 – EC, 2020;
- Framework Strategy for a Resilient Energy Union with a forward-looking climate change policy (2015);
- Paris Agreement under the United Nations Framework Convention on Climate Change (2015);
- Cooperative Mobility Systems and Automated;
- Driving: Summary and Conclusions (ITF-OECD, 2016);
- European Strategy for Low Emission Mobility EC (2016) 501;
- Strategic Transport Research and Innovation Agenda (STRIA) (EC, 2017);
- Europe on the Move (mobility packages I, II and III, 2017);
- European Environmental Convention, European Green Deal (COM(2019) 640 final) European Climate Pact (2020);
- European Data Strategy COM (2020/66);
- EC Sustainable and Smart Mobility Strategy (2020)789;
- Decision (EU) 2020/2228 of the European Parliament and of the Council of 23 December 2020 on a European Year of Rail (2021);
- Smart Cities and Inclusive Growth (OECD, 2020);
- Smart Cities, Smart Investment in Central, Eastern and South-Eastern Europe (EIB, 2018);
- ITF Transport Outlook 2019 (OECD, 2019);
- The State of Industry X in Automotive (Smith, B. et al. 2020. Center for Automotive Research);
- Connecting Europe Facility (CEF).

[55] Ministry of Economy of the Slovak Republic: *National Hydrogen Strategy "Prepared for the Future"*. Available at: https://rokovania.gov.sk/RVL/Material/26128/1

Justification for the domain selection

a) Current needs in the SR

The needs in relation to the current problems of the SR include the area of legal norms and regulations, technological (un)readiness of physical and digital transport infrastructure, programme management of the smart specialisation agenda at individual levels, in the concentration of support and development especially in road transport, but also in the development of the country's competitiveness and its new orientation towards sustainable economic development.

Table 8: Needs of Slovakia affecting the Mobility domain

Area	Problems and needs
Legal standards and regulations	Legislation and regulations not reflecting adequate technological progress and the requirements of the IPR protection agenda (duration of processes, unpreparedness of central authorities in accepting requirements for innovative practices, pilot and demonstration activities).
State of physical and digital transport infrastructure	Level of current development and in particular modernisation debt in the transport infrastructure, condition and safety of the railway infrastructure, incomplete system of the D/RC network, different standards of deployed technologies such as sensors, condition of bridges and congestion of class II and III roads, non-allocation of available resources according to relevant and achievable objectives and priorities, unresolved cross-border sections with regard to interoperability, etc.).
Programme management of the smart specialisation agenda at national and regional level	Weak or absent interconnectedness of different areas of use of smart solutions, weak linkage of public policy making to data (data driven policy) and foresight.
Sustainability of economic development	Stagnation of competitiveness in the domain.
	Disadvantageous position of the SR in the global domain production chain (integrated periphery).
	Lagging innovation activities in domain enterprises and low share of jobs in R&D compared to CEE and developed EU countries.
Supportive environment for the development of innovation in mobility	Lack of cooperation tools and platforms for more comprehensive and synergistic support of the RDI domain, lack of coordination between upcoming investment and RDI projects.
	Lack of medium-term (inter)departmental approaches to research, development and innovation, which is also a consequence of a fragmented support environment and leadership (Chief Smart Mobility Agenda Officer).
Negative environmental impacts of transport	Transport emissions have been rising continuously since 2015 for CO2, TPM, PM10 and PM2.5.

b) Global megatrends

Globally, there is an intensive sectoral interconnection of mobility (transport) with digitalisation, energy and environmental protection (cut-across/coupling). This is apparent in the ever-deepening trend

towards electrification of mobility, the development of alternative fuel propulsion, gradual emergence of functional prototypes and the uptake of connected, automated and autonomous vehicles, the use of artificial intelligence, Mobility as a Service (MaaS), Mobility on Demand (MoD), an increasing demand for personalisation of the product portfolio of vehicle manufacturers, Smart Industry (Advanced Manufacturing) or in the penetration of the Internet of Things (IoT) in all the areas of RDI.

Then there are societal changes and needs brought about by growing urbanisation, public health and safety issues for travellers, and the possibilities of teleworking (work from home) on a large scale also due to the COVID-19 pandemic. These trends naturally affect the mobility ecosystem in Slovakia.

Table 9: Global trends affecting the Mobility domain

Megatrend	Area	Description of problems and needs
Electrification and transport decarbonisation	Infrastructure facilitating the use of electrified drives	Slow development of infrastructure needed for the use of electrified drives, whereby in the coming years, the electrification of road passenger transport is expected to swiftly accelerate.
		Insufficient capacity and slow replenishment rate of energy carriers in energy storage, distribution and replenishment systems.
	Low-emission alternative energy transport propulsion	Utilisation rates of carbon-free and low-carbon drives in practice.
	Transport infrastructure and connected/smart cities	The state of readiness of the physical and digital transport infrastructure for a routine operation of innovative transport products.
	Transition to sustainable transport modes	Lack of development of multimodal access.
Using innovation in transport	Cooperative, connected and automated transport	The pace of the implementation of smart, autonomous driving assistance systems and the development of smart transport and mobility systems.
		The ability of industry, technology companies and future mobility operators to deploy vehicles with ever higher levels of autonomous and connected driving and to build the necessary active infrastructure.
	Smart mobility and services	Acceptance of the smart mobility concept by the general public.
		Improvement and interconnection of traffic control systems across all modes of transport.
Vehicle design and manufacture		Matching technological advances in the development of connected and smart mobility management systems, the use of environmentally sustainable drives and the application of MaaS (Mobility as a Service) delivery models to individual and institutional customers in practice.
		A trend towards deconcentrating production capacities of large producers is also envisaged.

Domain and priority areas selection process[56]

In addition to the common steps of the EDP process, in particular workshops, the design of the domain and its priority areas have been the topic of an ongoing cross-sectoral discussion with a team of experts. It consists of the experts from academic institutions, industrial and technology companies, civil society, associations, together with the state administration, who also cooperate in developing the Smart Mobility Slovakia platform.

The development of smart mobility in Slovakia, as well as competitiveness and R&D and innovation activities in enterprises, determines the way in which the leading sector of the Slovak economy – transport engineering (automobiles, railways and other means of transport) is being transformed. However, without the implementation of trends brought about by smart mobility, the industry loses its competitive advantage and the chance to maintain a sufficient pace of innovation.

Sectoral cooperation plays a key role in the transformation, with the public sector (state administration) playing an important role in triggering and creating a supportive environment through the development of legislation and the design and support of public policy for the development of this domain and R&D.

3.2.2 Domain goal

The domain's ambition is:

- Streamlining the use and networking of the already built and planned RDI capacities in the domain (IPCEI, RDCs, CCs, demonstration centres, specific and shared R&D infrastructure and the relevant ESFRI implemented and upcoming projects with Slovak participation, including the European Research Infrastructure Sharing Plan);
- Reducing the fragmentation of research teams and a more efficient networking of the RDI ecosystem at the level of research teams, projects and institutions in this domain;
- Improving existing networks, fostering new industry and service linkages with RDI organisations and relevant public sector actors (in particular, central government institutions, counties, cities, state agencies and businesses);
- Improving coordination of public investment in RDI infrastructure;
- Improving the quality and availability of human resources for RDI in the domain;
- Improving the evaluation of the system performance and of specific actors in the domain;
- Taking into account the cross-cutting nature of the issue and promoting the implementation of comprehensive and interdisciplinary research projects addressing current social issues;
- RDI programmes and project support in the domain are intended to facilitate combining STEM, biomedical as well as economic and social sciences and the development of comprehensive solutions;
- Efficient linking between European and domestic mobility research and innovation policies through a technology roadmap, an innovation and implementation strategy, and a regulatory framework for smart mobility.

[56] The domain is coordinated by a team led by a domain coordinator from MIRDI SR (Smart Mobility Department) and a co-coordinator from the Ministry of Economy SR (Industrial Policy Department) in cooperation with the visionaries representing the academic sector (STU in Bratislava) and the private sector (AIA SR, AIUT SR and M2M Solutions).

Table 10: Domain transformation goal

Domain priority area	Domain transformation goal
2-1: Connected and autonomous mobility	Setting up conditions for the operation of connected, automated and autonomous modes of transportation to promote further development of related sectors.
2-2: Smart mobility and smart transport system services	Ensuring a widespread and affordable use of smart mobility services for passenger and freight transport.
2-3: Decarbonisation of mobility	Preparing Slovakia's territory for a widespread deployment of alternatively fuelled vehicles and energy carriers under normal operation.

3.2.3 Priority Area 2-1: Connected and autonomous mobility

Transformation goal 2-1

- Setting up the conditions for the usage of connected, automated and autonomous means of transport in order to promote further development of related sectors;
- Advance preparation of the ecosystem and conditions for testing connected, automated and autonomous solutions across different transport modes to improve safety and efficiency;
- Setting up conditions for the validation of connected, automated and autonomous technologies in terms of their behaviour compared to human-controlled means of transport and their integration with the transport system;
- Setting up socio-economic conditions, including societal acceptance of connected, automated and autonomous technologies.

Justification for the priority area selection

- Promoting the transformation of industry to the production-development and development-innovation stage;
- Improving transport safety;
- Increasing traffic flow and reducing congestion;
- Reducing emissions and the harmful effects of transport on the environment and related climate change;
- Societal readiness for the deployment of automated means of transport (Slovakia does not meet the criteria and is not included in international comparisons, e.g., among the TOP 30 countries of the AVRI index), including legislative and regulatory instruments;
- Advance preparation of education system for the market demand for new professions related to new mobility (e.g. smart mobility planning, remote driver for autonomous vehicles, engineering specialist for R&D, etc.).

Indicative measures to meet the transformation goal (from the EDP)

Table 11: Enabling measures to meet transformation goal 2-1

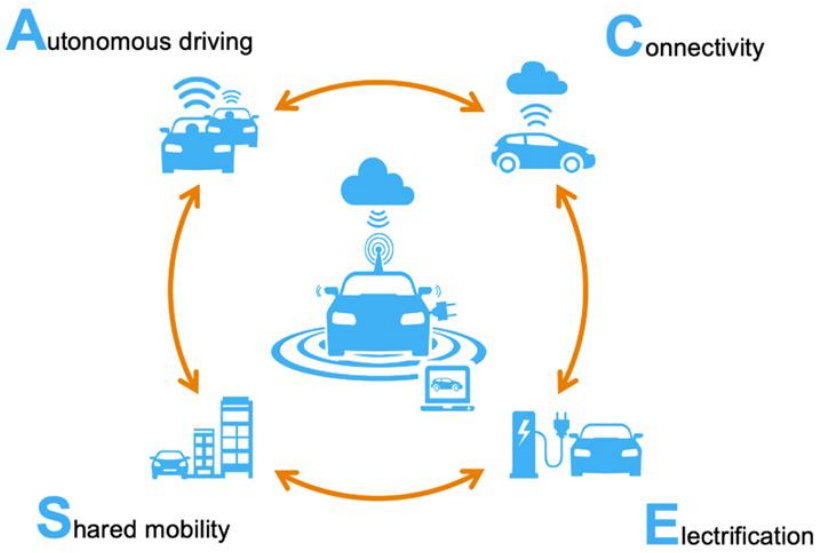
Measure	Measure description
Promoting investment in research, development and	Activities aimed at supporting RDI projects focusing on different phases of TRL connected, cooperative and automated mobility, incubation, validation, testing of smart solutions of transport of people and goods, creation of tools for real and/or

Measure	Measure description
innovation of connected and autonomous mobility products	virtual testing of connected, autonomous and automated vehicles (hereinafter referred to as "CAVs").
Promoting technology transfer, social innovation, eco-innovation, public service applications in transport infrastructure	Activities connecting the investment preparation of transport infrastructure, especially the digital part of the front and back offices with scientific research and innovation activities and technology transfer, assessment of the state and preparation of physical and digital transport infrastructure for the introduction of CAVs, popularisation of the issue in professional community.
Promoting integration technical solutions for new mobility	Research, development and implementation of technical solutions based on partially autonomous and fully autonomous solutions across all transport modes, in their combinations and interconnections in order to optimise the transport of people and goods.

3.2.3.1 Transformation map of Priority Area 2-1

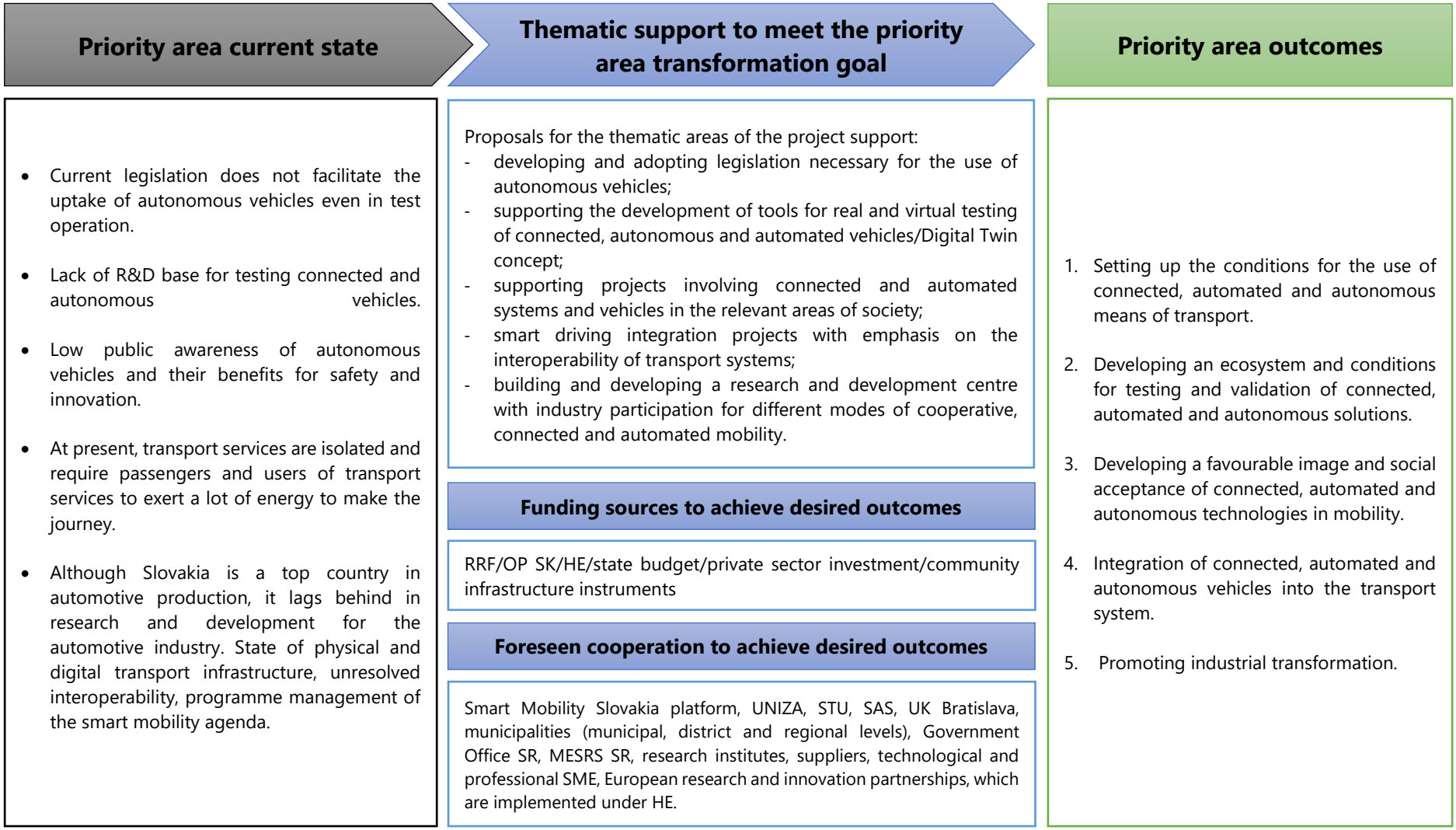
- Building and developing comprehensive (centralised or distributed) R&D centres for different modes of Cooperative, Connected and Automated Mobility (CCAM) such as Autocampus Helmond, Future Mobility Campus Ireland (Dublin), Smart City Mobility Lab Basel. The centres will comply with the principle of complementarity. The foreseen focus is on e.g. 5G+ connectivity, sensors, rail vehicles, automated public transport, integration of CAVs with the transport system and their testing, testing and validation of the vehicle "driver's license", cyber security in mobility, safety, process efficiency, inclusion, performance, traffic management, maintenance, Human-Technology Interaction, etc.);
- Incubation, validation, development, testing and demonstration activities involving connected and automated systems;
- Creating and developing tools for real and/or virtual testing of connected, autonomous and automated vehicles/digital twin concept;
- Setting up physical and digital transport infrastructure for the deployment of CAVs (connected places);
- Projects for the integration of smart vehicle driving, real-time mapping and vehicle support and control (HD maps/high resolution maps, Automotive Edge Computing, Local Dynamic Maps, GPS, map layers, navigation, etc., optimisation and new types of algorithms, cloud computing, V2V, V2I/cloud data transmissions, etc.);
- CAVs systems management and interoperability projects;
- Projects focusing on STRIA innovation milestones, transformation and development of connected and autonomous mobility in all modes of transport (e.g., embedded systems, socio-economic impacts and public acceptance, human factors, physical and digital infrastructure and safety at every level);
- Testing and demonstration activities of CAVs in agriculture, forestry, health, rescue operations, risk management, etc.

Figure 8: Concept C-A-S-E



Source: McKinsey

Figure 9: Transformation map of Priority Area 2-1



3.2.4 Priority Area 2-2: Smart mobility services and smart transport systems

Transformation goal 2-2

- Ensuring a widespread and affordable use of smart mobility services for the transport of persons and goods;
- Fostering a widespread and accessible use of reliable and new mobility services reducing the burden on the environment, increasing transport safety (reducing deaths and serious injuries) and economic efficiency (reducing lost time of transported persons and goods carried, cost-effectiveness);
- Improving, opening and integrating the data and analytics space in the Open Data concept and the interoperability of interconnected smart transport systems across all modes of transport for a better mobility planning and management at different levels.

Justification for the priority area selection

- Reducing the adverse environmental impacts of transport on the quality of urban life;
- Increasing the safety and efficiency of the transport system (increasing congestion incidence and intensity);
- Smart mobility solutions will be applicable to tasks related to environmental improvement and to other areas of smart specialisation (e.g., Smart City, Smart Industry or Smart Energy);
- Solutions successful in Slovakia can work in Europe and also globally and have a high export potential;
- Planning traffic flows and finding optimal modes of transport by combining different transport systems is a comprehensive task that is relevant across all agglomerations and has major social and environmental impacts on society;
- An information systems trend is shifting emphasis from hardware through software to information handling. The key problem is no longer collecting large volumes of data, but rather their processing and extracting useful information and finding solutions in real time;
- Supporting the development of the platform economy in a fast-growing sector and developing the potential for growth of platforms due to the accumulation of expert capacities.

Indicative measures to meet the transformation goal (from the EDP)

Table 12: Enabling measures to meet transformation goal 2-2

Measure	Measure description
Developing and applying new business models in mobility	Activities aimed at developing the basis for SMEs also in the context of internationalisation for the emergence and application of new business models in mobility (e.g., more operation-wise efficient modes or combinations thereof, deployment of smart transport and logistics systems in connection with multimodal transport, development and testing of smart fleet management systems). The use and sharing of data and infrastructure should result in efficient interoperability and optimisation of the use of individual transport systems in terms of environmental load, travel times and transport safety. This includes the introduction of business model innovations in Shared Mobility, in particular Mobility on Demand, and the development of the Mobility as a Service (MaaS) concept.

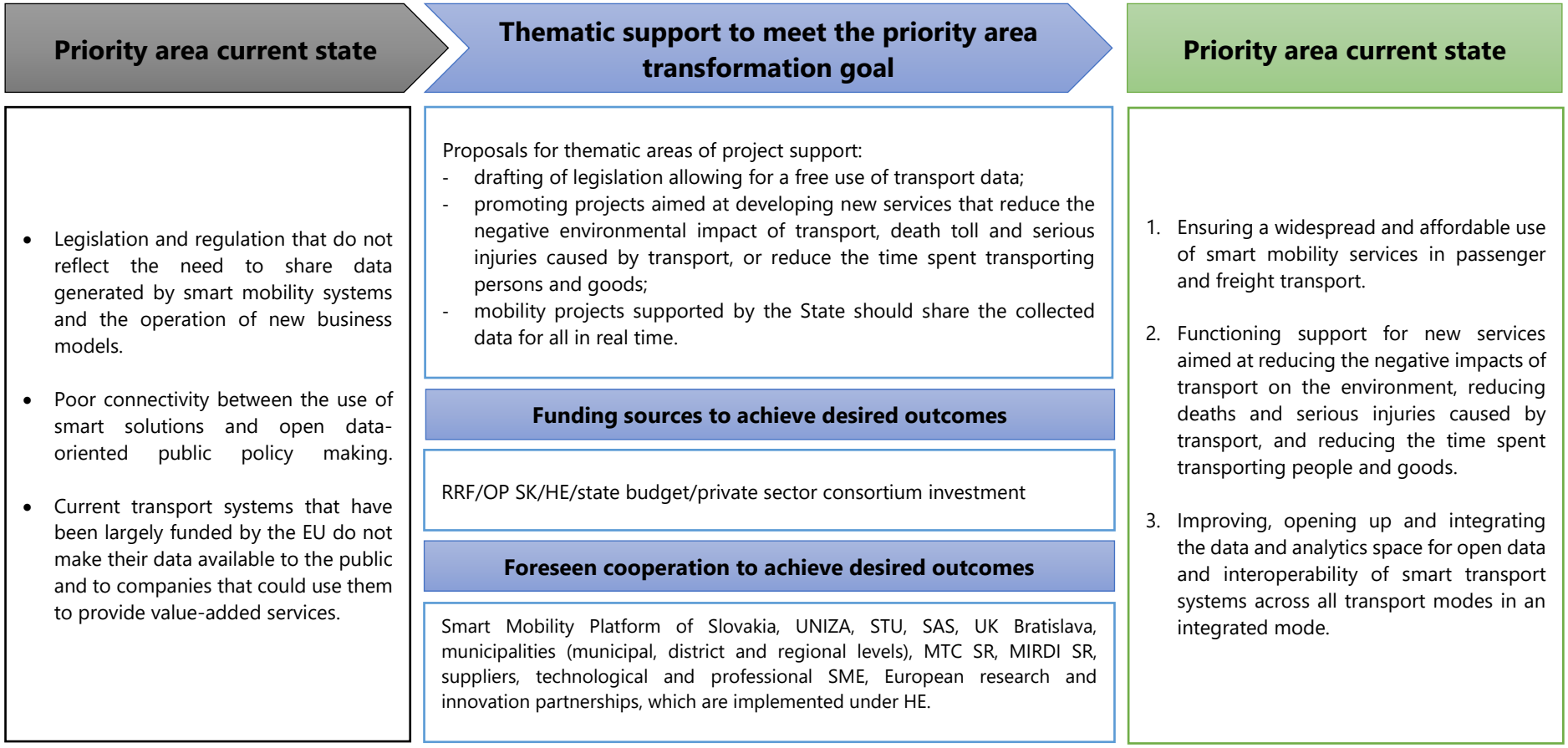
Promoting pilot and demonstration projects, early product validation and general-purpose technology dissemination for sustainable mobility in both urban and rural environments	Supporting pilot and demonstration activities of innovative traffic management systems, developing a space for the integration of traffic modes and environmental mapping (data collection in structure, density and frequency, capable of forming time series as a basis for HD maps) in cities. Creation and use of tools to support large scale demonstration activities (e.g., public transport, Last Mile Delivery). This should result in transport innovations in urban and rural areas, including traffic volume reduction and the application of emission-free zones with positive externalities raising positive awareness of the benefits of the smart mobility development, information models, based on the outputs of data analysis, which will facilitate the application of the priority of collision-free transport, increasing fluidity and other criteria for transport optimisation.
Promoting the development and implementation of new and innovative logistics models	Research and development activities of innovation, validation and calibration of the logistics model of supply chain of industry and multimodal transport (new scenarios for logistics models, application of the preference of goods transport by rail and water transport). This will result in applied logistics models that combine the functioning of the supplier system, including lean supply-chain approaches and an efficient distribution of the transport infrastructure load between different modes of transport.
Promoting technology transfer, social innovation, eco-innovation and public service applications with respect to modern transport infrastructure building principles	Activities of applied research and development of solutions linking modern principles of building transport infrastructure with improving the quality of the life of the citizens in terms of the impact of mobility on the environment, digital models in the management of the national, regional and local (urban) transport systems (e.g., digital twin, dynamic traffic management, cyber-physical systems). The outcome should be functional and efficient ways of managing traffic flows and the introduction of innovations in the application of new means of transport, including micromobility.
Promoting the emergence of a resilient and safe public transport system	Implementation and development of risk management systems in the operation of public transport systems to build resilience to security threats in the event of crisis situations such as pandemics, failure of power grids or communication systems.
Promoting the development of urban mobility solutions	Utilising data analytics for design to develop appropriate solutions for urban mobility. Examples include data collection, Big Data analysis and the use of machine learning). This results in efficient projects including public-private mobility services.

3.2.4.1 Transformation map of Priority Area 2-2

- Development and design, optimisation and implementation of the basis for innovative solutions for new business models in mobility (architecture and concept of operations for an efficient, resilient and adaptive multimodal system development of multi-actor organisational and business models with shared responsibilities, research and validation of next-generation multimodal NTM systems (including intramodal optimisation and interface development);
- Integration of infrastructure (connected cities), transport assets, systems and services into a truly multimodal network;
- Integration of prospective and operationally more efficient modes;
- Integrated smart mobility and logistics systems and multimodal transport;

- Developing systems for smart fleet management and predictive maintenance (Fleet Management);
- Sharing data and infrastructure to support future interoperability, optimise the use of individual transport systems in terms of environmental burden, reduce time lost in transport and severe injuries and deaths caused by transport;
- Innovation of the platforms for Shared Mobility, Mobility on Demand, Mobility as a Service (MaaS) and their use for strategic and operational transport planning and management;
- Innovations in comprehensive systems management, integration modes of transport and collision-free transport in cities, environmental mapping;
- Development, validation and calibration of a logistics model for industrial supply and combined transport (new scenarios for logistics models, preference for transporting goods by rail and by water transport);
- Developing and changing the principles of building transport infrastructure to improve the quality of the life of the citizens with respect to the impact of mobility on the environment:
    - comprehensive digital models of urban transport systems and the national transport system (digital twins, dynamic traffic management, cyber-physical systems);
    - innovations in micromobility;
    - traffic flow management.
- Promoting the incubation of own innovations through the support of RDCs and private-public cooperation, clusters, support for the use of public research infrastructure by the private sphere;
- Resilience and safety of public transport in the event of crisis situations (pandemics, blackouts of energy networks and communication systems);
- Demonstration activities in large-scale urban environments (e.g., public passenger transport, Last Mile Delivery);
- Analysis and design of appropriate solutions for urban mobility, including Big Data analytics, data collection and machine learning, public-private mobility services.

Figure 10: Transformation map of Priority Area 2-2



3.2.5 Priority Area 2-3: Mobility decarbonisation

Transformation goal 2-3

- Preparing Slovakia's territory for a widespread deployment of alternatively fuelled vehicles and energy carriers in normal operation;
- Accelerating the transformation of manufacturing enterprises operating in the domain into production-development and development-supply enterprises;
- Preparing the domain ecosystem for the uptake of new mobility business models for sustainable development;
- Reducing transport emissions by utilising alternative fuels;
- Strengthening R&D capacities for alternative fuels propulsion, decarbonisation infrastructure, transport vehicles and materials and technology research within the domain.

Justification for the priority area selection

- Reducing transport emissions and their harmful effects on the environment and associated climate change. Achieving sustainable intermodal transport requires prioritising users, who must be provided with more affordable, accessible, healthier, cleaner and more energy efficient alternatives to their current mobility habits, while supporting those who already use sustainable modes such as walking, cycling and public transport;
- The need to transform manufacturing enterprises operating in the domain into production-development and development-supply enterprises;
- The manufacture of the means of transport (mainly cars) contributes significantly to the GDP of Slovakia and has a wide range of subcontractors. The automotive sector accounts for the largest part of Slovakia's exports. It is important to maintain the competitiveness of this key sector. Innovation should therefore be directed in particular towards the required propulsion systems using alternative fuels and energy carriers for propulsion (electricity, hydrogen and hydrogen bonded, methanol, bio-methanol, CNG, LNG, etc.), or the development of efficient distribution and refuelling infrastructure;
- Slovakia needs to transform the manufacture of the means of transport along the entire value chain to a higher level and to respond to current developments with its own innovations.

Indicative measures to meet the transformation goal (from the EDP)

Table 13: Enabling measures needed to meet transformation goal 2-3

Measure	Measure description
Promoting research, development and innovation with a focus on alternative fuels and energy carriers	Research, development and innovation aimed at the use of alternative propulsion and energy carriers (e.g., electric propulsion, batteries, energy storage systems, propulsion using hydrogen fuel cells or direct combustion of H2, synthetic fuels or other energy sources for propulsion of transport vehicles). The development of specific solutions for the application of hydrogen in mobility and their implementation in land, water and air transport, and the development of technical support systems for the use of alternative fuels in future transport are also covered.
Promoting research, development and innovation focusing on	Activities in research, development and innovation of an energy network for efficient use in mobility. Examples are the development of Smart Grid, solutions for increasing grid stability, real-time and real-space grid capacity, or

different aspects of energy infrastructure	interconnections to local/distributed RES and energy storage, etc.). The result should be a seamless integration of the growing number of electrified vehicles into normal operation without impacting on an efficient energy management and safe operation of transmission and distribution networks.
Promoting the development of smart grid solutions for charging and refuelling stations	Activities in the development and innovation of infrastructure for electric vehicle charging, refuelling of alternative fuels and planning for their efficient use, availability and connection to distribution networks. The result is user-friendly transport systems for individual users and organisations.
Promoting research and development of materials, products and technologies applied in modern means of transport	Research, development and innovation activities focused on the design, construction, material composition and manufacturing processes for new components of electric vehicles and alternative fuel vehicles. The result is an improvement of the utility and operational characteristics of the vehicles, matched to the new propulsion systems.
Promoting the development of smart infrastructure solutions for mobility	Activities to develop solutions and components for smart infrastructure for mobility. Examples include new structural materials and technologies for applications in transport vehicles and engineering, construction and energy. The aim is to achieve sustainable operation and high energy efficiency in the operation of elements of mobility systems.
Promoting low-emission mobility system projects and design programmes	Promoting the development and testing of emission-free zone concepts in selected areas. Examples are urban zones, large, protected areas, new urban structures).

3.2.5.1 Transformation map of Priority Area 2-3

Electrification

Road transport[57]

- Extending a low-cost 400+ kilometre range for electric passenger vehicles;
- Developing small and lightweight smart electric vehicles;
- Promoting performance improvement and cost reduction of urban bus electrification;
- Promoting public and commercial procurement of electric vehicles;
- Promoting the development of electric vehicle test/driving cycles and standardisation;
- Developing electrochemical systems for high density batteries;
- Promoting the production of batteries, components and electric vehicles in the EU;
- Example of electrified road systems for heavy commercial vehicles.

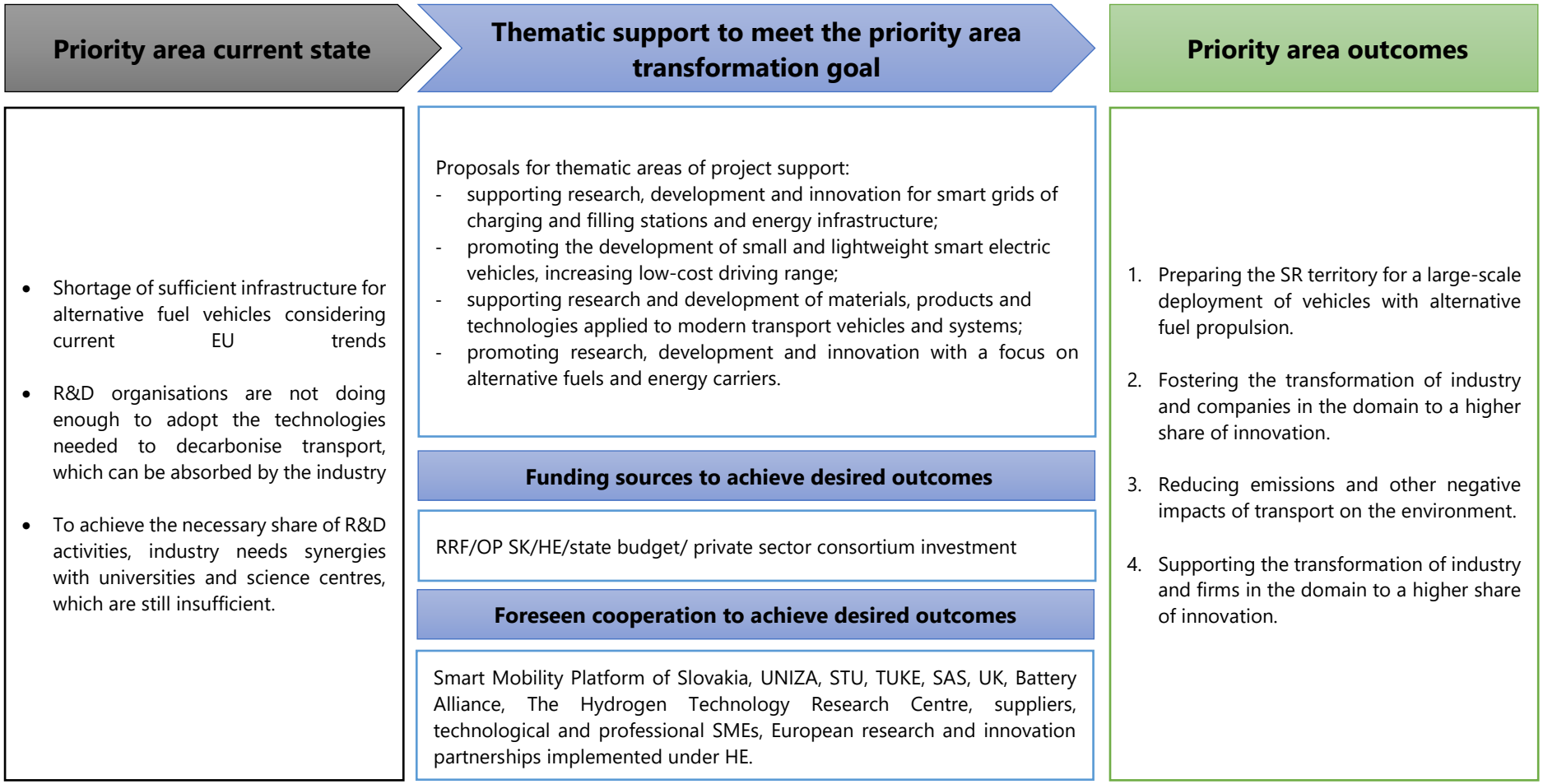
Low-emission alternative energy for transport

Reducing greenhouse gas emissions from transport consists of two main components, namely:

- Availability of cost-effective sustainable alternative low-carbon energy/fuels (wheel-to-tank – WTT);
- Improved efficiency in real-world use (tank-to-wheel – TTW);
- Joint planning of investments in the development of research and innovation infrastructure;
- Sharing research capabilities of scientific infrastructure across domains.

[57] European Commision: *Strategic Transport Research and Innovation Agenda (STRIA).* Available at: https://ec.europa.eu/info/research-and-innovation/research-area/transport/stria_en

Figure 11: Transformation map of Priority Area 2-3



Examples of research capacities available within the domain priority areas

Traditionally, University of Žilina in Žilina is focused on mobility (faculties, ERAdiate+ International Research Projects Centre, University Science Park and Research Centre), Slovak University of Technology in Bratislava and in Trnava (faculties, science parks and research centres), Technical University in Košice (faculties, science parks and research centres), Comenius University in Bratislava, P. J. Šafárik University in Košice (mainly faculties of natural sciences, science parks and research centres) and technical faculties and research teams of other universities (e.g. Slovak University of Agriculture in Nitra, Technical University in Zvolen, University of Economics in Bratislava, state universities - the Slovak Police Corps Academy in Bratislava and the Slovak Armed Forces Academy in Liptovský Mikuláš). Natural science and technically oriented institutes of the Slovak Academy of Sciences within several regional centres and selected ministerial and private research and development organisations of STEM or RTDI focus.

Capacities with laboratories specialised in smart mobility and exploring the concept of smart cities, smart infrastructure, products (IoT, smart autonomous components for production systems, internet technologies) and services (automated and control systems).

Existing R&D capacities of the private sector, in particular in Bratislava, Trnava, Púchov, Prievidza, Dubnica nad Váhom, Žilina, Košice, Poprad, Trenčín and Zvolen, are also available for use. University, departmental and private R&D organisations of STEM or RTDI focus with reference to mobility innovation, STRIA and interdisciplinary projects related to the domain.

For battery research related to the achievement of the domain goal, it is possible to use the capacities where such research is already being carried out, such as at the UPJŠ in Košice and at the SAS in Bratislava, with the potential to create a nationwide distributed battery centre. Hydrogen research is the focus of TU Košice with the potential to create a national Hydrogen Technology Research Centre as a joint project linking teams from several leading universities, academic departments and selected industrial entities. Capacities that have laboratories specialised in smart mobility and exploring the concept of smart cities, smart infrastructure, products (IoT, intelligent autonomous components for production systems, internet technologies) and services (automated and control systems).

Manufacturing processes, applied research and development are also addressed by domestic OEMs and their suppliers. The existing R&D capacities of the private sector are also ready for use, especially in Bratislava, Skalica, Vrábly, Púchov, Prievidza, Dubnica nad Váhom, Kysucké Nové Mesto, Žilina, Košice, Poprad, Trenčín and Zvolen.

Among potential users may also be research centres in the chemical and energy industries and other technological, development and competence centres under preparation in the automotive and other mobility areas.

Estimation of potential customers in application practice for the domain priority areas

End customers, educational institutions, local and regional governments, state administration and decision makers (central data layer manager for the domain), mobility operators, hauliers and transport undertakings, platooning operators, haulage and carriage operators across all transportation modes, logistics service providers, intermodal operators, OEMs and their suppliers in production and value chains in the transport engineering industry (heavy and light mobility including rail), construction, IT/digital industry companies, cybersecurity, platform designers and integrators, automation and robotics industries, creative industries, GIS and

precision digital mapping (HD maps) companies and organisations, energy sector companies (manufacturing and distribution, renewables, etc.), mobility providers such as MaaS services, electro-mobility companies, alternative fuel producers and suppliers.

Digital transformation of Slovakia

3.3 Digital transformation of Slovakia

3.3.1 Justification for the domain

Slovakia prepared its national digitalisation strategy, which supports the digital transformation of all areas of society to improve the quality of life of citizens, increase the competitiveness of industry and the economy as a whole, and ensure the efficient performance of public administration. The experience of countries with advanced levels of digitalisation suggests that those businesses that can innovate and digitalise their processes, but most importantly offer services and products with high added value, will succeed. At the same time, data is seen as a precious resource and a tradable asset. Building a data economy to make better use of data is essential for better decision-making processes based on analysis, while maintaining the protection of citizens' personal data. To seize these opportunities, Slovakia needs both a highly skilled workforce with basic digital skills, as well as experts with advanced digital skills, and also those who can design brand new solutions, bring new insights and thus contribute to Slovakia's transformation towards a knowledge-based economy.

Digital technologies will play a key role in the economic recovery, as the current COVID-19 pandemic has shown how important digital assets such as networks and connectivity, data, artificial intelligence and supercomputers have become. The European Council and the Commission have also committed to linking recovery support to a parallel transition to a climate-neutral and resilient digital transformation.

Domain definition

Digital transformation means the integration of digital technologies by all parts of society and the increased impact of technology on society. This RIS3 domain aims to promote innovative ways of deploying digital technologies in society, to enhance the security and added value of the data generated by digital technologies, and the application of technologies such as artificial intelligence, supercomputing, virtual and augmented reality, etc.

Strategy and policy materials of the SR relevant to the domain area

- 2030 Digital transformation strategy for Slovakia;
- MESRS SR, 2018: Draft national programmes for research and development 2019-2023 with outlook to 2028;
- Smart industry for Slovakia - draft policy (ME SR, GR 490/2016) and Action plan for smart industry SR (ME SR, GR-33624/2018);
- Report on the state of research and development in the Slovak Republic and its comparison with foreign countries in 2017 - 2019 (MESRS SR, informative material, 2018-2020);
- Integrated national energy and climate plan 2021-2030 (ME SR, GR 606/2019);
- Promoting innovative solutions in Slovak cities - Concept for support of Smart City projects (ME SR concept paper, 2017).

European and international strategy and policy materials relevant to the domain area

- Digital Economy and Society Index (DESI) 2019;
- OECD, OECD Economic Surveys Slovak Republic, 2019;
- European Data Strategy, COM (2020/66);
- European Commission, Work Programme DEP, HEU, CEF.

Justification for the domain selection

a) Current needs in the SR

Slovakia ranked 22nd out of 28 EU Member States in the European Commission's Digital Economy and Society Index (DESI) in 2020.[58] The country continues to increase fast and ultra-fast broadband coverage, the share of ICT professionals in total employment has increased, but e-commerce is stagnating, the use of big data analytics and cloud technology and e-government quality indicators are below the EU average. The choice of the domain is in line with the new Digital Transformation Strategy 2030,[59] according to which it is crucial to create conditions for the development of new technologies, methods and applications, thus helping researchers and innovators to keep pace with global trends. The strategy document defines the needs of Slovakia in the field of digitalisation of society.
The central theme is the ongoing digital transformation of the economy and society under the influence of innovative technologies and global megatrends of the digital era. Particularly important is the simultaneous development of human resources, digital infrastructure and regulatory changes to trigger the digital transformation in both the research and corporate sectors. Supporting a small number of priority areas in the digital domain will enable the focused development of solutions with a potential for market success, but at the same time promote digital innovations and their applications across all sectors and synergistically their acceptance in society.

b) Global megatrends

The digitalisation of all areas of public and private life is a fundamental trend that runs across all domains of smart specialisation. **It is also one of the most important topics in designing and managing strategies and visions for countries, businesses and organisations.** The general trends are defined in line with the Digital Europe agenda, which responds to current digital challenges and key technologies such as artificial intelligence, high-performance computing (HPC), decentralised recording (blockchain), 5G mobile networks or cybersecurity. **The specialisation of strategies to develop AI** has become a new trend, which is expected to revolutionise several areas of public life in the near future, such as transport, industry, healthcare and everyday working life.

The availability of high computing and storage capacity making efficient use of resources is another pivotal condition for success in the digital age. The age of quantum technologies is coming – **quantum computing, quantum cryptography and quantum sensors as part of IoT** are the technologies that will determine success in the new IT age. Industry 4.0, which refers to the current trend towards digitalisation and the associated automation of production and data exchange in manufacturing processes, will become the driving force of the country's economic growth.

Data is the foundation of the digital economy and its efficient use will enable the emergence of a competitive data economy, which is what innovative countries around the world are striving for. Data-driven decision-making requires both high-volume processing of inputs from the environment (sensors and the Internet of Things) and data mining from large databases (personalised healthcare, marketing, Industry 4.0, etc.). Last but not least, cybersecurity plays a very important role in the age of digitalisation and computerisation, as all data is transmitted in a virtual world that knows no borders.

[58] Index digitálnej ekonomiky a spoločnosti (DESI) 2020: *Slovensko*. Available at: https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=66957
[59] Stratégia digitálnej transformácie Slovenska 2030: *Stratégia pre transformáciu Slovenska na úspešnú digitálnu krajinu.* Available at: https://www.vicepremier.gov.sk/wp-content/uploads/2019/06/Strategia-digitalnej-transformacie-Slovenska-2030.pdf

Domain and priority areas selection process

The original Digital Slovakia and Creative Industry domain for the period 2014-2020 became the starting point for defining the renewed domain. We conducted consultations with members of the Digital Slovakia Transformation Implementation Working Group to identify key stakeholders who were then invited to a meeting on 16 July 2020. Stakeholders from industry, academia, civil society and public administration proposed a draft list of research specialisation areas in the digital domain. Subsequent discussions with stakeholders led to a shortlist of priority areas, which were discussed in September 2020 and confirmed at the workshops to fine-tune the research themes in November 2020. Due to the pandemic, the majority of the work was conducted via online video conferencing. We analysed the outputs with coordinators and visionaries of other domains and agreed that some sectoral themes were covered in other domains and some proposals were merged into common priority areas. The draft was the subject of several rounds of workshops where research practitioners commented on the draft priority areas, and we made further adjustments to the material accordingly.

3.3.2 Domain goal

The goal is to support digital transformation of all areas of society with the aim of improving the quality of life of citizens, increasing the competitiveness of industry and the economy as a whole, and ensuring the efficient performance of public administration.

The ambition of the domain is to:

- develop business activities in the top sectors of the digital economy with a prerequisite for a comparative advantage against competitors from neighbouring countries and a sufficient base of well-established companies or promising start-ups that cooperate with research institutions in the SR;
- promote networking between research teams and the commercial sector to achieve effective transfer of research and development into practice and the application of the latest knowledge in society;
- support and expand the base of top experts in the SR focusing on digital innovation;
- improve coordination of public investment and funding from EU direct programmes.

Table 14: Domain transformation goals

Domain priority area	Priority area transformation goal
3-1: Smart and connected sensors and devices	Increasing society's ability to make data-driven decisions from the level of personal decisions, through automated workplaces in enterprises, to the level of the critical state, environmental and urban infrastructures using statistical methods and machine learning.
3-2: Enhancing the value in use of all types of data and databases	Providing the public and businesses with the services of advanced information tools for processing text, image and sound from the existing digital archives and from emerging large-scale databases that will form the basis of high added value solutions.
3-3: Smart energy systems	Accelerating the transition to a more efficient and greener energy mix by developing tools to operate distribution systems and networks that serve large numbers of producers and consumers while maximising the reliability and cost-effectiveness of operations and the efficiency of the energy market, not only in the electricity sector, but also in the gas, heating and water sectors.

3-4: Cybersecurity and cryptography	Building a secure information society that uses modern technology and can defend against cyberattacks and promote cyber hygiene. Businesses and other entities should have digital solutions in which security is an integral part of the solution, so that they do not have to deal with the protection of their data and networks, continuity of production and protection against cyber-attacks with additional follow-up projects.

3.3.3 Priority Area 3-1: Smart and connected sensors and devices

Transformation goal 3-1

Increasing society's ability to make data-driven decisions from the level of personal decisions, through automated workplaces in enterprises, to the level of the critical state, environmental and urban infrastructures using statistical methods and machine learning.

Justification for the priority area selection

Data constitute the basis of many new products and services, they boost productivity and a more efficient use of resources in all sectors of the economy, they facilitate the making of more personalised products and provision of services and contribute to better policy-making and better public services. Unlike most economic resources, data can be replicated at almost zero cost and their use by one person or an organisation does not preclude its simultaneous use by another person or organisation.

Data availability is essential for tackling societal, climate and environmental challenges, while contributing to a healthier, thriving and sustainable society. A fundamental prerequisite for the functioning of the data economy is the creation of sufficient data resources and the provision of a trustworthy data management system. To have Slovakia create the preconditions for the emergence of a dynamic data economy, it is crucial to work on innovative ways of collecting and processing data, including their free movement. The aim is also to create "pools" of available data for AI needs in areas such as transport, healthcare and the environment, which will be compatible with data "pools" in other EU countries. Sensor systems, cloud storage and processing and smart autonomous devices and systems capable of processing large volumes of data are the backbone of an approach known as the digital twin of physical systems, an important development area of the Digital Europe agenda.[60]

Smart systems built-in production equipment and in finished products and the Internet of Things help build the expertise of Slovak industry in a novel way in electrical and mechanical engineering, with emphasis being put on high added value.

There is an urgent need for public administration to address the management of information on the state of the environmental components and on the State's technical infrastructure, as many information systems are inadequate or non-existent.

The development of the IoT devices focuses on monitoring the vital functions of living systems: monitoring the health condition of elderly and disabled people, monitoring and managing breeding stations, especially when it comes to laboratory animals, monitoring and managing growth chambers. From personalised healthcare services to a safer care for the elderly at home, digital tools and technologies provide more opportunities to improve important public services.

Indicative measures to meet the transformation goal (from the EDP)

[60] European Commission: *Digital Europe Programme*. Available at: https://ec.europa.eu/digital-single-market/en/europe-investing-digital-digital-europe-programme

Table 15: Enabling measures to meet transformation goal 3-1

Measure	Measure description
Development and application of compact sensors for the integration in all types of environments	Supporting research, development and innovation of sensors for sensing environmental properties (temperature, pressure, radiation, voltage, humidity, etc.), with an emphasis on their integration into devices and connectivity via the IoT and 5G networks, while reducing their cost, reliability and energy requirements. The development of such sensors is a prerequisite for their mass deployment in all application areas, such as smart mobility, healthcare, environmental monitoring, agriculture, consumer electronics, etc.
Implementation of systems for data collection from a large number of dispersed sensors and their aggregation in massive databases	Supporting the deployment of large-scale sensor data collection systems to be placed, for example, on public lighting poles or in all hospital rooms to demonstrate the added value of processing data from a large network of sensors.

3.3.3.1 Transformation map of Priority Area 3-1

Project proposals:

- Embedded systems and the IoT in transport, energy, electrical engineering, healthcare;
- Acquisition, provision and processing of sensor data in both natural and urban environments;
- Smart product design and production as well as services in applications for other domains.

Figure 12: Transformation map of Priority Area 3-1

Priority area current state

- Underuse of innovative sensors for data collection, resulting in a lower resource efficiency across all the sectors of the economy.
- 80 % of data processing and analysis takes place in data centres and centralised computing facilities and only 20 % in smart connected objects.
- Inadequate public administration information systems for processing and analysing environmental, technical infrastructure, industrial, and healthcare data and low levels of data sharing between organisations.
- Unavailability of big data repositories suitable for use and reuse, combined with the technical tools and infrastructures needed to exchange data across sectors.
- Low share of personalised products and services.

Thematic support to meet the priority area transformation goal

Transformation measures:

- Developing and applying compact sensors for integration into all types of environments.
- Promoting pilot and demonstration projects, early product deployment and technology dissemination.
- Implementing systems to collect data from a large number of dispersed sensors and aggregating them in massive databases.

Proposals for the thematic areas of project support:

- Embedded systems and the Internet of Things in transport, energy, electrical engineering, healthcare;
- Acquisition, provision and processing of sensor data in both natural and urban environments;
- Production and design of smart products and services in applications for other domains.

Funding sources to achieve desired outcomes

RRF/OP SK/HE/state budget /private sector investment/public administration investment

Foreseen cooperation to achieve desired outcomes

Private and public sector RDI centres working on sensor and embedded systems data processing. The topic is especially addressed by the workplaces in Bratislava, Žilina, Košice, European Research and Innovation Partnerships implemented under HE.

Priority area outcomes

1. Mass proliferation of sensors for sensing environmental properties.
2. Increased data collection and analysis in smart connected objects such as cars, home appliances or manufacturing robots, and in computing devices close to the user.
3. Uptake of smart and innovative solutions in cities and municipalities, which, through the use of technology, will improve the quality of the life of citizens and increase the quality and efficiency of public services provided by public administration.
4. The emergence of Slovak innovative solutions and new companies in the field of data products and services.
5. Enhanced ability to make data-driven decisions from the level of personal decisions, through automated workplaces in enterprises, to the level of the critical State, environmental and urban infrastructure using statistical methods and machine learning.
6. Benefits reaped from a better use of data, including greater productivity and resource efficiency, but also from improvements in healthcare and well-being, the environment, transparent governance and provided public services.

3.3.4 Priority Area 3-2: Enhancing the value in use of all types of data and databases

Transformation goal 3-2

To offer to the public and to businesses the services of advanced information tools for processing text, image and sound from the existing digital archives and from emerging large-scale databases that will form the basis of high added value solutions.

Justification for the priority area selection

In sectors such as industry, commerce, healthcare or the public sector, there is a large amount of high quality, non-personal data whose potential is untapped and which is expected to grow even more in the coming years. Advanced information tools for data processing, analysis, integration and presentation need to be provided in such a way that the potential of such data can be leveraged to the fullest for the benefit of companies, including SMEs, the public sector and research.

To make operational and strategic decisions based on clearly presented data analyses and predictions, businesses and other entities need supporting data which may include combinations of technical production data, audio and visual recordings, and economic data.

One such tool is the use of the digital twins in production. The presentation of digital copies of the real world using virtual and augmented reality tools is a fast-growing sector in which Slovak start-ups and research institutions have good potential to establish themselves internationally. Based on data analysis, the copies can provide predictions about potential risks or failures and thus increase productivity through predictive maintenance.

Natural language processing is another tool to help work efficiently with large amount of data, using it to process unstructured data in natural language, which may relate to market information, complaints or service records, for example. It is important to pay due attention to the processing of documents in the Slovak language, to use methods to transfer knowledge about Slovak language processing from world languages, or even related Slavic languages.

Using digitalised data and natural language processing in providing healthcare will make the work of healthcare professionals more efficient. Digital data may be used in research and development, statistics and, notably in the preventive diagnosis of diseases to make healthcare and personalised medicine more efficient. The use of the sound and image recognition algorithms will help people with sensory disabilities. The use of the digital archive of the cultural heritage of Slovak heritage institutions, as well as other digitalised data, provides an opportunity for the development of a cultural industry of international significance. It provides effective tools for recording, cataloguing and using large amounts of data on real-world objects that are used in the global marketplace, especially in the gaming and film industries, but also in the world's cultural and heritage institutions.

Indicative measures to meet the transformation goal (from the EDP)

Table 16: Essential measures to meet transformation goal 3-2

Measure	Measure description
Analysis, exchange and processing of large volumes of data	Developing systems to process large databases and mine important data about the system under monitoring.

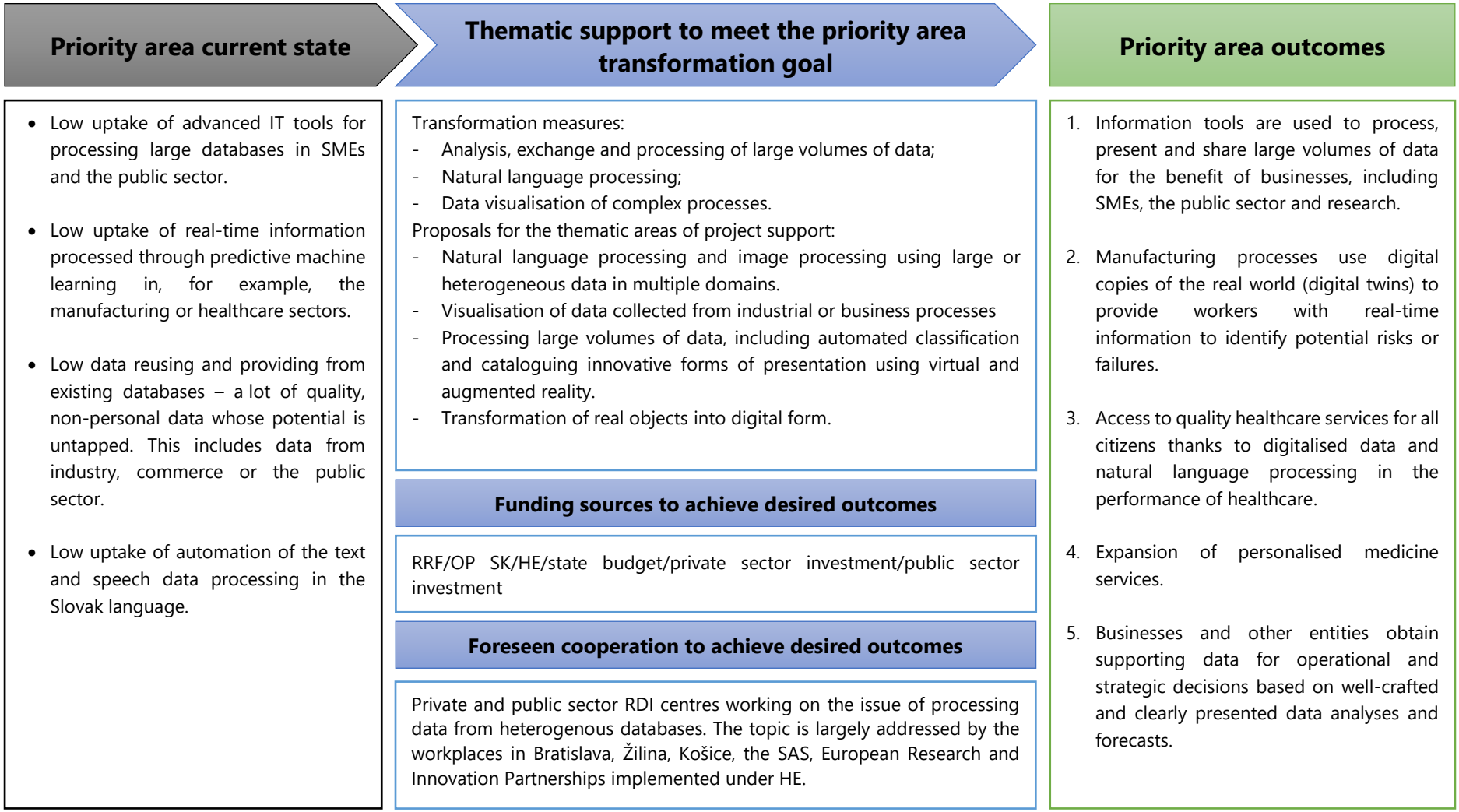
Natural language processing	Developing modules for audio transcription and logical processing of written text in Slovak.
Data visualisation of complex processes	Promoting the development and deployment of technical solutions to display information on the evolution of complex systems clearly and efficiently, particularly in enterprise and commercial environments.

3.3.4.1 Transformation map of Priority Area 3-2

Project proposals:

- Natural language processing and image processing using large or heterogeneous data in multiple domains;
- Visualisation of data obtained from industrial or business processes;
- Processing of large volumes of data, including automated classification and cataloguing innovative forms of presentation using virtual and augmented reality;
- Transforming real objects into digital form.

Figure 13: Transformation map of Priority Area 3-2



3.3.5 Priority Area 3-3: Smart energy systems

Transformation goal 3-3

Accelerating the transition to a more efficient and greener energy mix by developing tools to operate distribution systems and networks that serve large numbers of producers and consumers while maximising the reliability and cost-effectiveness of operations and the efficiency of the energy market, not only in the electricity sector, but also in the gas, heating and water sectors.

Justification for the priority area selection

The energy sector is undergoing a transition towards digitalisation and decentralisation, which requires new tools for the management of both the energy systems and clearing systems and for the standardised, flexible and non-duplicated exchange of data between the energy market participants.

The European Commission is developing a joint action plan for digital transformation of the EU energy system[61] to help accelerate the deployment of digital technologies in the energy sector while maintaining the highest level of cyber security. Transformation goal 3-3 is developed to complement to the extent possible the forthcoming European initiative.

The development of small producers (prosumers) requires new business models from system operators and complex control systems to integrate the multitude of small off-take and production points in the system.

Businesses in particular will be given an opportunity to improve the energy efficiency of their operations using modern digital tools and at the same time optimise their engagement in the energy market.

Slovak research capacities in the field of smart energy systems have long-standing good cooperation with clients in application practice, which is a significant export opportunity.

In 2019, the Slovak Republic signed up to a commitment to achieve carbon neutrality by 2050. The development of the SR energy sector is aimed at optimising the energy mix so that greenhouse gas and pollutant emissions are reduced as much as possible while maintaining or increasing energy security and affordability of the individual types of energy.

Indicative measures to meet the transformation goal (from the EDP)

Table 17: Enabling measures to meet transformation goal 3-3

Measure	Measure description
Developing a clearing system for energy flows between prosumers	Promoting the development and deployment of technical solutions for non-decentralised clearing of electricity supply and consumption among a large number of small producers (households and small enterprises) without a central authority.
Production and consumption data forecasting	Promoting the development of systems to predict production from different types of RES, in particular photovoltaic and wind power plants. Developing systems to predict consumption in distribution systems.
Data collection and visualisation in distribution systems	Promoting systems development to aggregate data from a large number of smart meters and visualise the status of large distribution systems for the needs of dispatch management and for clearing between market participants.

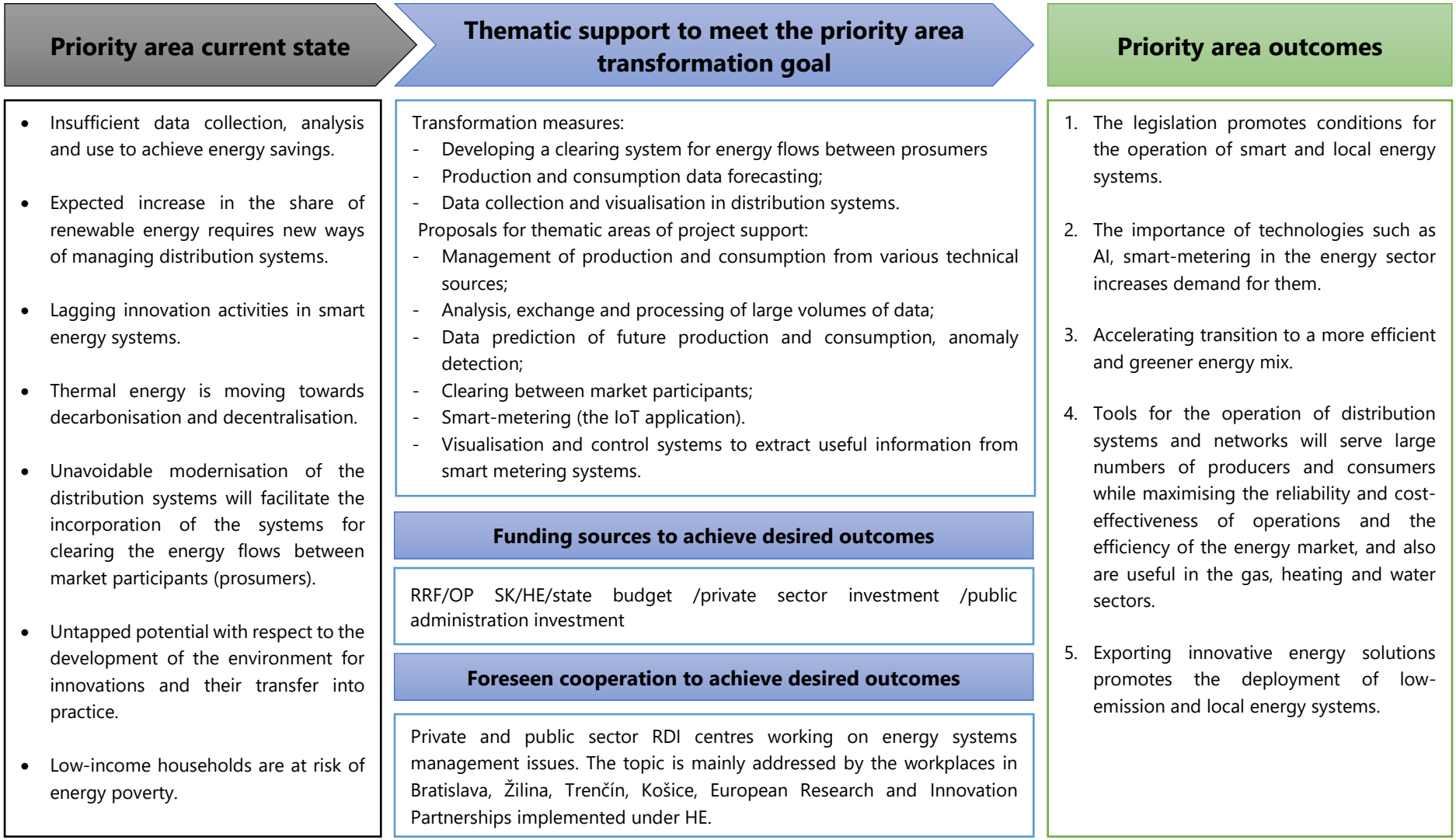
[61] European Commission: *In focus: The digital transformation of our energy system*. Available at: In focus: The digital transformation of our energy system | European Commission (europa.eu)

3.3.5.1 Transformation map of Priority Area 3-3

Project proposals:

- Management of production and consumption from various technical sources
- Analysis, exchange and processing of large volumes of data
- Data prediction of future production and consumption, anomaly detection
- Clearing between economic agents
- Smart-metering (as the IoT application)
- Visualisation and control systems and measures to eliminate energy poverty.

Figure 14: Transformation map of Priority Area 3-3



3.3.6 Priority Area 3-4: Cybersecurity and cryptography

Transformation goal 3-4

The goal is to build a secure information society that uses modern technologies and is able to defend against cyber-attacks and promote cyber hygiene. Businesses and other actors should have digital solutions where security is an integral part of the solution, so that they do not have to deal with the protection of their data and networks, production continuity and protection against cyber-attacks by way of additional follow-up projects.

Justification for the priority area selection

Ensuring cyber security is a prerequisite for the successful functioning of any state in the digital age, as citizens and businesses need to trust the security of their applications and products. Building the information society faces risks both at the level of the technical security of information systems and at the level of information dissemination in the information space, and it is in the public interest to develop this area in the domestic research environment.

According to the international index,[62] which compares the cybersecurity engagement of 193 countries, Slovakia moved from 83rd to 45th position between 2017 and 2018. The improvement is due to the establishment of formal cybersecurity requirements and rules, but the challenge lies in putting them into practice.

Increasing the resilience of ICT systems to attacks, and increasing the resilience of society to the spread of misinformation, are important tasks in maintaining essential services for the state and society as a whole. To succeed in this area, it is important to research and develop natural language-processing tools so that the tools and methods can be adapted to the Slovak environment.

Slovakia has a critical mass of research and application capacity to develop the potential of this priority area in both technical research and applied humanities.

Businesses and other entities should have digital solutions in which security is an integral part of the solution, so they do not have to address the protection of their data and networks, production continuity and protection from cyber-attacks with additional follow-on projects.

Moreover, the analysis and design of methods for secure firmware development, its regular updating for embedded systems, especially for systems with a wireless communication layer, the development of a secure operating system and key software based on open-source code, are important.

There is a need to have an auditable operating system with guaranteed security at the level of the state, or at the level of the European Union for use in critical infrastructure, but also on standard workstations (possibility of certification for different classification levels).

[62] National cybersecurity index: *Slovakia*. Available at: https://ncsi.ega.ee/country/sk/

Indicative measures to meet the transformation goal (from the EDP)

Table 18: Enabling measures to meet transformation goal 3-4

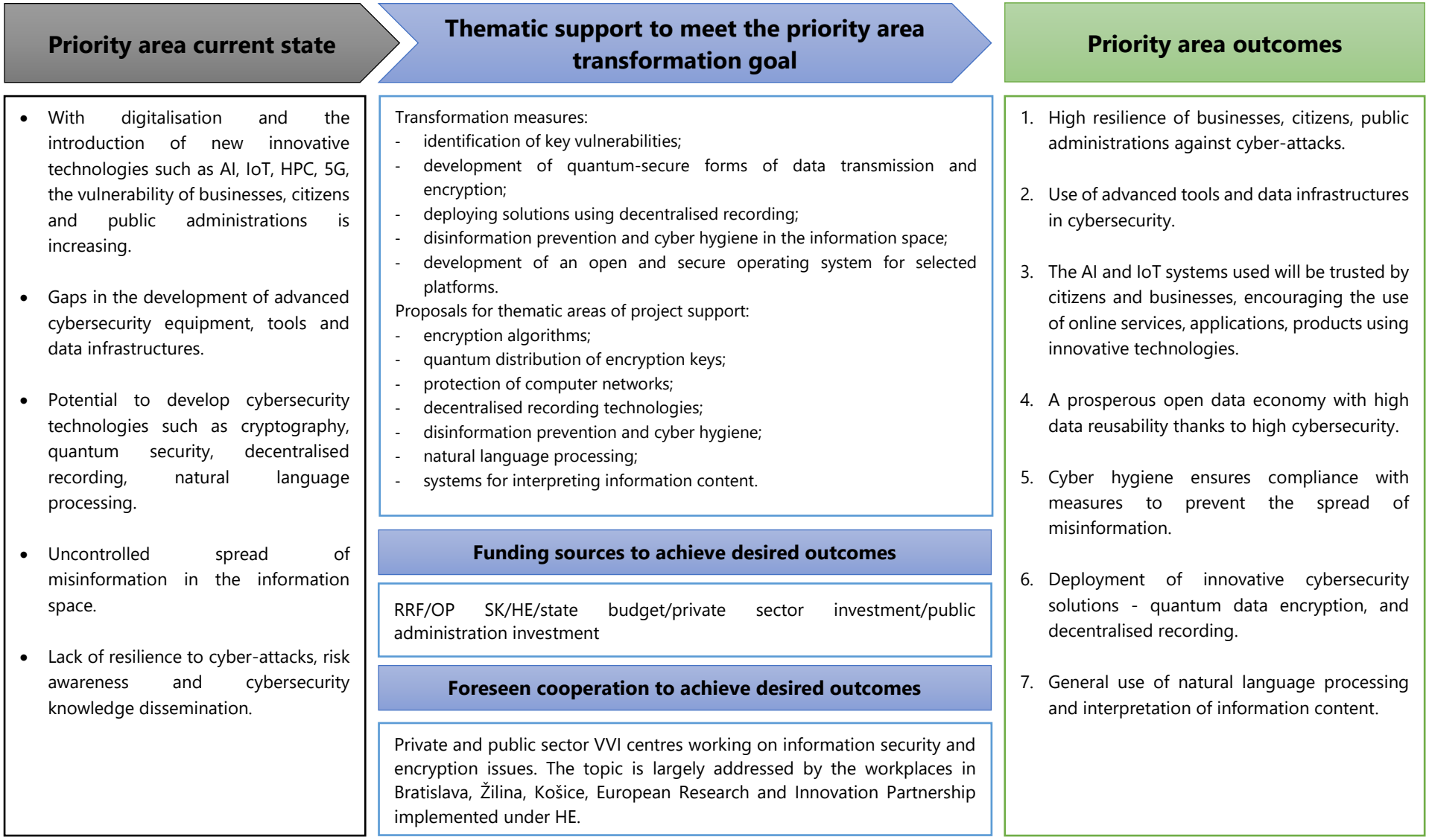
Measure	Measure description
Identification of key vulnerabilities	Performing research on the most frequent incidents in application practice and identification of trends of future attack vectors on cybersecurity and, in a broader context, threats to cyber hygiene in the public environment.
Development of quantum-secure forms of data transmission and encryption	Supporting the development and deployment of post-quantum encryption systems and quantum-safe data transmission via fibre-optic networks and optical satellite transmission.
Deploying solutions using decentralised recording	Development and pilot applications of technical solutions based on blockchain technology following the initiatives of the European EPSI network.
Disinformation prevention and cyber hygiene in the information space	Support for technical solutions to analyse tracking of the spread of disinformation in the information space, in particular to social networks. Developing effective defensive measures to prevent their adverse impact on society.
Development of an open and secure operating system for selected platforms	Supporting development teams to develop an open operating system for computers and other electronic devices with guaranteed security for critical infrastructure needs even on standard workstations with the possibility of certification for different classification levels.

3.3.6.1 Transformation map of Priority Area 3-4

Proposals for projects:

- encryption algorithms;
- quantum distribution of encryption keys;
- protection of computer networks;
- decentralised recording technologies;
- disinformation prevention and cyber hygiene in information space;
- natural language processing;
- systems for interpreting information content.

Figure 15: Transformation map of Priority Area 3-4



Examples of research capacities available within the domain priority areas

Private and public sector VVI centres that have references on sensor data processing and embedded systems. The science parks in Bratislava, Martin, Žilina, Košice, Slovak Academy of Sciences and research teams in the private sector are working on this topic.

Estimation of potential customers in application practice for priority domain areas

Companies engaged in the design and manufacture of hardware and software for embedded systems, analysis of large volumes of data, processing of structured sensor data, processing of satellite and aerial imagery, programming of embedded systems, development of digital twin systems. Companies processing large databases in the domain of industry and commerce, healthcare IT services, creative studios focusing on a variety of specialised professions, the gaming and film industries, architectural studios and companies focusing on spatial and process design of operations of all types. Companies performing analysis of power systems and consumer behaviour, forecasting of electricity production from renewable energy sources, use of weather data, production and consumption management, energy audits, collection of data from smart meters, analysis of relationships between market participants and in the power system. Energy communities and other entities that will take on new roles under EU legislation as aggregators, operators of charging stations, energy storage facilities and closed distribution systems. Companies providing protection against cyber threats, protection of classified information and encryption, development of decentralised recording technologies (blockchain), quantum technologies for cryptography.

Healthy society

3.4 Healthy society

3.4.1 Justification for the domain

Domain definition

Health is influenced by many social, ecological and environmental variables as well as economic ones. The health status of a society is the result of these variables and, at the same time, influences and changes them. We live in a time of globalisation, environmental change, industrial development, digitalisation and increased demands on a "healthy society", which has to respond adequately to these complex changes. The current COVID-19 pandemic has only confirmed the need for and importance of promoting and protecting health, which has a direct impact on a country's economy. The pandemic highlighted fundamental deficiencies in the Slovak healthcare system (hereinafter referred to as "HC"), including Slovak science lagging behind in the field of healthcare, from the lack of a functional roadmap of research infrastructures to inappropriately defined conditions for the implementation of biomedical R&D tasks and the implementation of their results into practice.

The original RIS3 Domain 4 "Population health and healthcare technologies" has been renamed "Healthy society", due also to the need to change the approach to defining the domain's goals. Supporting transformation of the domain is crucial not only in relation to population health but also within the context of building an effective health system in the Slovak Republic. This must be built on the basic pillars of a modern society – R&D, education, personnel and material support and, last but not least, on a stable system for financing the three main priority areas identified in the EDP. We work with a vision of adjusting the way we regard health so that we can respond effectively to current and future demands in the areas of disease prevention, diagnosis, treatment, and follow-up care in relation to the expected quality of life. The ambition of the domain transformation is also to highlight a fact that health and its aspects are also important and highly relevant for the development of sectors in other SK RIS3 2021+ domains and, conversely, the promotion of certain, specific areas within other domains can directly or indirectly influence the health status of the population.

Strategic and policy materials of the SR relevant to the domain area

This includes concrete specific themes, measures and recommendations in relation to RDI based on the policy documents of the Government of the Slovak Republic from 2009 to 2020. The basis for the transformation of the "Healthy society" domain is the Summary report of the EDP process, in particular the Product lines for the "Population health and healthcare technologies" domain. As there was no effective implementation of the RIS3 strategy under the Operational Programme Research and Innovation (hereinafter referred to as "OP RI") in the 2014-2020 programming period,[63] the above summary report from 2018 contains overlaps with the current objectives of the three priority areas identified in the new EDP.

- The "Strategic framework for healthcare for 2013-2030" is based on the efforts of the Ministry of Health of the Slovak Republic to apply the principle of "health in all policies" (hereinafter referred to as "HiAP"), and thus to cooperate in the development and implementation of health policy with all sectors in order to achieve the objectives.
- One of the most relevant areas of the state research and development programmes for 2019-2023, with an onward view to 2028, is "Quality of health and nutrition of the population,

[63] OP RI: *Záverečná správa Hodnotenie výskumno-vývojového a inovačného potenciálu SR v roku 2020*. Available at: https://www.opvai.sk/media/101370/hodnotenie-vvi-potencialu_zaver-sprava.pdf

development of biotechnology and agriculture, protection and improvement of the environment", especially in the sub-programme "Innovations in the prevention, diagnosis and therapy of civilisation diseases".

- The "National Oncology Programme (NOP) 2018-2020", is a strategic plan which, together with its action plans, includes measures to reduce cancer incidence and mortality, as well as to improve the quality of life of cancer patients. Its continuity is currently reflected in the AP NOP for 2021-2025* (*new AP NOP approved by the Government of the Slovak Republic on 20 July 2021, as well as the AP NOP read-outs for 2019 and 2020).[64]
- - Population health surveys highlighting the prevalence of major diseases of civilisation and their risk factors, including:
  a) "Slovak Republic – Country Health Profile 2021" (SR: Country Health Profile 2021; OECD), which represents EUROSTAT and OECD evaluations based on national statistics data;
  b) "Slovakia – Health System Review 2016" (Health Systems in Transition, 2016. European Observatory on Health Systems and Policies- a partnership hosted by WHO), which provides a detailed description of health system settings, related planned reforms and policy initiatives;
- The Mission Against Cancer programme, launched in September 2021, as well as the endorsed "Roadmap for Research Infrastructures" (SK VI Roadmap 2020-2030[65]).

European or international strategic and policy documents relevant to the domain area

- Consistency with the Cohesion Policy 2021-2027, especially in the context of the "EC Slovakia Report 2019" (which highlights Slovakia's underperformance in key areas of RDI, the Recovery and Resilience Plan, the Slovakia Operational Programme and the Partnership Agreement) and the "EC Slovakia Report 2020" (which highlighted the under-utilisation of favourable economic times and underperformance, especially in areas that are key to future growth: quality of public administration; education, RDI; balancing regional disparities; quality of the environment, while Slovakia has to face other challenges such as an ageing population, climate change and digital transformation).
- Consistency with several HE domains, in particular the "Health" cluster, represents the first cluster of the second HE pillar, which is large, complex and multidisciplinary, covering a wide portfolio of areas and topics. The Health cluster will also contribute to the objectives of the European climate convention: An economy that works for people; A Europe fit for the digital age and A stronger Europe in the world. The proposal for transformation of the domain also builds on the above-mentioned cancer mission as well as the Cancer Action Plan; the EU4Health programme and the planned programmes of the European Institute of Innovation & Technology (EIT).
- Consistency with the objectives of the European Social Pillar, according to which every citizen has the right to timely and accessible healthcare, prevention and a good quality of life.
- Within the framework of the new European Research Area (ERA), the ERAvsCorona Action Plan, which is directed at supporting RDI in times of pandemic, also partially affects the domain.

[64] The National Oncology Programme: *Akčné plány NOP 2021-2025 NOP a odpočty za roky 2019 a 2020.* Available at: https://www.noisk.sk/o-nas/narodny-onkologicky-program
[65] *MESRS SR: SK VI Roadmap 2020-2030. Available at:* https://www.minedu.sk/cestovna-mapa-vyskumnych-infrastruktur-sk-vi-roadmap-2020-2030/

- In addition to these key strategies, the domain also reflects other programmes and initiatives, such as the European Partnerships; European Universities; Digital Europe; and others.

Justification for the domain selection

a) Current needs in the SR

The health of the Slovak population has improved over the last fifteen years, but most indicators of the health status of Slovak society still lag behind the EU average. In addition to the current low levels of health-spending, the health sector faces long-term fiscal sustainability challenges that require significant and continuous improvements in the efficiency of the healthcare system. Improvements in efficiency must include strengthening RDI and education, including the establishment and profiling of research hospitals.

The "Healthy society" domain focuses on the following areas as a priority, with necessary support for several key points:

Improving the health status of the population in Slovakia

The life expectancy of the Slovak population is around four years lower than the EU average, while the proportion of preventable deaths (due to conditions that are treatable in modern healthcare) is relatively high. Cardiovascular, oncological, metabolic and neurological diseases (specifically chemical heart disease, stroke, lung and colorectal cancer) account for a large proportion of mortality, (OECD[66]). Slovakia has a higher mortality rate from digestive tract, kidney, breast and genital cancers than the EU average (GLOBOCAN[67]). Musculoskeletal problems and depression are also common causes of many diseases. The prevalence of overweight and obesity in children is increasing (OECD). There is also an increase in the number of deaths from infectious diseases in 2020, mainly linked to the ongoing COVID-19 pandemic. Healthcare is largely based on conservative approaches with a small proportion of innovative preventative, diagnostic and therapeutic approaches. In addition to the lack of systemic continuous support for R&D by the state, including long-term underfunding from national sources, there is no clear link between R&D and clinical practice. The R&D system is outdated, R&D processes are incorrectly set up or not addressed, and have not been subjected to innovation for a long time.

On the basis of EDP outputs, it may be stated that Slovakia has covered practically all medical areas, but has largely been limited to basic research activities. Overall, these outputs reaffirm the long-standing absence of implementation of a central/targeted science state policy with prioritisation of specific areas in which Slovakia has the ambition to become a breakthrough/excellent partner (see Annex 1: Outputs of the EDP-questionnaire).

The smart specialisation process targets specific, carefully selected health topics based on supply and demand, with a direct impact of "megatrends" and a systemic approach. The implementation of innovations in healthcare is conditioned by an effective link between academic research and healthcare providers, as well as with practice and industrial development. The transformation of this domain also requires a fundamental shift in the perspective and attitude of the state in order to determine the necessary diagnostic and therapeutic options for the patient based on the management of innovation and the introduction of new, innovative products and services into the system of the provision of healthcare through health insurance companies. Successful transformation of this domain also requires

[66] National Health Information Centre: *„OECD HEALTH STATISTICS"*. Available at: https://www.nczisk.sk/Medzinarodna-spolupraca/OECD/Pages/Health-Data-OECD.aspx
[67] World Health Organization: *International Agency for Research on Cancer, Globocan 2020.* Available at: https://gco.iarc.fr/today/data/factsheets/populations/703-slovakia-fact-sheets.pdf

systemic ongoing inter-ministerial financial support in the three main priority areas identified in the EDP.

Revision of legislation

Within the framework of legislative regulation, the domain needs to revise the legal norms reflecting the strategy of systematic support for the improvement of R&D, the development of biomedical translational and clinical research, including biobanking, funded from European and national sources, whose outputs have the potential to significantly increase the quality and efficiency of the provision of healthcare in the SR as well as on the global level. All the proposals necessary for legislative amendments are presented as part of Annex 2.

Completion, maintenance and development of infrastructure

In the last programming period, Slovakia supported the construction of several science parks and centres that are wholly oriented towards biomedical R&D. However, no systematic support has been provided to these centres and, due to elimination of the possibility to also use resources from the ESIF, they have attained a state bordering on sustainability. In addition, the impossibility of using capital funds within the Bratislava self-governing region is a disadvantage, which discriminates against an extensive group of researchers.

In addition to serious shortcomings in the area of infrastructure (see also Chapter 2), healthcare providers, especially hospitals, currently have only minimal opportunities to participate in R&D projects and programmes due to their unbalanced financial management which is, however, conditioned by the overall incorrectly set system for financing the state healthcare system. The premises of hospitals are archaic and the instrumental infrastructure is technically and morally obsolete after five years. Strategies aimed at strengthening RDI and education in healthcare, including building and profiling research hospitals, have not yet been implemented in practice; this further exacerbates the already significantly reduced possibilities of implementing R&D in appropriate conditions. Innovations in the field of R&D are very difficult to apply in the environment of the existing health infrastructure. At the same time, there is a need to resolve the opportunity for hospitals, especially state hospitals, to apply for support from EU Funds. This area is crucial for the viability of biomedical/clinical research and the real link between R&D and clinical practice.

Systematic support should be based on a functional Biomedical R&D Roadmap with a focus on the formation of clusters wherein a research centre/university/faculty/hospital or specialised medical centre/small, medium and large enterprises (hereinafter referred to as "SMEs") would be interlinked.

Strengthening human resources

The goal of the domain transformation is not only to support the development of health research topics of long-term relevance for the SR, but also prospective areas of specialisation that have adequate intellectual capital. Within the framework of the EDP, we have progressively analysed the whole field of biomedical R&D in Slovakia, including relevant actors from the academic and business sectors, healthcare providers and regional public health authorities (hereinafter referred to as "RPHAs"), while also addressing non-profit patient organisations and foundations that support R&D.

One of the keys to the domain transformation is to stabilise quality human resources and to effectively use the existing intellectual potential in Slovakia in both the public and private sectors. The EDP outputs confirmed that the biomedical community is relatively well-structured, albeit fragmented, and research is thematically granular. It is mainly concentrated within medical faculties, university hospitals and

institutes of the Slovak Academy of Sciences. However, RDI support in the field of health has long been systemically undersized, which is reflected not only in the state of infrastructure (see above), but also in the lack of sustainability of quality human resources (with a growing tendency of leakage of top experts and young researchers abroad). EDP also pointed to the need to significantly and continuously enhance staffing at the appropriate level, together with the creation of appropriate motivational conditions for their application in the field of R&D in Slovakia.

Development of cooperation

A most important point of the transformation is to establish a good functional roadmap of research infrastructures, which is still lacking. For this reason, the Healthy society domain will also seek to create a roadmap of biomedical R&D that can reliably and interactively identify opportunities for the collaboration, sharing and use of infrastructural and personnel resources between all the relevant actors. The EDP confirmed that the lowest level of cooperation is displayed by the RPHAs, which will need to be actively integrated into R&D processes, especially in the areas of effectiveness of health intervention programmes, prevention programmes, population screening, quality assessment and access to health services. This Roadmap should also include space for building support points, such as a platform of professional project managers to support project preparation; a platform oriented towards technology transfer and IPR protection in medicine; a platform of incubators/accelerators, institutions/organisations focused on supporting innovative research teams, SMEs and start-up/spin-off companies; a platform of mobility and exchange opportunities, etc.

Effective integration of the results of Slovak biomedical R&D into practice also requires the cooperation of clinical, educational, research and business spheres in the context of interdisciplinary solutions. An integral part of the future project plans is digitalisation with the aim of creating a digital platform aimed at building archives of structured medical data which will serve as a basis for R&D activities.

This transformation goal defines the establishment of an effective support platform for the introduction of digital innovations into the healthcare environment. Digitalisation and the use of big data in high-performance technologies represent perhaps the largest and most important areas for the interdisciplinary interconnection of medical and technical sciences, which enhances the conditions for the wider involvement of top research teams from Slovakia in R&D projects within the EU.

Support for project activities associated with national nodes of pan-European infrastructures of the ERIC type within the ESFRI platform also forms an essential part of the European Strategy Forum on Research Infrastructures, (hereinafter referred to as "ESFRI") relevant to the health field, including SLOVACRIN (which is part of the pan-European consortium ECRIN, hereinafter referred to as "ECRIN") linking sites focused on academic clinical research in the SR. The results of the new EDP confirmed that more than half of the respondents from the academic sector have not yet collaborated with a business/company, which is associated with the very low level of involvement in collaborative contract research.

EDP confirmed that only properly established projects can effectively increase the share of joint RDI with a positive impact on all the organisations involved and a real input into practice.

Protecting intellectual property rights and innovation

The unfavourable situation in this area also reflects the low IP awareness in Slovakia, as confirmed by the EDP outputs of this domain. It is reflected in weak IPR protection (including the low number of patents granted in the SR and abroad), ineffective technology transfer and ineffective enforcement of exclusive rights (especially patent protection). The health product lines (inventions and innovations)

represent the core know-how of the portfolio with the potential for the highest added value and exclusivity. In order to enhance cooperation between the public sector and industry, it is essential that an integral part of the activities for the effective transfer of knowledge from basic research into real practice is the effective promotion of quality IPR protection through targeted orientation projects and cooperation with the scientific community through RDI support organisations, including incubators/accelerators/hubs, clusters, or a platform such as a pooled Technology Research Centre (hereinafter referred to as "TRC").

Global megatrends

On the global level, population health is one of the most important priorities. Promoting health, including the establishment of stable and sustainable healthcare ecosystems built on education and RDI, is key to building healthy societies, as evidenced by the COVID-19 pandemic. Despite the fact that, in highly innovative countries, the effective implementation of biomedical research results into practice contributes to significantly better outcomes in the provision of healthcare and improves the quality of society as a whole, R&D in the field of health is often undervalued and underfunded in the SR in comparison with other areas.

The transformation of the domain requires a fundamental change of attitude and strategy on the part of the state, which will condition the strengthening and expansion of the attractiveness of the Slovak Republic by increasing the innovative and added value of the life/medical sciences sector within the identified areas, in order to successfully keep pace with international competition. Support for medical research is also a motivating factor for the retention of young, excellent scientists who bring innovative solutions.

The current megatrends in the field of biomedical R&D are:

- **Patient-centred healthcare** ("Patient-Centric", i.e. personalised/precision medicine);
- **Leveraging big data to represent key prospective drivers of health.** Modern, rapidly emerging high-throughput technologies in life and medical sciences such as Next Generation Sequencing (NGS), digital pathology, Real-World Evidence (RWE) generation, etc.;
- **Innovative health products: for diagnosis, therapy and prevention** (e.g. molecular biomarkers, diagnostic tests, cell- and antibody-based drugs, vaccines, kits and chips, etc.);
- **Digital applications in healthcare** (e.g. online/virtual consultations, digital data and records, AI-based decision-making tools, integration of information in complex patient care);
- **Innovative partnerships between the public and private sectors** (new diagnostic approaches, methods, reagents and tools, point-of-care (POC) tests, locally/regionally developed and manufactured health products);
- **More active involvement of patients in healthcare** (e.g. home self-diagnosis tests).

Healthcare is a critical component of national stability, hence health protection/healthcare delivery must be built on the effective collaboration of all relevant actors who are equal partners in this synergy. The systematic orientation of such concentrated partners towards the above megatrends will consequently be reflected in the overall improvement of the health of society.

Domain and priority areas selection process

For the purpose of EDP implementation, we created an inter-ministerial domain platform that conducted regular meetings and workshops, either in person or in an online/virtual format, where we actively discussed the entire EDP setup and the recommendations of experts from the consulting

company BAK economic intelligence. The basic initiation input to our domain profile analysis consisted of five main areas:

1. R&D (research topics, research areas, types of research, demand).
2. Infrastructure and staff capacity.
3. Networking, cooperation and training.
4. Technology transfer and IPR protection.
5. Interdisciplinarity or cross-cutting links with other domains.

Setting the priorities for the transformation of Domain 4 and the related topics of future calls in the programming period 2021-2027, the Domain Platform has conditioned a thorough audit of the demand of individual research organisations within the domestic grant schemes in the field of medical, natural, social and technical sciences (APVV and VEGA), calls of the Ministry of Health of the Slovak Republic for R&D in healthcare, as well as in the context of the Operational Programme Research & Development of the previous programming period 2014-2020, especially in the field of long-term strategic research (hereinafter referred to as "DSR"). At the same time, the domain platform focused on evaluation of the number of publications and citations in different areas of medical sciences.

These analyses were complemented by a custom domain questionnaire developed and implemented by members of the domain platform in October-December 2020.

Our own domain-specific questionnaire survey for researchers in the field of applied research in healthcare, especially biomedicine (https://www.health.gov.sk/Clanok?dotaznik-aplikovany-vyskum) was directed at all potential target groups of stakeholders - academic organisations, the business sector, providers of healthcare and other organisations such as regional public health authorities, non-profit organisations, foundations, etc. In the context of the EDP, this survey made it possible to identify in the domain the existing staff and infrastructure capacities, research areas and specific research topics, the level of collaboration between the public and private sectors, the situation in the promotion and protection of IPR, technology transfer or societal demands on health. At the same time, the questionnaire outputs more clearly identified interdisciplinary linkages and cross-cutting with other sectors, disciplines or megatrends in areas such as environment, materials and digitalisation. It also included suggestions from respondents for supporting the development of biomedical R&D in the SR; see Annex 1.

The outputs of the EDP confirmed the original intention of creating three main priorities and the definition of a strategic objective to create a domain platform in health for participatory decision-making, collaboration and the potential for new partnerships, strengthening intellectual property protection rights and technology transfer, speedier commercialisation of R&D outputs, as well as increasing employment in biomedical R&D. Last but not least, we will also focus on supporting the development of new options and opportunities that enable investment in the highest value-added medical products and processes. Transformation of the domain requires systematic continuous support of the state associated with the implementation of especially complex projects of excellent research and innovation (discoveries/inventions) with the potential of exclusive rights, based on effective multi-expert cooperation, often also conditioned by the convergence and harmonisation of different areas of science, enhancing national/international partnerships and collaborations for better health and healthcare in Slovakia and in Europe.

3.4.2 Domain goal

Table 19: Domain transformation goals

Domain priority areas	Priority area transformation goal
4-1 Personalised/precision medicine	Creation of sustainable biomedical infrastructures and staff capacity to support R&D for prevention, diagnosis, treatment (including biobanking - storing samples in biobanks with associated data) and follow-up care, with consequent improvements in population health and quality of life.
4-2 Innovative products (including (bio)materials and biotechnologies)); processes and procedures in healthcare	Introduction of new healthcare products, processes and procedures into clinical practice and improvement of existing products, processes and procedures used in clinical practice.
4-3 Breakthrough technologies in healthcare	Promoting unique, frontier R&D in medicine and related sciences, empowering Slovakia as an innovator on a global scale.

The transformation of the Healthy Society domain within the three main priority areas needs to be comprehensive, with continuous implementation and with systematic support from the state in order to achieve the objectives, which include:

- modern infrastructure for research and innovation-driven provision of healthcare;
- a better working environment, motivation and career progression for researchers in the field of healthcare;
- an inspiring, attractive and sustainable environment for the retention and return of Slovak health researchers/experts;
- strong and sustainable collaboration between academic researchers, healthcare providers and industry, including through the establishment of a functional Biomedical R&D Roadmap;
- effective inter-ministerial cooperation, functional management, reduction/elimination of bureaucracy and simplified implementation of projects and their results into practice in the health sector;
- an effective legislative-organisational and procedural environment for a significant increase in R&D spending in the field of health, at least to the level of the average of the other three V4 countries;
- continuous and synergistic funding for biomedical R&D;
- effective support for health-focused SMEs, start-ups and spin-offs, e.g. through access to existing research infrastructure, financial support for business start-ups and development, professional support, support for collaboration etc.;
- effective promotion of biomedical clusters, which play a critical role in contributing to the growth and development of industry in the country by providing synergies and platforms for academia, industry, policy-makers and investors to collaborate with each other;
- enhancing international cooperation and internationalisation of Slovak science, RDI in the field of health, including participation of the SR in European partnerships, as well as in the framework of project activities of ESFRI national nodes of research infrastructures (such as SLOVACRIN);
- establishment of the pharmaceutical and biotechnology industry as an essential part of the Slovak knowledge-based economy.

3.4.3 Priority Area 4-1: Personalised/precision medicine

Transformation goal 4-1

The objective of the priority area "Personalised/Precision Medicine" is to build and develop a sustainable eco-system with scalable capacities to support RDI in prevention, diagnosis, treatment of diseases (including biobanking - storing samples in biobanks with associated data). Aftercare of patients with socially serious diseases, will ultimately improve the health status of Slovak population and its quality of life.

Personalised/precision medicine is a prerequisite for improved health and healthcare. It is based on the possibility of using predominantly genetic but also other molecular data in a standard system of healthcare provision. These data afford not only a better understanding of the mechanisms of major diseases but, more importantly, the search for new opportunities for more targeted prevention, diagnosis and therapy in disease management. Personalised/precision medicine also improves the safety and efficacy of treatment, and the implementation of its principles and practices in clinical practice has been shown to reduce morbidity, mortality, hospital admissions, and pharmacotherapy costs, as well as significantly reducing healthcare spending. The active interest and involvement of the population in RDI will not only bring more sources of knowledge but will also provide society with the tools and opportunities to influence its own health.

This priority area also represents a societal challenge in terms of the progressive integration of knowledge from medicine, biology, chemistry, socio-environmental parameters and other interdisciplinary fields. The Entrepreneurial Discovery Process (EDP) has identified low penetration of complex "omics" methods, not only due to limited availability of infrastructure, but also due to insufficient analytical experience to interpret their outputs. Moreover, the acceptance rate of such methods by healthcare payers in clinical practice in Slovakia is very low and their use is further reduced despite their undeniable advantages. In terms of strengthening this area, there are several research teams in the SR with high potential, the interconnection of which could lead to more significant and synergistic outputs.

These issues are also closely related to use of big data, which represents a key market-driver for healthcare applications in the future. Modern, rapidly developing and highly efficient technologies in the life sciences/medical sciences are emerging, including Next Generation Sequencing (NGS), digital pathology, Real World Evidence (RWE) data generation, etc.

Data integration, virtualisation and modelling have become important in the development of personalised/precision medicine, which incorporates not only data from "omics" sciences, but also information on lifestyle, clinical or therapeutic outcomes. In this context, data protection and security aspects also need to be taken into account. Health and disease annotations/health records are regarded as sensitive information, hence are subject to specific ethical and legal provisions.

The planned concept for the use of big data will include solutions for the secure and synergistic use of hardware and software systems, for the storage and management of different data formats (genomic data, clinical research data, imaging data, etc.) in the sense of open data and open access under predefined conditions. Such an approach should include the standardisation and harmonisation of data, while taking into account the already existing as well as planned platforms in this area. When complying with the international standards, it will be important to take into account specific ethical and legal

provisions, standards and certification protocols, including references to relevant European research infrastructures (e.g. ELIXIR, BBMRI-ERIC, Euro-BioImaging, etc).

Biobanking is also an important basis for the development of personalised/precision medicine. It represents a sophisticated, highly organised system for the long-term storage of biological material with relevant clinicopathological, epidemiological and biomolecular information. It is a prerequisite for high-quality biomedical R&D, including the acquisition of information on biomarkers of disease and the discovery of new target molecules – so-called "targets" in the development of innovative drugs. The biobanking system involves the interconnection of processes ranging from informing the healthy population and patients and obtaining their consent to donate biological material, collecting data on respondents, collection of biological material and its collection, storage and warehousing, quality control, cataloguing, accessibility, processing, to the distribution and assignment of samples according to type to the biobanking system's centres.

The long-term absence of systemic biobanking in the SR is reflected in the implementation of a project aimed at building a national biobank at the Jessenius Medical Faculty in Martin, Comenius University, in cooperation with the Biomedical Centre of the Slovak Academy of Sciences, the Centre for Social and Psychological Sciences of the Slovak Academy of Sciences, the Faculty of Medicine of Comenius University in Bratislava, the Ministry of Health of the Slovak Republic, the National Institute of Oncology, the National Institute of Rheumatic Diseases and the University of Žilina. The consortium will gradually be expanded to include other actors in order to create an effective Slovak biobanking hub. This initiative in the field of oncology is complemented by the AP NOP. The strategic approach of co-financing from national sources makes possible the creation of synergies with the above-mentioned activities of European projects. The new EDP has confirmed the necessity for future projects aimed also at further continuous development of systemic biobanking infrastructure, which determines the quality of biomedical R&D in the Slovak Republic. Thus, the support of biobanking is considered to be crucial in the context of personalised/precision medicine.

If Slovakia has the ambition to contribute effectively to international efforts in this area, it needs to ensure compatibility in the area of infrastructure, increase staff capacity and, at the same time, build excellence based also on RDI expertise from previous or ongoing project activities identified in national grants/EU funding schemes.

Justification for the priority area selection

The application of personalised/precision medicine in practice is conditioned on the identification and implementation of the most modern and optimal methods in disease prevention, diagnosis, treatment and follow-up care. The key point of this area is biomedical R&D, which has a direct impact on the clinical implementation of results in medical practice, i.e. the therapeutic procedure and comprehensive patient management is based on comprehensive and correctly interpreted diagnostic information in the context of the patient's specific clinical situation, the patient's preferences, knowledge and experience of the persons involved in the patient's care.

Summary of justification:

- It represents a societal challenge based on the progressive integration of knowledge from medical and non-medical sciences, including biology, chemistry and socio-environmental parameters.

- The individualised treatment approach has a high potential for streamlining clinical medical practice, reducing clinical trial (hereinafter referred to as "CT") error rates and reducing the cost of healthcare.
- It entails a proactive approach and the involvement of the population in R&D activities, in view of the increasing demand for a personalised approach.
- It is highly interdisciplinary - it is based on rigorous data analytics (including high-volume).
- The SR has a number of high-potential research teams working in this area, and linking them could lead to more significant and comprehensive results and synergies.
- It includes the continuity of further development of the biobanking system infrastructure.

Indicative measures to meet the transformation goal (from the EDP)

Table 20: Enabling measures to meet transformation goal 4-1

Measure	Measure description
Systematic support for research activities in specific areas	The reason underlying the selection of specific areas of support is largely the fragmentation of R&D and the excessive granularity of research tasks. The goal is to support strategic long-term projects covering the whole area of disease management – prevention, screening, diagnosis, treatment, follow-up care through intersectoral and interdisciplinary collaboration. Due to the need to comply with several strategic documents of the SR and the EU, we consider it important as a first step to support large collaborative projects in the above-mentioned settings in the following topics: oncological diseases, neurological and psychiatric diseases, metabolic diseases, diseases of the cardiovascular system and rare diseases.
Systematic support for big data analysis	In view of the tremendous progress in the use of information technologies in medicine, digitalisation and the introduction of artificial intelligence processes into clinical medical practice, it is essential to focus in particular on the creation of standards for the use of these technologies, the establishment of bioinformatics laboratories and the building of structured registries for the needs of healthcare/biomedical R&D.
Systematic support for biobanking	Biobanking is the basis of biomedical R&D, hence this process needs to be treated legislatively, logistically and operationally in the SR. Sustainability of the national biobanking infrastructure requires the establishment of continuous co-financing by the state. In order to achieve synergies, systematic support for the development of local biobanks is also necessary from state sources, especially within the framework of national programmes targeting disease areas with the highest morbidity and mortality in the Slovak Republic (including NOP, etc.).

3.4.3.1 Transformation map of Priority Area 4-1

In connection with the above, we propose the following areas of project support in the priority area:

- **Support of biobanking infrastructure** – continuity and complementarity with the ongoing projects of the national biobank for cancer and rare diseases and the digital biobank, as well as further development of the systemic biobanking infrastructure in the SR.
- **R&D projects in oncology** – complementary long-term strategic research projects on selected malignancies – in particular breast cancer, colorectal cancer, lung cancer, prostate cancer and testicular cancer. The projects will be in line with the strategy of the new NOP and Mission Against Cancer action plans.

- **R&D projects in neurosciences** – projects focusing on neurodegenerative and psychiatric diseases – in particular Alzheimer's dementia, Parkinson's disease, multiple sclerosis, sensory and motor nervous system disorders and autism.
- **R&D projects on metabolic diseases** – in particular on diabetes mellitus, both in childhood and adulthood, including its complications, metabolic syndrome, obesity and selected disorders of amino acid metabolism (alkaptonuria) and lipid metabolism (hyperlipoproteinemia).
- **R&D projects on the cardiovascular system** – in particular on haemocoagulation disorders, hypertension in childhood and adulthood, and ischaemic heart and brain disorders.[68]
- **R&D projects on rare diseases** – up to 300, 000 people in Slovakia suffer from rare diseases. A rare disease can occur in anyone at any time of life. Because of their rarity, these diseases are not studied in detail. They have limited diagnostics and therapies, which represents a challenge for personalised/precision medicine.
- **R&D projects on infectious diseases** – the requirement for these types of projects in the Slovak Republic is based on the current pandemic situation – the COVID-19 disease, but also on other potential risks of infectious diseases.

All projects in a given priority area should be comprehensive, i.e. oriented towards disease prevention, diagnosis, therapy to follow-up care or patient-monitoring. Projects must have a direct output into clinical practice. The prevention project area may also focus on public health research to elucidate the impact of determinants of health, i.e. factors (genetic, environmental, social, including biomonitoring, etc.) that determine the health of a population. The goal is to use this knowledge to design and implement evidence-based actions and policies that will help improve public health and reduce health inequalities. Projects can be appropriately complementary to the digitalisation and use of smart IT solutions, in particular in the fields of bioinformatics, artificial intelligence, virtual reality, etc.

[68] **R&D projects on metabolic and cardiovascular diseases** – these diseases are very closely linked, either directly or through various complications. It is therefore not inconceivable that, in terms of complexity, this will be a common theme, especially in an area of penetration such as obesity.

Figure 16: Transformation map of Priority Area 4-1

Priority area current state

Personalised/precision medicine is a prerequisite for improved health and healthcare. Currently, the development of diagnostics and personalised medicine is based on the analysis of big data, which represents a unifying trend in biomedical research.

- Lack of thematic prioritisation of long-term biomedical research strategy according to disease trends.
- Low-capacity research teams.
- Excessive granularity of their research tasks.
- Inadequate protection of IPR.
- Shortage and poor sustainability of human resources.
- Low penetration of complex, so-called "omics" methods into research practice.
- Shortage of skilled manpower in biomedical research.
- Poor state of infrastructure.

Thematic support to meet the priority area transformation goal

- Establishment and continuous development of a systemic biobanking infrastructure in the SR as a prerequisite for the development of biomedical RDI.
- Support for complex projects thematically oriented in the field of socially serious diseases; with direct outputs into clinical practice:
  - R&D projects in oncology;
  - R&D projects in neuroscience;
  - R&D projects on metabolic diseases;
  - R&D projects on the cardiovascular system;
  - R&D projects on rare diseases;
  - R&D projects on infectious diseases.
- Potential project complementarity with digitalisation and the use of intelligent IT solutions (bioinformatics, artificial intelligence, etc.).

Funding sources to achieve desired outcomes

RRF/OP EN/HE/state budget/private sector investment/other funding source: Recovery and Resilience Plan, IPCEI, EU4Health

Foreseen cooperation to achieve desired outcomes

Cooperation with ESFRI infrastructures for RDI: ECRIN; BBMRI, EATRIS, ELIXIR also in the context of EMBL; European 1+Million Genomes and with prestigious international research institutions, European Research and Innovation Partnerships implemented under HE.

Priority area outcomes

1. Using research evidence to design and implement evidence-based actions and policies that will improve public health and reduce health inequalities.
2. Building sustainable and competitive biomedical infrastructures and capacities to support R&D in the field of prevention (including public health research), diagnosis, therapy to follow-up care or patient-monitoring in the context of socially serious diseases, with consequent improvement in population health and quality of life in Slovakia.
3. Implementation of priority project activities, with the potential for direct output into clinical practice.
4. Enhancing the protection of IPR and the position of the Slovak Republic as an innovator in biomedicine.
5. Introduction of new, innovative products and services into the system of provision of healthcare.

3.4.4 Priority Area 4-2: Innovative products (including (bio)materials and biotechnologies); processes and procedures in healthcare

Transformation goal 4-2

The objective of the priority area "Innovative products" (including (bio)materials and biotechnologies)) with major focus on processes and procedures in healthcare is primarily dependent on the effective introduction of (i) new healthcare products, processes and procedures into clinical practice and (ii) the improvement of existing products, processes and procedures used in clinical practice.

In comparison with other EU countries, Slovakia uses significantly fewer original/innovative products, including materials and medicines, in the provision of healthcare, representing only about 30 % of the total compared to other developed countries. In doing so, new medicines and materials have a strong potential to significantly improve, especially qualitatively, the comprehensive management of patient care. We have identified a similar problem in the area of services, organisation and processes of healthcare delivery. Processes are outdated, modern "guidelines" are absent, and there is the lack of an optimal system for ensuring disease prevention, screening, diagnosis, treatment and follow-up care. This is also due to the outdated infrastructure of healthcare facilities, which restricts the possibilities of introducing new processes into practice.

In Slovakia, support for predominantly only basic and preclinical research remains, with the absence of R&D based on direct demand/requests from clinical practice, as well as effective implementation of clinical research, including academic clinical trials (hereinafter referred to as "ACTs"). This has been confirmed by the new EDP, in which we identified that inefficient and uneconomical use of resources in healthcare lies behind the problem of inadequate implementation of biomedical R&D results into clinical practice.

As such, new materials (including (bio)materials)), biotechnology, healthcare technologies and innovations in medicine represent essential know-how that has enormous potential to be an important part of the knowledge-based economy. In addition to strengthening R&D in this priority area, the goal of the transformation is, in particular, to increase the uptake of its outputs into clinical practice, in conjunction with the correct setting of legislative processes and reimbursement mechanisms. In this sense, amendments to several legal norms are relevant, which specify and harmonise the Slovak legislation for biomedical research and ACTs, including the support for non-commercial research resulting from EU Clinical Trial Regulation (CTR) 536/2014. At the same time, this regulation requires the support of non-commercial commissioners, who often rely on funding deriving partly or wholly from public funds or charities. In order to maximise the value contribution of non-commercial sponsors and to further support their research, which affords access to innovative diagnostics and treatments without burdening health-insurers but without compromising the quality of clinical trials, Member States should put in place measures to incentivise these sponsors to perform ACTs. In the context of Decree No. 4/2018 of the Ministry of Health of the Slovak Republic (together with Appendix No. 1 to this Decree, which represents a model tripartite agreement between the main parties to the clinical trials), other legal norms aimed at making the Slovak Republic more attractive for the implementation of the clinical trials in hospital medical facilities are also planned.

A very small number of ACTs are still being implemented in Slovakia. In 2019, this amounted to a total of 8 new ACTs, of which 6 were in the field of oncology. In 2020, 5 new ACTs were approved, 3 of them with an oncology focus. Accordingly, systematic support for the project activities of SLOVACRIN (part

of the ECRIN Consortium of European Research Infrastructures for CT) is essential for the domain transformation. This national hub strategically builds the research infrastructure for ACTs, including a Slovak roadmap of centres focused on ACTs (especially in oncology, cardiovascular and rare diseases). This approach accelerates and streamlines access to innovative treatments for patients, increases the prestige of physicians and scientists, enables publication activities. It helps in direct savings from public health insurance, creates new jobs and provides follow-up training. It also improves the quality of national and international clinical research.

In this sense, synergy with the activities of the National Oncology Institute (hereinafter referred to as "NOI"), the central platform of the NOP, which is involved, among other things, together with the Slovak Cooperative Oncology Group (hereinafter referred to as "SCOG"), in the establishment of a network of oncology centres specialised in clinical trials, is essential. In order to strengthen the clinical research platform in the SR, it is also necessary to continue the certified training of coordinators and heads of clinical trials departments in healthcare facilities, which was initiated in 2019 by the Ministry of Health of the Slovak Republic through the IVV (BIOHUB SK) in cooperation with the National Cancer Institute (hereinafter referred to as "NCI")/Department of Clinical Trials (hereinafter referred to as "DCT") and SLOVACRIN.

Overall, there is a low number of innovative application outputs in healthcare in the SR. Transformation of the domain in this priority area also implies systematic support of the state in setting up effective cooperation with health-insurers aimed at enhancing innovation in healthcare through aligned incentives and innovation traction (e.g. by introducing Acceleration and Innovation Tariffs). According to examples from abroad, it is possible to set up such business models in the SR in the context of two private health insurance companies (Union and Dôvera) and the state-owned General Health Insurance Company, which accounts for about 60 % of the domestic market. For example, in Germany, a system called "Healthy Hub" has been introduced where digital health start-ups can join a consortium of five insurance companies in order to validate and test their innovative solutions and products directly on the market. Following successful clinical validation, these diagnostic tests will then be integrated into the German reimbursement system. Transformation of the domain reflects such a potential to involve interested insurance companies[69] in Slovakia and to test their interest in cooperation, e.g. by joining a bio-incubator in a given region (Bratislava, Martin, Košice).

Support in this area is closely linked to the expansion of knowledge potential and, consequently, to the strengthening of the country's knowledge economy. In order to meet this societal challenge, it is essential to facilitate projects focused on R&D and the production of new and innovative materials, including (bio)materials, biotechnologies, sensors, medical technologies with strong potential for exclusive rights based on quality IPR protection. The implementation of projects related to the transfer of innovative results directly into practice, as well as scientific research and educational activities aimed at improving procedural steps in healthcare are planned. The stated transformation goal is to strengthen a competitive and innovative environment for translational medicine and to effectively connect R&D and clinical practice.

Justification for the priority area selection

Selection of the priority area was based on an analysis of the current environment of healthcare provision and the demand for new products and services across the healthcare sector. Domain

[69] Now: *Prvé klinické skúšanie umelej inteligencie na Slovensku*. Available at: https://www.teraz.sk/slovensko/prve-klinicke-skusanie-umelej-inteli/595227-clanok.html

transformation in this area will focus on strengthening R&D and the production of new materials, including (bio)materials, biotechnology, sensors, medical technologies and others linked to the transfer of results into practice, as well as projects focusing on process improvement steps in healthcare.

Summary of justification:

- New materials (including (bio)materials)), biotechnology, healthcare technologies and innovations in medicine as such represent extremely important innovation 'know-how' with high added value and are an important part of the knowledge-based economy.
- This priority area reflects a societal challenge; we innovate little in comparison with other countries.
- Slovakia's current position as an "emerging innovator" is also related to the inadequate protection of IPR (especially the low number of patents), ineffective transfer of R&D results in this area into practice, coupled with ineffective enforcement of exclusive rights.
- Long-term inefficient and wasteful use of resources in the health sector, also due to the relatively low utilisation of R&D results in practice. No clear link between R&D and clinical practice.
- Limited access to new trends and innovative outcomes in healthcare through coverage and reimbursement mechanisms of health insurance companies in the SR.
- The healthcare system is outdated, processes in this area are incorrectly set up and unaddressed, and have not been innovated for a long time. This is also linked to the lack of innovation in health infrastructure and the lack of hospitals with research and innovation potential.
- Poor implementation of application outputs, continued support for basic and pre-clinical research, absence of R&D based on direct demand/requests from clinical practice, with inadequate systematic support for clinical research activities, including a low number of ACTs.

Indicative measures to meet the transformation goal (from the EDP)

Table 21: Enabling measures to meet transformation goal 4-2

Measure	Measure description
Systematic support for research activities in specific areas	The reason underlying the selection of specific areas of support is mainly the fragmentation of R&D and the excessive granularity of research tasks. The goal is to support strategic long-term projects with the greatest potential for application of a product or service in clinical practice. Due to the need to comply with several strategic documents of the SR and the EU, we consider it to be important to support large collaborative projects in the above-mentioned setting in the first step in the following topics: Materials and biomaterials for healthcare, Medicines and dosage forms (including nutraceuticals, probiotics and nutritional supplements), 3D printing and 3D bioprinting, Regenerative medicine, Sensors and technologies for health-monitoring.
Systematic support for (academic) clinical trials, registration and approval of new products	In the SR, a very low number of ACTs are implemented which allow access to innovative treatments (without burdening health insurance companies) and strengthen the quality/prevalence of clinical research in Slovakia as well as in international collaborations. This is due to the lack of ongoing support for both the academic sector and the clinical sphere in hospitals, start-ups/spin-offs and the lack of professional guidance on these

	processes and procedures. It is necessary to systematically support ACTs projects (co-financing from state resources), to strengthen the training of coordinators for CTs, also within the framework of cooperation with SLOVACRIN and NCI/DCT. Legislative changes aimed at supporting the development of ACTs[70] in the SR are also highly relevant. It is also essential to set up a functional Ethics Committee at the Ministry of Health of the Slovak Republic focused on the assessment of clinical trials and medical device projects.[71]

3.4.4.1 Transformation map of Priority Area 4-2

In connection with the above, we propose the following areas of project support in this priority area:

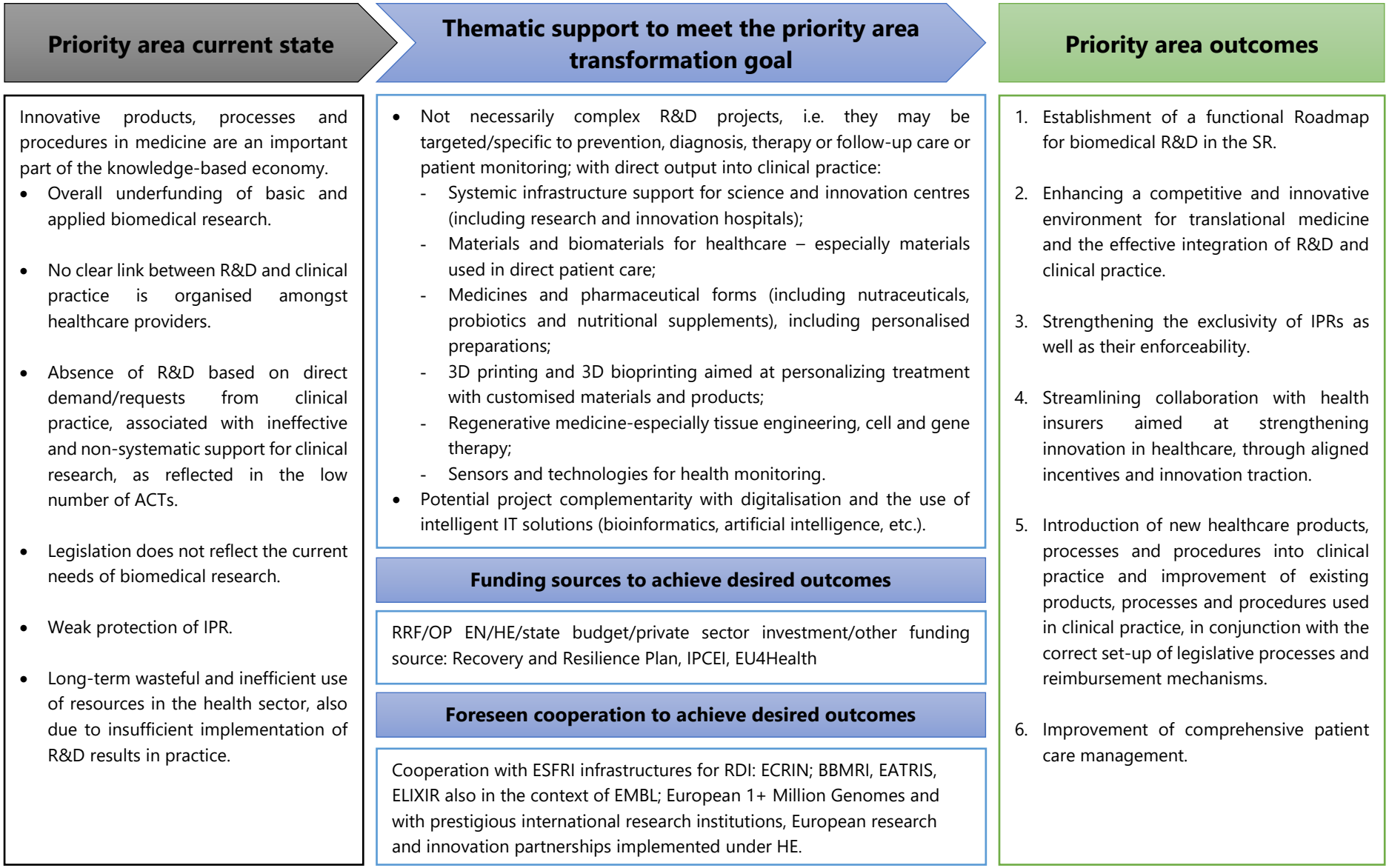
- **Systematic support for the infrastructure of scientific and innovation centres (including research and innovation hospitals)** – complementarity with the already approved projects of biomedical research centres or centres of excellence built within the network of providers of healthcare, including the provision of support for the Bratislava self-governing region. The support should also be linked to the proposal for optimisation of processes in these infrastructures.
- **Materials and biomaterials for healthcare** – especially materials used in direct patient care. In this context, the type of material will not be preferred, but especially the potential of its applicability in clinical practice in relation to efficacy, safety and possibility of use (e.g. antibacterial materials, nanomaterials, plasma, materials containing a medicinal product, etc.).
- **Medicines and dosage forms (including nutraceuticals, probiotics and nutritional supplements)** – support will be mainly directed to R&D on new forms of application, improving safety, efficacy, reducing toxicity, as well as the development of new medicines (including nutraceuticals, probiotics, nutritional supplements, antibodies, etc.). Personalised preparations should also be the subject of projects, which is an emerging trend also in the field of pharmacotherapy.
- **3D printing and 3D bioprinting** – the focus on this type of projects is based on the requirement to personalise the treatment with customised materials and products. In this context, it is mainly about implants (bone, teeth, etc.) as well as new 3D printing options (e.g. absorbable materials, skin, etc.). Personalised implants should also be a topic for projects.
- **Regenerative medicine** – it belongs to the dynamically developing areas of R&D also within Slovakia. Its promotion is one of the key areas, as this topic is multidisciplinary and has a high potential in the field of provision of healthcare. Specific areas include tissue engineering, cell and gene therapy.
- **Sensors and technologies for health monitoring** – at the time of the COVID-19 pandemic, the demand for systems that monitor the patient's health status non-contact and remotely increased significantly. At the same time, sensor systems within healthcare providers are enabling IoT-based management.

Projects in a given priority area do not necessarily have to be comprehensive, i.e. they can be targeted/specifically focused exclusively on prevention, diagnosis, therapy or follow-up care patient-monitoring. However, projects must have a direct output into clinical practice. They may be

[70] The abbreviation (CT)s is used in the context of distinguishing the clinical trial option "CT" or the academic clinical trial option "ACT".
[71] An ethics committee at the Ministry of Health focused on the assessment of CTs and medical device projects is being established in the current period.

appropriately complementary to the digitalisation and use of intelligent IT solutions, in particular in the field of artificial intelligence, virtual reality, etc.

Figure 17: Transformation map of Priority Area 4-2



3.4.5 Priority Area 4-3: Breakthrough technologies in healthcare

Transformation goal 4-3

The objective of the priority area "Breakthrough technologies in healthcare" is to support unique, frontier R&D in medicine and related sciences, in order to enhance the competitiveness of Slovakia as an innovator on a global scale.

Breakthrough technologies are seen as key to sustainable development and competitive advantage. They are a prerequisite for the emergence of "Really New Innovations" (RNIs), or disruptive innovations that either transform or create new markets. The most recent example is new coronavirus vaccines based on mRNA technology. This type of innovation has enormous potential to transform medicine in the fight against various types of infectious diseases and potentially cancer.

Most of the breakthrough technologies come from the academic environment. Original ideas emerge from a community of (young) scientists or students who often lack sufficient experience in putting innovations into practice. It is not entirely rare to see an excellent idea that has not been subsequently supported for various reasons (e.g. reflects potential start-up activity without initial financial support, the innovator does not have "sufficient" publications or citations, lack of quality mentoring, advice, networking, etc.). In the absence of systematic support, the potential for innovation is quickly reduced or even lost. At the same time, such innovations can bring significant and unique technological advances that can significantly improve the quality of society's health beyond the SR.

Slovakia lacks a strong and stable ecosystem to support unique (breakthrough, unique) ideas. Most acceleration and incubation services are permanently undersized. These platforms do not receive adequate funding for operational costs from the state budget, and many of them struggle with lack of funding after they stop using EU funds. The effective development of this ecosystem requires, in addition to continued financial support, the systemic strengthening and development of public sector-industry collaboration. In this sense, according to the most recent models from Germany and Austria, the establishment of a "TRC" – a specialised incubation programme run by industry experts (biotech, pharma), which will focus on innovations in the field of "life sciences"/medical sciences and breakthrough technologies – has a significant project potential. In Slovakia, it is possible to establish TRCs as a model of cooperation with Slovak universities, Slovak Academy of Sciences, non-university research institutions and industry experts (for co-financing opportunities). The main responsibilities would include identification of basic research results that have promising/high potential for development of commercially viable innovative products beyond Slovakia (e.g. medtech, pharma, industrial biotechnology), their validation according to industry standards and initiation of the initial phase of product development in connection with setting up quality IPR protection. The intention would be to better bridge the gap in the transfer of knowledge from basic research to application in the field of biomedicine, which is notoriously underfunded in the SR compared to developed EU Member States. The transformation of the domain reflects the setting up of such a project that will effectively increase the share of collaborative R&D with a positive impact on all organisations involved and a real result/entry into practice.

Within the EDP, we have observed that the entrepreneurial spirit of young scientific talent, especially in Slovak universities and colleges, is not sufficiently supported in practice. It is not rare that the highly innovative potential that underpins the creation and development of most start-up companies is not exploited to the maximum extent possible. Despite the underfunding of health R&D, a relatively high

number of respondents to the EDP questionnaire indicated the potential for 'breakthrough innovations' in their research portfolios. It is therefore essential to implement targeted scouting projects aimed at such cutting-edge innovations; which include expert support at early/advanced stages (e.g. through incubators/accelerators/hubs/TRC-type platforms), clustering; networking, networking with domestic and international investors.

In the EDP, we have identified the requirement for systematic and continuous support for new areas based on the principles of scientific excellence. The transformation of the domain has the ambition to strengthen competitiveness in breakthrough innovations and to provide a space for exploring new ideas, strategies with new directions, new knowledge and skills; to support and motivate the "new/future" generation of researchers. This objective reflects the building of a culture of objective, systemic and continuous strengthening of scientific excellence in Slovak healthcare/biomedical sciences and interdisciplinary fields.

Justification for the priority area selection

The selection of the priority area aims to support ambitious talented innovators/researchers with a great idea who are motivated and have the ambition/potential to transform the idea into reality through professional mentoring and collaboration.

Summary of justification:

- Original ideas are identified in the field of biomedical R&D, but they need support and guidance in line with the principles of scientific excellence.
- Often these ideas originate in a community of (especially young) researchers or students who do not have sufficient experience in transferring innovation into implementation, thus their potential is significantly reduced or lost.
- In biomedical R&D, it is also necessary to identify and strengthen new, promising areas of research and capacity in this field that require a specific type of management and governance.
- Absence of a strong ecosystem supporting the development of unique (breakthrough, unique) technologies, products and services with the potential to innovatively improve the quality of society's health beyond Slovakia.
- It is essential to strengthen Slovakia's competitiveness by providing space for the implementation of new ideas, orientation strategies, knowledge and experience. The "next" generation of researchers needs to be encouraged and motivated and a culture of excellence needs to be built within the Slovak biomedical community.
- Unique ideas may also present new opportunities for cross-cutting with other RIS3 domains.

Indicative measures to meet the transformation goal (from the EDP)

Table 22: Enabling measures to meet transformation goal 4-3

Measure	Measure description
Strengthening technology transfer and cooperation on breakthrough technologies	Collaboration between the public sector and industry, especially in the context of knowledge transfer from basic research to health/biomedical applications, is ineffective. Effectively increasing the share of collaborative R&D with real results/input into practice is reflected e.g. in the TRC project – a dedicated incubation programme run by industry experts that would target cutting-edge innovations in life sciences/medical sciences and breakthrough technologies.

3.4.5.1 Transformation map of Priority Area 4-3

The following types of projects will be supported in the priority area:

- Unique frontier R&D projects in medicine.
- Scouting projects for such cutting-edge innovations; which include expert support at early/advanced stages (e.g. through incubator/accelerator/TRC-type platforms), clustering; networking, networking with domestic and international investors.
- Project to strengthen the ecosystem targeting the development of unique (breakthrough, unique) technologies, products and services - e.g. through the establishment of TRCs.

Projects in a given priority area do not have to be comprehensive, i.e. they can be specifically focused solely on prevention or diagnosis or therapy or follow-up care or patient-monitoring. However, projects need to have a direct output into clinical practice. The projects may be appropriately complementary to the digitalisation part and the use of intelligent IT solutions, in particular, artificial intelligence, virtual reality, etc. However, they do need to be unique, original and contain novel ideas with a high innovation potential, including disruptive technologies capable of having an impact beyond Slovakia.

Figure 18: Transformation map of Priority Area 4-3

Priority area current state

Breakthrough technologies are key for sustainable development and competitive advantage of the SR. They are a prerequisite for the emergence of "brand new" or "disruptive innovations" that either transform or create new markets.

- Collaboration between the public sector and industry, especially in the transfer of knowledge from basic research to health/biomedical applications, is ineffective.
- Financial incentives for startups/MSPs are non-systemic, discontinuous, significantly undersized.
- Lack of legislation effectively supporting the activities and development of innovative startups/MSPs.
- Insufficient protection of IPR.
- Low representation of investors in Slovakia focused on breakthrough technologies in healthcare.

Thematic support to meet the priority area transformation goal

Proposals for thematic areas of project support:

- Projects must be original, with unique ideas that have high innovation potential, including disruptive technologies, with impact beyond Slovakia. Not necessarily complex projects, i.e. they may be specifically focused on prevention, diagnosis, therapy or follow-up care or patient monitoring only; with direct output into clinical practice:
  - Unique frontier R&D projects in medicine;
  - Scouting projects for cutting-edge innovation; which include expert support at early/advanced stages (e.g. through incubator/accelerator/TRC-type platforms), clustering; networking, networking with domestic and international investors;
  - Projects to strengthen the ecosystem targeting the development of unique (breakthrough, unique) technologies, products and services - e.g. through the establishment of TRCs.
- Projects can be suitably complementary to the digitalisation and use of intelligent IT solutions, artificial intelligence, virtual reality, etc.

Funding sources to achieve desired outcomes

RRF/OP EN/HE/state budget/private sector investment/other funding source: Recovery and Resilience Plan, IPCEI, EU4Health

Foreseen cooperation to achieve desired outcomes

Cooperation with ESFRI infrastructures for RDI: ECRIN; BBMRI, EATRIS, ELIXIR also in the context of EMBL; European 1+Million Genomes and with prestigious international research institutions, European research and innovation partnerships, which are implemented under HE.

Priority area outcomes

1. Optimal legal standards, including a law to promote innovation and technology transfer.
2. Implementation of systemic, continuous grant schemes to improve the commercial exploitation of R&D results of breakthrough technologies/cutting-edge innovations.
3. Effective increase of the share of collaborative R&D with real results/input into practice, also through e.g. TRC - a specialised incubation programme run by industry experts.
4. Strengthening technology transfer and cooperation in the field of breakthrough technologies at national/international level.
5. Effective innovation diplomacy outcomes in countries with a high share of the pharmaceutical/biotechnology industry.
6. Strengthening IPR protection in relevant global markets.

Examples of research capacities available within the domain priority areas

The available research capacities include in particular medical faculties, faculties of natural sciences and engineering, the Slovak Academy of Sciences and its workplaces, capacities in the field of pharmacy, capacities in the field of human and veterinary medicine, hospitals, outpatient clinics, specialised institutes, the Institute of Public Health and its workplaces, non-profit organisations and other private and public research institutions active in the field, which can contribute to the fulfilment of the priority area goals. The capacities identified in the EDP process are listed in the Evaluation Questionnaire (Annex 1).

Estimation of potential customers in application practice for priority domain areas

The key customers of R&D results are mainly the providers of R&D services. First and foremost, these are university hospitals, which are considered to be the places with the highest quality of healthcare provision and which should steadily implement innovations, knowledge and experience. Of course, it is also other healthcare providers, whether within the public or private sector, that support building competitiveness in several areas of patient managemen. Other organisations and institutions, such as national specialised institutes for selected diseases, the primary outpatient care sector, the specialised healthcare sector, facilities providing spa treatment, etc., will also be users of the R&D results.

In a broader context, the final user of the results is also represented by the state administration, especially the Ministry of Health of the Slovak Republic in the optics of preparation and implementation of legislative changes of relevant laws enabling the application of the results in clinical practice as well as in the support of the implementation of these outputs in the healthcare system. At the same time, it creates a basis for the Ministry of Health of the Slovak Republic, which helps to optimise the prioritisation of objectives in the field of provision of healthcare within the framework of disease prevention, diagnosis, treatment and follow-up care of patients. Other organisations and institutions, such as national specialised institutes for selected diseases, the primary outpatient care sector, the specialised care sector, facilities providing spa treatment, etc., will also be users of the R&D results.

Last but not least, the results of R&D in this topic should benefit companies that participate as important players in the development of new screening diagnostic and therapeutic methods, products and services, especially in the context of increasing the competitiveness of the SR in the EU and at the global level.

Other areas of the national economy, such as food and agriculture, will also be recipients of R&D results, as sterile or antimicrobial materials are also used in these sectors.

Domain-specific measures to meet the domain transformation goal

Measure	Measure description
Systematic support "core facilities"	The current situation reflects the previous unsystematic support for infrastructure and staff capacity development, including duplication in funding as well as the departure of top scientists abroad. Therefore, it is necessary to continuously build a stable R&D infrastructure as defined in the Roadmap for biomedical R&D, in parallel to strengthen staffing at the appropriate level and to support the development of collaborative R&D, contract R&D or services in biomedical R&D and its internationalisation.

Systematic support for clusters, building and modernisation of research and innovation centres	Innovations in the field of healthcare are very difficult to apply in the existing health infrastructure environment. In the last programming period, Slovakia supported the construction of several science parks and centres that are completely oriented towards biomedical R&D. However, no systematic support has been provided to these workplaces and, due to the elimination of the possibility to draw resources also from the ESIF, they have reached a state bordering on sustainability. In addition, the impossibility of drawing on capital funds within the Bratislava self-governing region is a disadvantage, which discriminates against a huge group of researchers. Systematic support should be based on the Biomedical R&D Roadmap and focus on the creation of clusters where research centre/university faculty/hospital or specialised medical centre/small, medium and large enterprises would be interlinked. At the same time, it is necessary to resolve the possibility for hospitals, especially state hospitals, to apply for support from EU Funds as well as from the state budget for R&D projects. This area is crucial for the possibility of biomedical/clinical research and the real link between R&D and clinical practice.
Systematic support for the development of innovative SMEs, including start-up/spin-off companies in the health sector	Initial financial support is crucial, especially for innovative start-ups. Financial incentives for SMEs are currently significantly undersubscribed and therefore the implementation of systemic continuous grant schemes is essential to improve the commercial exploitation of R&D results in the health sector.
Strengthening the protection of intellectual property rights and technology transfer in the health sector	Although interest in IPR protection is gradually increasing in Slovakia, the majority of actors indicate low awareness of IPR protection, which is also reflected in Slovakia's position as an "emerging" innovator. It is therefore essential to improve the state of the current lacklustre 'IP awareness', with a consequent strengthening of IPR protection and effective technology transfer through targeted projects and collaboration with the scientific community through innovation support organisations, including incubators/accelerators, hubs, clusters, a TRC-type platform – a dedicated incubation programme run by industry experts, targeting life sciences/medical sciences and breakthrough technologies innovations. In this context, the regulation of legal norms, including the amendment of the Act on Slovak Academy of Sciences transformation into public research institutions (hereinafter referred to as "PRIs") and the forthcoming Act on the promotion of innovation and technology transfer, also play an important role.
Support for coverage and reimbursement mechanisms	Slovakia has limited access to technological innovations and new trends in the provision of healthcare. In this context, it is essential to change the view and attitude of the state and health insurance companies to determine the necessary diagnostic and therapeutic options for the patient on the basis of innovation management and the introduction of new, innovative products and services into the system of provision of healthcare.

Healthy food and environment

3.5 Healthy food and environment

3.5.1 Justification for the domain

Domain definition

The Healthy food and environment domain aims to create long-term sustainable and resilient land-use production systems in Slovakia that provide resources and services to society and the environment. Land-use production systems include a wide range of agricultural, forestry and biomass-based production, associated industries (food and materials), as well as ecosystem services providing the conditions for healthy living, healthy and sustainable food systems and the environment.

The domain has been selected because of the importance of biomass, as approximately one third of all materials extracted or produced in Slovakia are biomass. Agriculture, forestry and water cover more than 80 % of the territory of Slovakia. These natural resources are crucial for healthy ecosystems and, last but not least, they are crucial for the quality of life of people living in Slovakia. Healthy ecosystems are vital for human health and also provide us with essential goods and services, including food and water security or recreation. They are also a major factor in carbon sequestration as well as in the regulation of natural hazards.

Strategic and policy materials of the SR relevant to the domain area

- Partnership Agreement of the SR for 2014-2020;
- Rural Development Programme 2014-2020;
- Operational Programme Quality of Environment 2014-2020;
- Operational Programme Research and Innovation 2014-2020 (later merged with OP Integrated Infrastructure);
- RIS3 SK 2014-2020 – Technology Priority 6: Environment and Agriculture (page 46 of RIS3) – focusing on modern technology and practices in agriculture and food production in order to ensure a sufficient supply of good-quality foodstuffs;
- Developing selected areas of Slovak specialisation in terms of available scientific and research capacities in line with the RIS3 strategic area Agriculture and Environment 2015;
- RIS3 Implementation Plan 2017 – Healthy Food and Environment Domain for RIS3 2014-2020;
- Agricultural Development Policy for 2013-2020;
- Environmental Policy Strategy of the Slovak Republic until 2030;
- Policy material of the MARD SR "Soil – the carbon and water bank of the country" (approved by the MARD SR leadership on 9.12.2021)

European and international strategic and policy documents and programmes relevant to the domain area

- H2020 (in particular Societal Challenges 2 and 4):
  a) EJP SOIL is a European Joint Research and Innovation Programme Cofund on Agricultural Soil Management, addressing key societal challenges including climate change, water and future food security;
  b) EIT Food – a European platform, supported by the EC, focusing on EIT food cooperation between public and private actors, researchers, entrepreneurs and innovation policy makers, with the aim of building a food system fit for the future.

- Horizon Europe (in particular Clusters 6 and 5):
  a) European Research and Innovation Partnership on agroecology living labs and research infrastructures;
- LIFE Programme;
- European Green Deal:
  a) EU Biodiversity Strategy for 2030;
  b) Farm to Fork Strategy;
  c) Common Agricultural Policy;
  d) Common Soil Strategy 2030 (approved on 17.11.2021);
  e) EU Strategy to reduce methane emissions (approved on 14.10.2020);
  f) Chemicals Strategy for Sustainability;
  g) Circular Economy Action Plan;
  h) The new EU Forest Strategy 2030 (approved on 16.07.2021);
- The updated EU Bioeconomy Strategy (2018);
- EU Soil Mission 2021;
- BIOEAST – Central and Eastern European Initiative for Knowledge-Based Agriculture, Aquaculture and Forestry in the Bioeconomy – Joint statement by the Ministers of Agriculture and Research of the Visegrad Group (Czech Republic, Hungary, Poland and Slovakia), Bulgaria, Croatia, Estonia, Latvia, Lithuania, Romania and Slovenia on the future role of the BIOEAST initiative in the context of the HE programme;
- BIOEAST – foresight exercise Sustainable Bioeconomies towards 2050 (approved in September 2021);
- Paris Climate Agreement (2015);
- Agenda 2030 and Sustainable Development Goals (SDGs);
- Food 2030 – EU research and innovation policy to transform food systems and ensure that everyone has enough affordable and nutritious food for a healthy life;
- A new EU Forest Strategy: for forests and the forest-based sector, COM (2013) 659 final;
- Ministerial Resolutions and Forest Europe 2015 Decision in Madrid;
- Standing Committee on Agricultural Research (SCAR) of the European Commission – Foresight: Resilience and Transformation – Natural resources and food systems: Transitions towards a safe and just operating space;
- EU Water Legislation – Fitness Check – 2019.

Justification for the domain selection

a) Current needs in the SR

Identified needs that require action in the field of research and innovation:

- Relatively high exports of raw timber and crops offer great scope for creating added value through the implementation of innovative value chains.
- Relatively large blocks of monocultures on agricultural land and in forests are under increasing pressure for necessary changes.

- Although rivers in Slovakia are highly regulated, there is a clear lack of innovation in the sustainable use of freshwater systems for ecosystem services, biodiversity conservation, food production or energy production.
- High food imports distributed through large concentrated warehouses and retail chains leave local food production in a slump. Innovations in local food systems using sustainable solutions are needed to implement the Farm to Fork strategy.
- The dependence of the Slovak economy on imported resources and materials makes the economy vulnerable, while the potential for sustainable use of domestic resources remains untapped.
- The intensification of primary production causes a loss of biodiversity, hindering the development of ecosystem services or the deterioration of natural resources. Changing the system requires innovative solutions as well as innovative approaches to link research and innovation with primary producers and the public, for example in the form of Living Labs.
- It is necessary to address the weak participation of the Slovak R&I ecosystem in the H2020 programme. It is essential to provide high-level support for involvement in partnerships, participation in R&I activities and initiatives, additional funding for successful projects, etc.
- Slovakia lags behind almost all EU countries in building a functional agricultural knowledge and innovation system. Emerging EIP operational groups should make use of international cooperation in HE innovation projects from the very beginning of their existence.
- The EDP process reveals the need for capacity building or scaling up opportunities for specific areas. Future calls should be based on supporting actions needed to address identified needs.

a) Global megatrends

Climate change

- Unprecedented changes on a global scale affect entire ecosystems and primary production systems worldwide, including Slovakia;

Epidemic crises

- COVID-19 has a huge impact on the entire food system;
- Livestock are threatened by the regular occurrence of uncontrolled spread of various diseases;

Depopulation of rural areas and regional disparities

- The constant shift of economic activity from primary production to industry, but especially to services concentrated in urban areas, is driving people out of the countryside;
- Increasing disparities in the quality of life between regions, urban and rural areas;

Changes in consumer preferences affecting the whole of the diet and food system

- Expected significant increase in the preference for plant-based diets in some countries (e.g. following the Nordic countries' example, also expected in Slovakia);
- New types of cultured food as an alternative, e.g. lab-grown meat starting to penetrate the market (first restaurant allowed in Singapore and huge R&D investments made in the last 10 years);

Demographic changes, including longer life expectancy

- A significant decline in mortality and a dramatic increase in life expectancy pose new challenges for the world's population;
- Individual personalised nutrition is increasingly important;

Societal changes, such as higher levels of education and changing perceptions of the relationship between human society and nature

- Educated people are able to harness their relationship with the environment;
- The detachment from nature is mostly pronounced in urban areas, causing a change in the perception of nature as well as the in traditional rural relationship with nature;

Globalisation, travel and information exchange

- The unprecedented intensity of travel allows people to discover different lifestyles, learn about different foods or materials, observe different environments, and at the same time compare and evaluate the potential for change at home or abroad;

Digitalisation, automation and Earth observation

- A whole new way of looking at the environment and the entire planet thanks to the availability of large amounts of exploratory data;

European Union and geopolitics in general

- The harmonisation of the policy-making process, which often puts pressure on measures that are otherwise hard to achieve by one state (HE programme, Farm to Fork, Paris Agreement);
- Collaboration of transnational research teams and access to advanced research infrastructures;

Failures of conventional production systems

- The necessity to take strong protective measures to safeguard monoculture production systems and prevent cases of medium- and large-scale destruction;

Sustainability of non-conventional production systems

- Successful cases of introduced species as the basis for new value chains;
- Risks to production systems due to increased pressure from various threats (spread of plant diseases, spread of invasive species, low resilience of new varieties and breeds).

Domain and priority areas selection process

A key factor in defining the priority areas of Domain 5 is synchronisation with the main directions for research and innovation in Cluster 6 (and partly in Cluster 5) of the EU Framework Programme for Research and Innovation HE. We believe that the HE participatory programming process is a very robust and precise way of defining the most pressing issues for all EU countries, including Slovakia. Thousands of scientists, policy makers and other stakeholders from all EU countries have contributed to the current HE programme. This is the approach we have been calling for since the early stages of the EDP process. We have participated in five HE Cluster 6 meetings organised by the EC as well as several meetings of the Partnership on Agroecology Living Labs and Research Infrastructures. A working group has been set up for Domain 5, consisting of 27 members from different ministries, research institutes and private sector representatives. The following Table 26 shows the main domain improvement workshops and events under the EDP with a brief description. The EDP process involved a wide range of stakeholders from both the public and private sectors.

Table 23: Workshops on the EDP process and defining the main domains

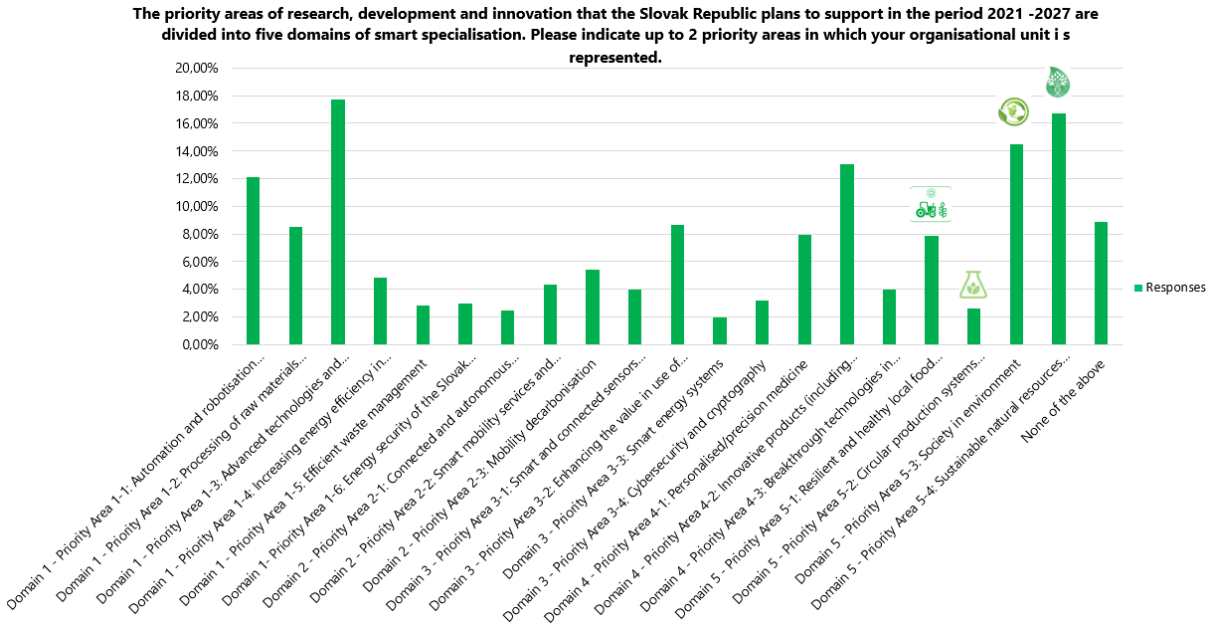
Date	Activity	Number of participants	Short description
16.7.2020	Workshop on improving domains	100+	A major event for all domains. A proposal for Domain 5 was presented. During the parallel Domain 5 meeting, an important working group discussion helped to shape the domain definition. The name *Healthy food and environment* was approved by the working group.
10. 9.2020	Domain 5 working group meeting	20	Meeting of the Domain 5 working group to further develop the definition of Domain 5, including the 4 priority areas.
2.10.2020	EDP workshop	26	Detailed discussion of priority areas and potential themes for projects. Several attempts to develop transformation plans.
14.10.2020	EDP workshop	55	Private sector presentations on innovation in the food industry. Discussion on changing consumer preferences and the latest trends in healthy food.
23.10.2020	EDP workshop	38	Detailed discussion of priority areas and potential themes for projects. Good feedback from the private sector, including several primary producers.
28.10.2020	EDP workshop	69	Detailed discussion of priority areas and potential themes for projects. Good feedback from the private sector, including several primary producers.
4.11.2020	Group consultations	21	Discussion on 25 different research and innovation priorities for EIP operational groups, including natural resources, bioeconomy, agroforestry, etc.
15.11.2020	Individual consultation	7	Discussion with the Technical University of Zvolen on the definition of forestry-related topics within Domain 5.
17.11.2020	Workshop	44	Research and innovation priorities on various aspects of land management, water erosion, climate change, etc.
30.11.2020	Second validation workshop	100+ (26)	Workshop focused on the discussion of the draft Smart Specialisation Strategy for Slovakia 2021+. Presentation and discussion on the transformation plans and themes of the project.
9.2.2021	Individual consultation	2	Identifying private companies looking for highly skilled professionals, researchers or research and innovation managers in Domain 5. We identified 17 job vacancies in food industry, precision agriculture, microbiology or forestry.
9.2.2021	International conference	203	Research and innovation in agri-food systems. To promote the involvement of industry in collaborative research and innovation initiatives, including Living Labs.
10.2.2021	National selection of promising start-ups	258	Innovative start-ups in various domains including bioeconomy, livestock monitoring and climate change.

The EDP process also included consultations and discussions that took place during various conferences, project meetings, workshops of major national and international projects. This has proved to be a very effective way of engaging with various stakeholders, especially from the private sector.

A questionnaire that was sent to a large group of stakeholders during the EDP process to obtain feedback on all domains and priority areas provided a useful assessment of the proposed priority areas for Domain 5. The graph shows the relative number of responses received for all domains. The columns

with pictograms above represent the priority areas for Domain 5. The priority areas for research and innovation in Domain 5 (the columns marked with pictograms), as identified by the stakeholders, are attractive to operators involved in research and innovation.

Figure 19: Stakeholders' interest to participate in research, development and innovation in the domains and priority areas of SK RIS3 2021+ (outcome of the EDP 2020 process)



3.5.2 Domain goal

The Healthy food and environment domain aims to:

- Catch up with the latest global developments in research and innovation;
- Help create added value for primary producers;
- Address the weak diversification of the Slovak economy;
- Respond to the challenges associated with major megatrends such as sustainability of current land use;
- Take measures to halt biodiversity loss and sustainably manage available genetic resources;
- Provide solutions to ensure the quality, stability and resilience of natural resources and natural capital;
- Accelerate the transition from unsustainable land use to green production ecosystems;
- Manage different threats such as pandemics, infectious diseases, natural hazards or the impacts of climate change;
- Improve nutrition and develop sustainable local food systems;
- Ensure that existing research and innovation capacities within the domain continue their research activities and move research results towards real-life applications;
- Push stakeholders within the domain towards better participation in the European Research Area, in particular in the HE programme, innovation programmes and other support instruments.

Table 24: Domain transformation goals

Domain priority areas	Priority area transformation goal
5-1 Resilient and healthy local food systems	Improve the resilience, safety, security and added value of local food systems providing healthy food.
	Harness the potential of equitable and environmentally sound local food systems.
5-2 Circular production systems based on biomass	Promote innovation and ensure the long-term sustainability of biomass-based production systems
	Improve the position of primary producers in the value chain by enabling the sustainable production of higher value-added products.
5-3 Society in environment	Promote innovative and knowledge-based changes in land use and the transition to a green economy.
	By adopting new technologies, enable the creation of information-rich added value based on large amounts of environmental observation data.
	Facilitate the uptake of innovative solutions to ensure the long-term sustainability of land use.
5-4 Sustainable natural resources (soil, water, air, biodiversity, ecosystems)	Ensure the quality, security and sustainability of natural resources, including biodiversity and ecosystems.
	Improve the resilience of human society as well as ecosystems to climate change and various types of threats related to human-nature interactions.

3.5.3 Priority Area 5-1: Resilient and healthy local food systems

Transformation goal 5-1

- Improve the resilience, safety, security and added value of local food systems providing healthy food.
- Harness the potential of equitable and environmentally sound local food systems.

Justification for the priority area selection

- The importance of disease-resilient food production, transport, storage and marketing is highlighted by the current COVID-19 situation, but also by African swine fever or other emerging epidemiological risks.
- The safety of the entire food chain, ensuring the health of food producers, animals and plants, as well as healthy nutrition are everyday problems that require innovative solutions.
- Local food systems are a key factor in mitigating the impacts of climate change, the equitable distribution of the value produced and the sustainability of food systems.

Indicative measures to meet the transformation goal (from the EDP)

Table 25: Enabling measures to meet transformation goal 5-1

Measure	Measure description
Enable synergies between the operational programme and the national strategic plans for the CAP 2023-2027	Investments in research and innovation, experimental infrastructures are not eligible under the CAP. This should be addressed and the operational programme should be planned in a coordinated way with the national strategic plans for the CAP 2023-2027.
Support HE Cluster 6 partnerships	Provide funding for Slovakia's contribution to HE partnerships, in particular "the European Partnership on Accelerating the Transition of Agricultural Systems: Agroecology, Living Labs and Research Infrastructures" and "Safe and Sustainable Food Systems for People, Planet and Climate".

Support the establishment of a national network of living labs and demonstration facilities	Support the establishment of living labs in Slovakia in Domain 5 areas, support the completion of infrastructure and staff capacity from the public and private sector (see also Priority Area 3).

3.5.3.1 Transformation map of Priority Area 5-1

- disease-resilient food production;
- food safety and security;
- innovation for local food systems;
- health and social aspects of food and food consumption (nutrition and health, personalised nutrition, disease prevention, sustainability, consumer behaviour);
- innovative pilot projects in agri-food aimed at increasing economic efficiency and sustainability at different levels of intensity (intensive and extensive);
- precision agriculture and livestock farming, including digitalisation and robotic systems "Agriculture 4.0";
- agroforestry;
- innovative methods of applying nutrients to the soil;
- usability of waste in the food chain;
- secondary treatment of food production waste and processing of by-products;
- residues and environmental burdens and their penetration into the food chain;
- agroecology living labs and research infrastructures;
- traceability of food products;
- innovative systems for monitoring and ensuring livestock welfare.

The following figures show examples of the identification of project themes based on available capacities and opportunities as a result of the EDP process. P(i), i=1,...,n – project themes and their links. P1 – health and social aspects of food and food consumption, P2 – innovations for local food systems, P3 – precision agriculture and livestock farming including digitalisation and robotic systems, P4 – residues and environmental burdens and their penetration in the food chain, P5 – agroecology living labs and research infrastructures.

Figure 20: Project themes for Priority Area 5-1

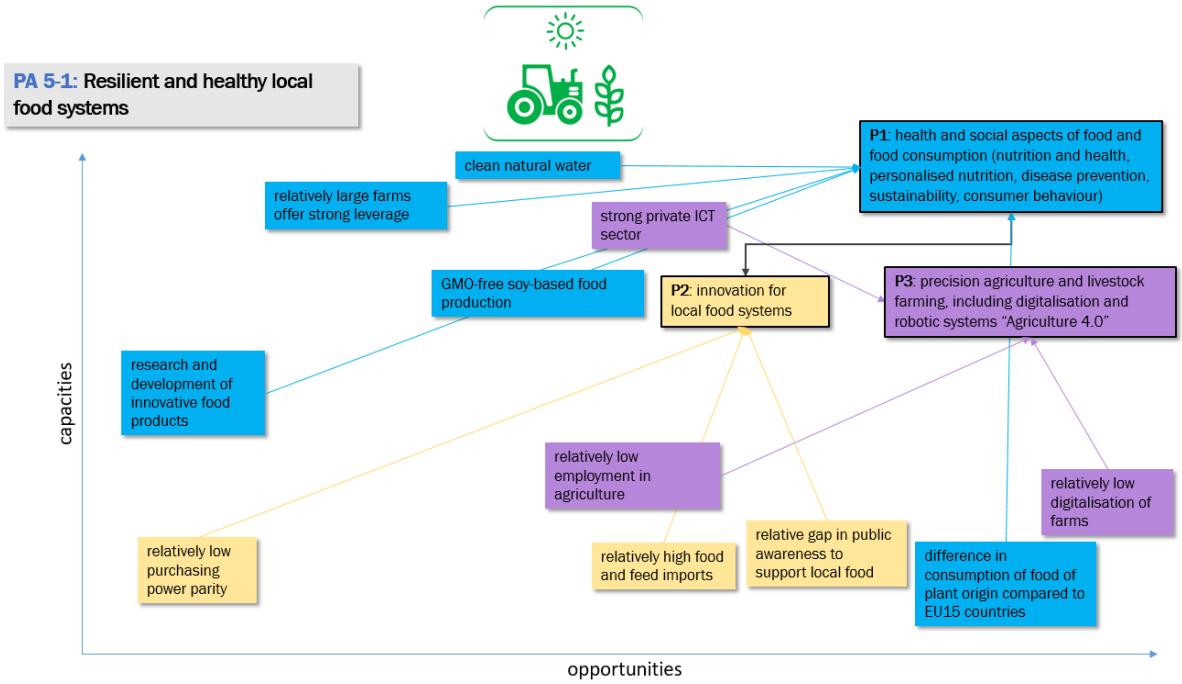


Figure 21: Project themes for Priority Area 5-1

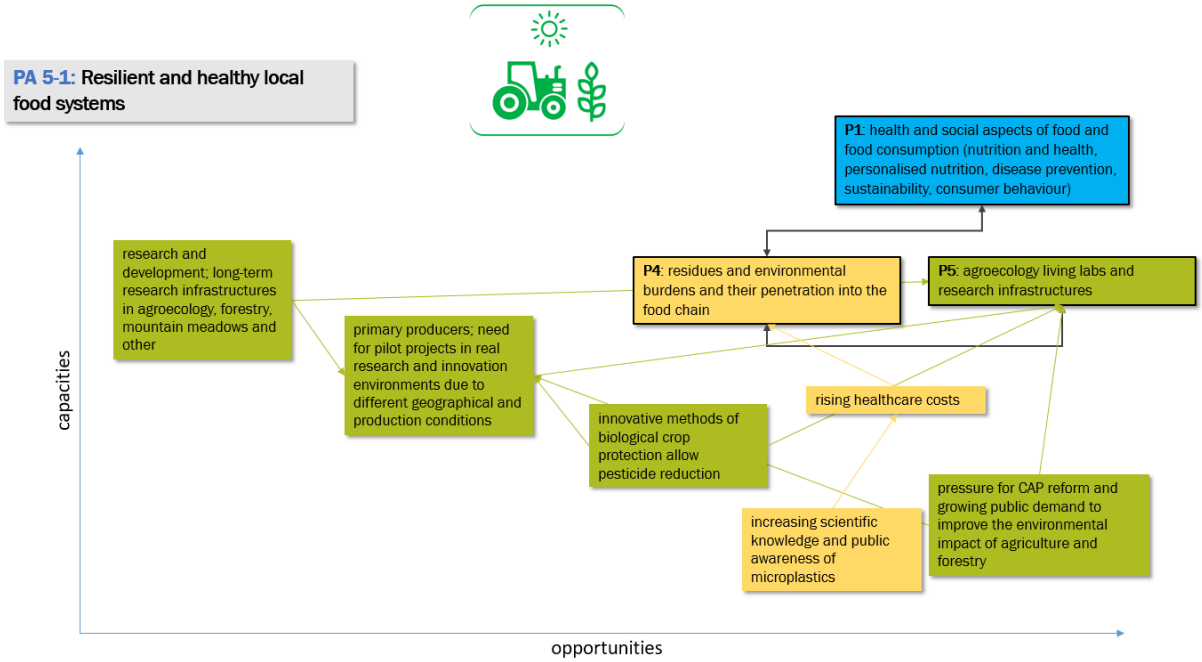


Figure 22: Transformation map of Priority Area 5-1

Priority area current state

- Low added value of primary production in the agri-sector and the disadvantageous position of primary producers in the food chain.
- Innovation activities on farms are lagging behind.
- Poor complementarity and synergy between programmes to support knowledge transfer and innovation (RDP 2014-2020, AKIS, support for innovation in local food systems) and R&I programmes (OP R&I - OPII).
- Poor innovation performance of the Slovak agri-sector reduces competitiveness in the EU.
- Low involvement of primary producers in innovation, lack of support instruments/ineligibility of applicants.
- Lack of thematic prioritisation of R&I for economically sustainable, disease-resilient food systems.
- Non-systematic support for building research infrastructure and supporting human capacity, poor funding of sectoral research.
- Significant potential for implementation of innovative production practices;
- Underestimating importance of local food systems and their innovation.

Thematic support to meet the priority area transformation goal

Proposals for thematic areas of project support:

- Building and developing R&D infrastructure for research and innovation in local food systems. R&D projects aimed at:
  - disease-resilient food production – food safety and security
  - innovation for local food systems;
  - health and social aspects of food and food consumption (nutrition and health, personalised nutrition, disease prevention, sustainability, consumer behaviour);
  - innovative pilot projects in agri-food aimed at increasing economic efficiency and sustainability at different levels of intensity (intensive and extensive);
  - precision agriculture and livestock farming, including digitalisation and robotic systems "Agriculture 4.0";
  - agroforestry;
  - innovative methods of applying nutrients to the soil;
  - usability of waste in the food chain;
  - secondary treatment of food production waste and by-product processing;
  - residues and environmental burdens and their penetration into the food chain;
  - agroecology living labs and research infrastructures;
  - traceability of food products;
  - innovative systems for monitoring and ensuring livestock welfare.

Funding sources to achieve desired outcomes

OP SK/HE and others/state budget/departmental research, private sector investment/other sources of funding: Recovery and Resilience Plan

Foreseen cooperation to achieve desired outcomes

Scientific institutions, consortia and platforms at national and international level, (e.g. BIOEAST, Alliance Towards a Chemical Pesticide-Free Agriculture, etc.), European research and innovation partnerships under HE Cluster 6, ministries, entities involved in AKIS within the CAP, SMEs, unions, associations, secondary schools.

Priority area outcomes

1. The application of research results will improve the resilience and security of local food systems.
2. Completion and systematic support of sustainable research infrastructures and capacities to support R&D in local food systems, living labs, pilots.
3. Strengthening the applicability of results in practice – farmer-driven research.
4. Improved synergy between public research, farmers, producers and businesses, support and involvement of EIP AGRI operational groups (CAP) in research and innovation.
5. Increased innovation performance of primary agricultural production and local food processors and producers.
6. New innovative products and services in food production.
7. Enhanced involvement of the SR in the international research and innovation environment, better use of international know-how.
8. Effective local implementation of European policies and strategies (Farm2Fork, Green Deal, etc.) and based on scientific evidence.
9. Involvement in major European cooperation structures (HE - Agroecology living labs, Food systems, JRC, etc.).

3.5.4 Priority Area 5-2: Circular production systems based on biomass

Transformation goal 5-2

- Promote innovation and ensure the long-term sustainability of biomass-based production systems.
- Improve the position of primary producers in the value chain by enabling the sustainable production of higher value-added products.

Justification for the priority area selection

- Biomass-based circular solutions have the potential to reduce our dependence on non-renewable resources.
- Sustainable biomass-based production systems are key factors in the implementation of the bioeconomy.
- Innovations in biomass processing systems and biomass-based solutions have the potential to support the local economy, create new jobs and improve the quality of life in rural areas.

Indicative measures to meet the transformation goal (from the EDP)

Table 26: Enabling measures to meet transformation goal 5-2

Measure	Measure description
Bioeconomy implementation under the updated EU Bioeconomy Strategy 2018	Develop a national bioeconomy strategy and/or action plan.
Support for HE Cluster 6 partnerships	Provide funding for Slovakia's contribution to higher education partnerships, in particular the "European Partnership for a Circular Bio-based Europe".
Support for the BIOEAST initiative	Allocate more staff capacity and funding to improve Slovakia's involvement in the BIOEAST initiative aimed at implementing the bioeconomy in the CEE macro-region.

3.5.4.1 Transformation map of Priority Area 5-2

- sustainable biomass production systems;
- innovative solutions for sustainable biosystems and biotechnologies;
- innovative solutions for bioenergy and biofuels;
- added value of biomass-based products;
- innovative solutions for the implementation of the circular bioeconomy;
- biomass cascading;
- biodegradable materials;
- lignocellulosic packaging materials in the food industry;
- innovation in the use of biorefinery secondary products;
- biochemical and environmental aspects of biomass production and processing.

The following figures show examples of the identification of project themes based on available capacities and opportunities as a result of the EDP process. P(i), i=1,...,n - project themes and their mutual links. P1 – sustainable biomass production systems, P2 – added value of biomass-based products, P3 – innovative solutions for bioenergy and biofuels, P4 – biochemical and environmental

aspects of biomass production and processing, P5 – lignocellulosic packaging materials in the food industry.

Figure 23: Project themes for Priority Area 5-2

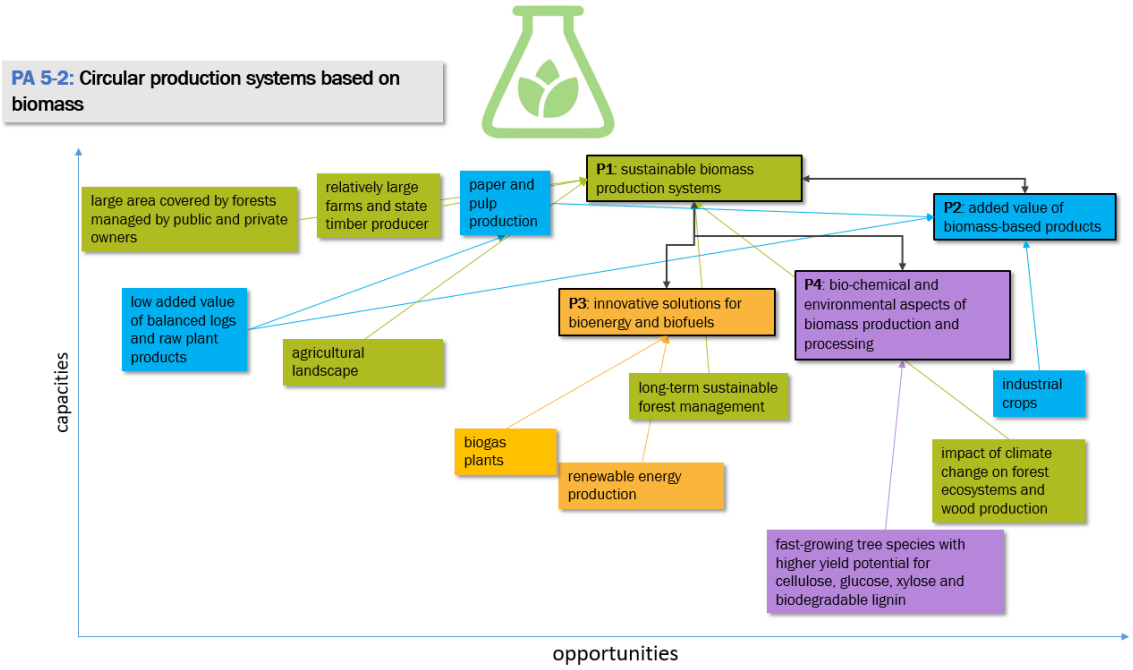


Figure 24: Project themes for Priority Area 5-2

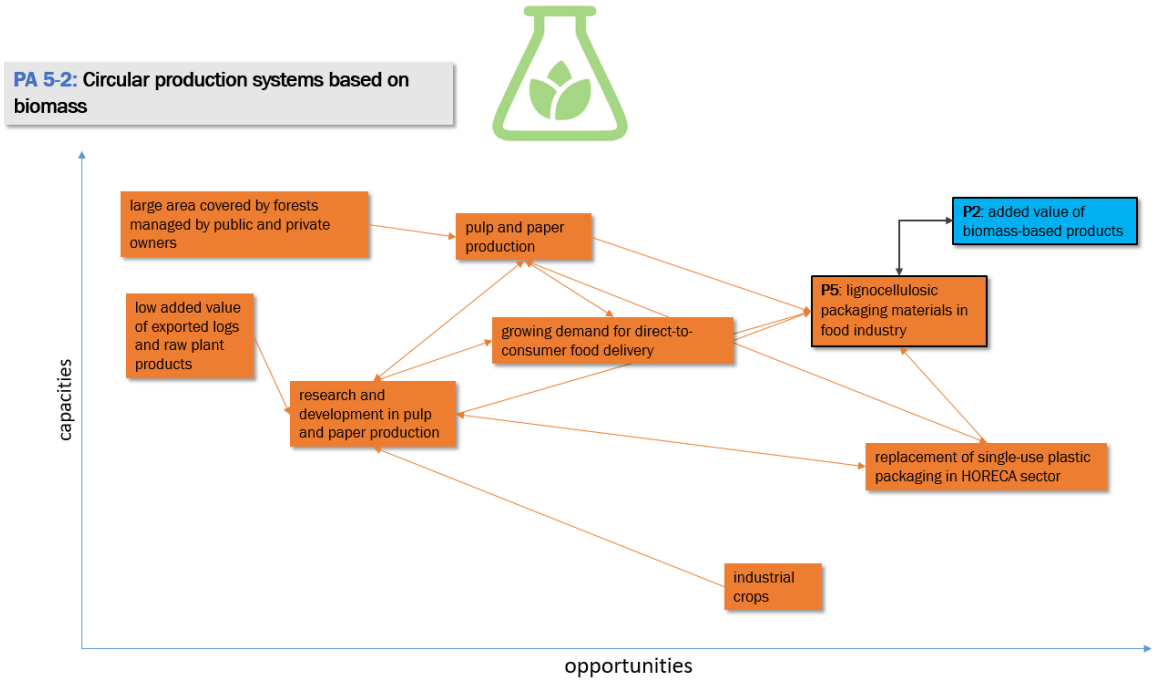


Figure 25: Project themes for Priority Area 5-2

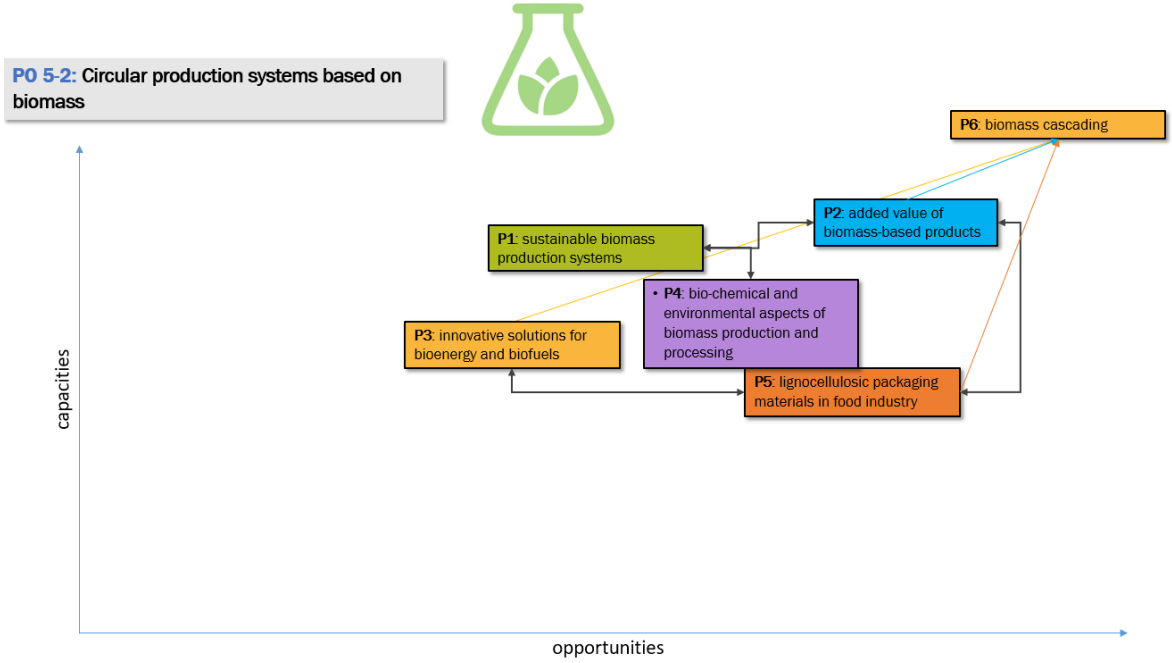


Figure 26: Transformation map of Priority Area 5-2

Priority area current state

- Misunderstanding of the concept of biomass as a strategic resource produced from the soil on the soil.
- The unsustainability of current linear biomass-based production systems.
- Low added value of biomass-based production, poor finalisation.
- Weak position of primary producers in the value chain.
- Insufficient and incorrect use of biomass potential in the SR (large areas of state-owned forests, large farms, unused land unsuitable for food production (brownfields).
- Biogas plants built in the past without regard to local availability of biomass and long-term sustainability.
- Insufficient use of closed systems for biomass utilisation on farms.
- Weak and poorly supported public-private cooperation in research and development.
- Lack of funding, synergies and an excessively bureaucratic system of support for research, innovation and cooperation with primary producers and businesses.

Thematic support to meet the priority area transformation goal

Proposals for thematic areas of project support:

- R&D projects, including demand-driven projects, living labs focused on:
- sustainable biomass production systems;
- innovative solutions for sustainable biosystems and biotechnologies;
- innovative solutions for bioenergy and biofuels;
- added value of biomass-based products;
- innovative solutions for the implementation of the circular bioeconomy;
- biomass cascading;
- biodegradable materials;
- lignocellulosic packaging materials in the food industry;
- innovation in the use of biorefinery secondary products;
- biochemical and environmental aspects of biomass production and processing.

Funding sources to achieve desired outcomes

RRF/OP SK/HE/state budget/departmental research, private sector investment/other sources of funding: Recovery and Resilience Plan

Foreseen cooperation to achieve desired outcomes

BBI JU, HE Cluster 6, Bioeconomy Knowledge Centre JRC EC European Bioeconomy Policy Forum, BIOEAST, scientific institutions, consortia and platforms at national and international level, ministries, entities involved in AKIS under the CAP, SMEs, unions, associations, secondary schools, third sector, European research and innovation partnerships that are implemented under HE.

Priority area outcomes

1. Improved finalisation of research results through established innovations in the priority area.
2. Enhancing technology transfer and cooperation in breakthrough technologies at national/international level.
3. Active involvement of stakeholders (farmers, companies, etc.).
4. Improved awareness of all stakeholders on the use of biomass as a strategic resource, understanding of the concept of circular economy.
5. Knowledge for better biomass recovery in the SR and application of the "food first" principle and the circularity principle in the economy.
6. Improved economic position of primary producers in the value chain (innovative products with added value and better diversification of production).
7. New research and innovation centres, living labs, pilots, innovation incubators.
8. More efficient local use of bioenergy.
9. Knowledge and data for better knowledge-based policy making, implementation of the EU Bioeconomy Strategy.
10. Support and involvement of EIP AGRI operational groups in research and innovation.

3.5.5 Priority Area 5-3: Society in environment

Transformation goal 5-3

- Promote innovative, knowledge-based changes in land use and the transition to a green economy.
- Enable the creation of information-rich added value based on large amounts of environmental observation data through the adoption of new technologies.
- Facilitate the adoption of innovative solutions to ensure the long-term sustainability of soil use.

Justification for the priority area selection

- The increasing pressure of human lifestyles on the environment and the intensification of land use require innovative solutions to ensure the long-term sustainable provision of ecosystem services.
- New technologies make it possible to use large amounts of environmental information and data for better decision-making.
- The green economy is a response to various crises the world has faced in recent years, with an alternative paradigm that offers the promise of economic growth while protecting the Earth's local and global ecosystems.

Indicative measures to meet the transformation goal (from the EDP)

Table 27: Enabling measures to meet transformation goal 5-3

Measure	Measure description
Create a national network of Living Labs	To set up this network of Living Labs, the following should be used: long-term research facilities, long-established field experimental facilities, certified facilities, research fields, research forests, demonstration farms, indoor research facilities, etc.
Support HE Cluster 6 partnerships	Provide financial support for Slovakia's contribution to HE partnerships, Cluster 6, in particular "Agriculture of Data".
Innovation along with land redevelopment projects	Innovation along with land redevelopment projects.

3.5.5.1 Transformation map of Priority Area 5-3

- environmental monitoring (including remote sensing) and creating added value for applications;
- Closer-to-Nature Forest Management – methods for stock-taking, modelling, planning and control;
- innovation in rural areas;
- innovation in the use of ecosystem services;
- innovation in land use and land-use change;
- building sustainable cities/settlements to improve the quality of space and life;
- innovation for the long-term sustainability of trees in settlements;
- innovation in assessing and managing global change and its impacts;
- building green infrastructure and stability of agricultural landscapes;
- impacts of climate change on agricultural and forest landscapes;
- the creation of nature laboratories;

- development of an integrated system on the territory;
- integrated river basin management;
- innovative agrivoltaic systems.

The following figures show examples of the identification of project themes based on available capacities and opportunities as a result of the EDP process. P(i), i=1,..., n – project themes and their links. P1 – environmental monitoring (including remote sensing) and creating added value for applications, P2 – closer-to-nature forest management – methods for stock-taking and modelling, planning and control, P3 – innovation in land use and land-use change, P4 – innovative agrivoltaic systems.

Figure 27: Project themes for Priority Area 5-3

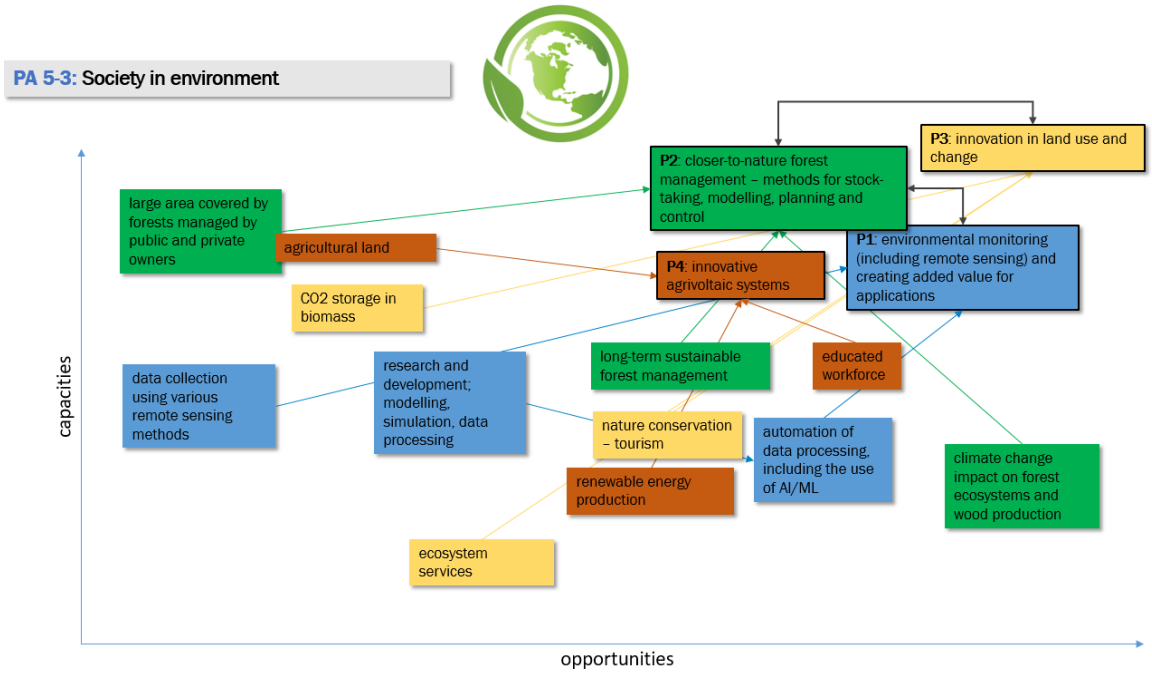


Figure 28: Transformation map of Priority Area 5-3

Priority area current state

- Unsustainable land use.
- Poor intersectoral coordination in the development of measures on agricultural land and in the countryside.
- Acceleration of climate change – pressure to reduce CO2 emissions, to change energy base and technology, to track carbon footprint, rising prices, rising risks.
- Increasing pressure of human lifestyles on the environment.
- Carbon neutrality in land use, forestry and agriculture sectors by 2035 – Slovakia's commitment to capture and store 6.8 MtCO2 by 2030.
- Increasing demand for greening processes, resource efficiency, circular economy, tracking/reducing carbon footprint.
- Insufficient use of data from different sources for better decision-making and policy implementation, few data-driven support tools.
- Insufficient support for research and innovation focused on environmental innovation, ecosystem services, rural innovation.
- No systematic support for experimental living labs.
- Weak collaboration between public and private partners, research, companies, cities, municipalities.

Thematic support to meet the priority area transformation goal

Proposals for thematic areas of project support:

- R&D projects, living labs and demand-driven innovation projects on the following topics:
  - environmental monitoring (including remote sensing) and creating added value for applications;
  - Closer-to-Nature Forest Management – methods for stock-taking, modelling, planning and control;
  - innovation in rural areas;
  - innovation in the use of ecosystem services;
  - innovation in land use and land-use change;
  - building sustainable cities/settlements to improve quality of space and life;
  - innovation for the long-term sustainability of trees in settlements;
  - innovation in assessing and managing global change and its impacts;
  - building green infrastructure and stability of agricultural landscapes;
  - impacts of climate change on agricultural and forest landscapes;
  - the creation of nature laboratories;
  - development of an integrated system on the territory;
  - integrated river basin management;
  - innovative agrivoltaic systems.

Funding sources to achieve desired outcomes

RRF/OP SK/HE/state budget/departmental research, private sector investment/other sources of funding: Recovery and Resilience Plan, INTERREG, etc.

Foreseen cooperation to achieve desired outcomes

LIFE programme, cooperation with platforms, projects, infrastructures, European research and innovation partnerships implemented under HE Cluster 6, Cluster 5, scientific institutions, consortia and platforms at national and international level, ministries, entities involved in AKIS within the CAP, SMEs, unions, associations, municipalities, secondary schools, non-profit organisations, etc.

Priority area outcomes

1. Building a sustainable system to support infrastructures for R&D and in the priority area, including a living labs system.
2. Developing a "Carbon and Water Bank" model as a transformative and financial tool to address climate change.
3. Development of new, innovative products and services for the environment taking into account the NEXUS: water – soil – vegetation – climate – energy – food.
4. Building and reinforcing a sectoral approach and a holistic/integrated approach.
5. Implementing effective ecosystem services and innovation in rural areas.
6. High-quality integrated databases and data systems, applications for effective landscape management, conservation, climate change management, ecosystem services (e.g. carbon calculator, etc.).
7. Knowledge for implementation of new evidence-based policies (Green Deal, Fit for 55 (LULUCF), UN Climate Agreement and Sustainability Goals, etc.).
8. Support and involvement of EIP AGRI operational groups in research and innovation.
9. Involvement in major European cooperation structures (HE - Agriculture of Data, JRC, etc.)

3.5.6 Priority Area 5-4: Sustainable natural resources (soil, water, air, biodiversity, ecosystem)

Transformation goal 5-4

- Ensure the quality, security and sustainability of natural resources, including biodiversity and ecosystems.
- Improve the resilience of human society as well as of ecosystems to climate change and various types of threats related to human-nature interactions.

Justification for the priority area selection

- Increasing pressures of human lifestyles and more intensive land use require innovations to mitigate the impacts of climate change or reverse the deterioration of natural resources.
- Human activities are often confronted with natural phenomena that have a significant impact on infrastructure.
- Ensuring the quantity and quality of water resources is critical to the sustainability of human activities and the environment.

Indicative measures to meet the transformation goal (from the EDP)

Table 28: Enabling measures to meet transformation goal 5-4

Measure	Measure description
EIP AGRI operational groups	Improve the current state of the EIP AGRI operational groups and enable support for potential international cooperation through synergies with university work programmes, e.g. Objective 7 – Innovative governance, environmental observations and digital solutions in support of the Green Deal – Enhancing agricultural knowledge and innovation systems
AKIS (Agriculture Knowledge and Innovation Systems)	Provide support to all valid members to become part of the AKIS system currently proposed by the MARD SR.

3.5.6.1 Transformation map of Priority Area 5-4

- solutions to mitigate the impacts of climate change;
- innovative methods for pollution detection;
- elimination of flood risks;
- measures to mitigate the impacts of drought, natural hazards and risks;
- biosecurity and biorisks;
- ensuring the quality and yield of water resources;
- ensuring sustainable soil fertility;
- innovative soil management practices, including the application of nutrients to the soil;
- efficiency of bio-based production;
- solutions to ensure the long-term sustainability of biodiversity;
- genetic resources in soil management;
- ensuring the sustainability of local genetic resources;
- innovative solutions for biodiversity management in the context of climate change impacts.

The following figures show examples of the identification of project themes based on available capacities and opportunities as a result of the EDP process. P(i), i=1,...,n – project themes and their links. P1 – solutions to ensure the long-term sustainability of biodiversity, P2 – ensuring the sustainability of local genetic resources, P3 – innovative methods of land management, including nutrient application to the soil, P4 – measures to mitigate the impacts of drought, natural hazards and risks.

Figure 29: Project themes for Priority Area 5-4

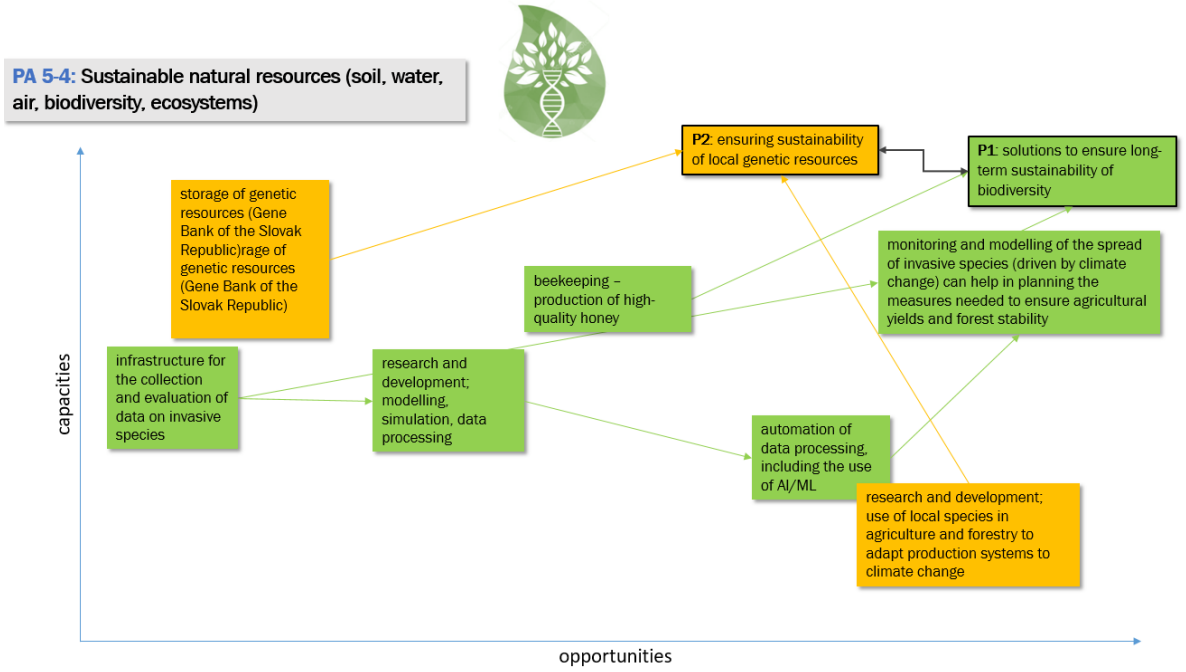


Figure 30: Project themes for Priority Area 5-4

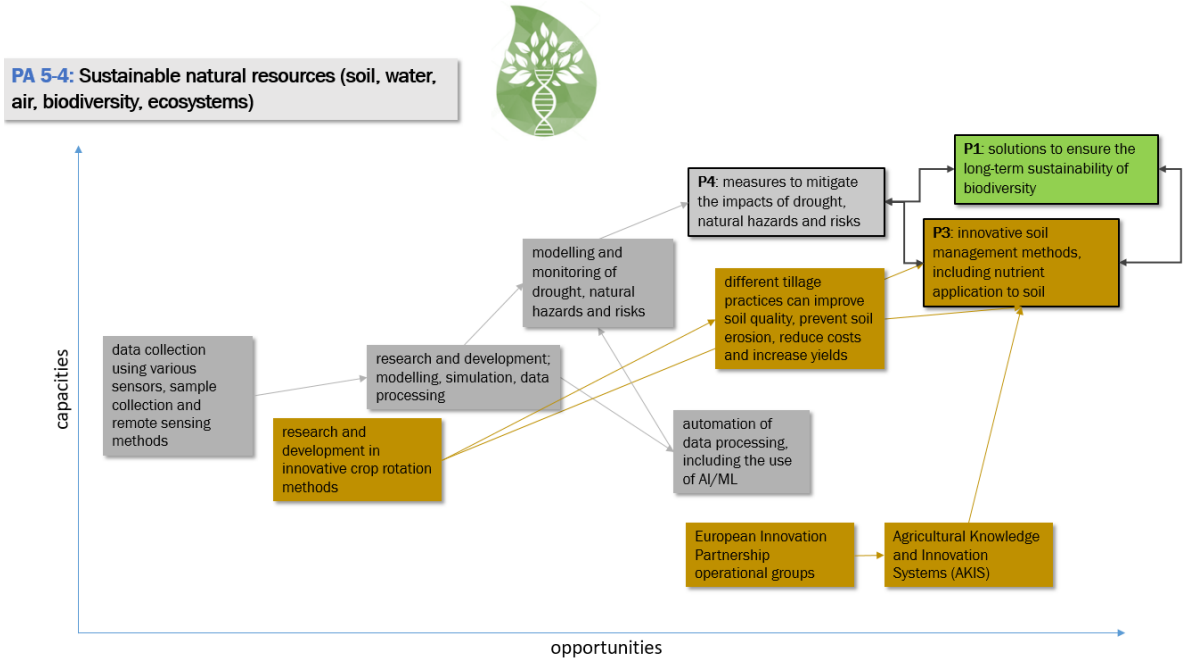


Figure 31: Transformation map of Priority Area 5-4

Priority area current state

- Growing trend of human lifestyles associated with intensive land use vs. lack of innovation for climate change mitigation, remediation and protection of natural resources.
- Confrontation of human activities with natural phenomena in relation to landscape infrastructure.
- Non-systematic and insufficient adaptation of forest and agricultural landscape structure to climate change, deteriorating quality of soil, water resources.
- Unresolved environmental pressures and their impact on deteriorating environmental quality and health.
- Risks to production systems caused by various threats (spread of plant diseases, spread of invasive species, low resistance of new varieties and breeds).
- Non-systematic protection of the management of the cultivation of native species of cultivated plants and domestic breeds of livestock, lack of/outdated national legislation.
- Weak application of strategic tools and lack of natural introduction of innovation and innovation processes, no local planning.
- Weak to moderate balancing, monitoring and regulation of appropriate preventative remediation and adaptation measures, lack of integrated management in the landscape.
- Lack of control and incentive mechanisms, and of systematic stabilisation of ecosystems, financial unsustainability.
- Non-application of the holistic principle in the economic use of land and environmental protection.
- Lack of support for research and innovation in natural resource management, greening of land management systems, transition to agroecology, poor awareness of operators, misinformation, one-sided view.

Thematic support to meet the priority area transformation goal

Proposals for thematic areas of project support:

- R&I projects, living labs, demonstration facilities on the following topics:
  - solutions to mitigate the impacts of climate change;
  - innovative pollution detection methods;
  - elimination of flood risks;
  - measures to mitigate the impacts of drought, natural risks and hazards;
  - biosecurity and biorisks;
  - ensuring the quality and yield of water resources;
  - ensuring sustainable soil fertility;
  - innovative soil management practices, including the application of nutrients to the soil;
  - efficiency of bio-based production;
  - solutions to ensure the long-term sustainability of biodiversity;
  - genetic resources in soil management;
  - ensuring the sustainability of local genetic resources;
  - innovative solutions for biodiversity management in the context of climate change impacts.

Funding sources to achieve desired outcomes

RRF/OP SK/HE/state budget/departmental research, private sector investment/other sources of funding: Recovery and Resilience Plan

Foreseen cooperation to achieve desired outcomes

LIFE programme, cooperation with platforms, projects, infrastructures, European research and innovation partnerships implemented under HE Cluster 6, Cluster 5, scientific institutions, consortia and platforms at national and international level, ministries, entities involved in AKIS within the CAP, SMEs, unions, associations, municipalities, secondary schools, non-profit organisations, etc.

Priority area outcomes

1. Knowledge for quality and security, sustainability of land use, natural resources including biodiversity and ecosystems, data, knowledge and understanding to cope with various threats such as pandemics, infectious diseases, natural hazards or the impacts of climate change.
2. Knowledge and data for the implementation of knowledge-based policies (Biodiversity Strategy, environmental policies, Green Deal, Fit for 55, UN Climate Agreement and Sustainability Goals, etc.).
3. Effective measures to halt biodiversity loss and sustainably manage available genetic resources.
4. Solutions to ensure the quality, stability and resilience of natural resources and natural capital.
5. Collaborative infrastructures (living labs, clusters, innovation pilots and training sites, etc.) built to undertake research, demonstration activities, effective knowledge transfer and public awareness raising.
6. Implementation of strategic and innovation tools.
7. Application of appropriate natural preventative remediation measures.
8. Strengthening and building natural resource management taking into account local planning and ecosystem systematisation.
9. Enhancing the systematic adaptation process to climate change impacts.
10. Financial sustainability and planning.
11. Support and involvement of EIP AGRI operational groups in research and innovation.
12. Involvement in major European cooperation structures (Mission Soil – living labs and lighthouses, JRC, etc.).

Examples of research capacities available within the priority areas of the domain

- Public research institutes (e.g. National Agricultural and Food Centre (NPPC), Slovak Academy of Sciences);
- Public control and testing organisations (e.g. Central Control and Testing Institute in Agriculture (ÚKSÚP);
- Universities (e.g. Slovak University of Agriculture, Comenius University, Slovak University of Technology, University of Veterinary Medicine and Pharmacy, University of Žilina in Žilina, Technical University of Košice, Technical University of Zvolen and others);
- Science parks and research centres (e.g. AgroBioTech Research Centre of Slovak University of Agriculture in Nitra, Comenius University Science Park in Bratislava);
- Private research institutes (e.g. Research Institute of Chemical Technology (VÚCHT));
- Private companies active in research and innovation in related fields;
- Platforms, initiatives and clusters.

Estimation of potential customers in application practice for priority domain areas

- all levels of food systems;
- primary producers in agriculture and forestry;
- state-owned enterprises;
- food industry;
- chemical industry;
- pulp and paper industry;
- heat and electricity producers;
- water companies;
- local and regional governments;
- towns and municipalities;
- state and public authorities;
- environmental management companies, including waste management;
- industrial companies with a high environmental impact;
- transport companies;
- food retailers;
- catering establishments;
- ICT companies.

4 Synergies across domains

The themes and projects supported under the smart specialisation domains in the area of RDI will be related to other domains in a number of priority areas. The aim of identifying synergies is to align and clarify the possibilities of cooperative relationships and links that will contribute to successfully achieving the transformation goals of the individual domains and the transformation of the Slovak economy.

In defining cooperative relationships, it is important to focus on the following:

- considering the cross-cutting nature of the domains and supporting the implementation of comprehensive and interdisciplinary research projects addressing current societal issues;
- identifying projects and activities that aim to foster links across disciplines and may increase the potential for new ones;
- joint planning of investments in RDI infrastructure, funding of its sustainability and long-term maintenance, and sharing of research capacities of scientific infrastructure across domains.

Domain	1	2	3	4
5	new biomass-based materials; bioenergy; biorefineries; food industry	food logistics; biomass logistics, including biohubs; autonomous vehicles for land management, and soil use and management; alternative fuels and their impact on emission reduction livable cities environmental benefits automated vehicles in agriculture	sensors, remote sensing; IoT and AI applications; use of blockchain technology in food supply chain and wood processing; simulations; precision agriculture; modelling of natural hazards and risks/threats	functional foods, dietary supplements and nutraceuticals and their health impact; environmental risks – nanoplastics and microplastics in air, water, soil, food and their health impact; disease-resilient food production; biological risks; healthy environment/quality of life.
4	development of medical technologies (e.g. production of ventilators and laminar boxes), development of new materials (smart technologies, implants, biopolymers), robotics for healthcare, 3D printing using new materials and (bio)materials	autonomous mobile vehicles in the hospital; use of drones for transporting samples, logistics systems for sample collection, patient transport; inclusive mobility including for people with disabilities; in the application of telemedicine and telediagnosis and new forms of mobility: collection of biological material, support for screening examinations (e.g. drones, autonomous mobile docking units).	bioinformatics, AI and big data applications in healthcare, telemedicine and virtual reality	
3	production of advanced electronics for the digital economy, smart operations management, applications of blockchain technology in the supply chain	smart transport systems, environmental mapping, platform economy especially in urban mobility, Blockchain open data access DLT Algorithmic Age digital simulations integrated information systems data-driven policy data-led regulations digital applications (app-based ride and taxi services, transport services for hire) data: collection, visualisation, smart data, Big Data and transport cybersecurity in automotive		
2	industrial production of new drives, electric batteries and alternative fuel tanks; regulatory sandboxes cross-sector infrastructure new vehicle types and business models IoT smart products innovative solutions in the energy sector, the use of RES in the operation of mobility products as well as in manufacturing industries			

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Annex 1 – Evaluation of the questionnaire from the EDP Domain 4 Healthy society

Annex 2 – Proposed legislative changes for Domain 4 Healthy society

Biomedical R&D is provided for in Act No. 576/2004 Coll. on Healthcare, Services Related to the Provision of Healthcare and on amendments to certain acts. R&D as such is defined in Act No. 172/2005 Coll. on State Support for Research and Development and on the amendment to Act No. 575/2001 Coll. on the Structure of Government Activities and Central State Administration, as amended; in Act No. 133/2002 Coll. on the Slovak Academy of Sciences, as amended; in Act No. 243/2017 Coll. on Public Research Institutions and on amendments to certain acts; in Act No. 131/2002 Coll. on Higher Education Institutions and on amendments to certain acts; and in other related legislative documents.

For the transformation of Domain 4 Healthy society, it is essential to amend the aforementioned Act No. 576/2004 Coll. in terms of legislative support for biobanking, which is crucial for biomedical R&D. Specifically, the definition of biomedical research Biomedical research and radiological exposure, Biomedical research and communication with health insurance companies. An alternative is the preparation and implementation of a new Biobanking Act into our legislation.

Also relevant are legal changes that clarify and harmonise the Slovak legislation for biomedical research and (academic) clinical trials in the implementation of EU Regulation 536/2014 (CTR Regulation), which, among other things, requires Member States to put in place measures to encourage sponsors to perform academic clinical trials.

The domain reflects the importance of the transformation of the SAS into an R&D institute, whose selected workplaces are among the main stakeholders in biomedical R&D. Equally important are the planned amendments to relevant legislation aiming to simplify and support research through changes to Act No. 343/2015 Coll. on Public Procurement and on amendments to certain acts, or to its application in the financial management system of EU structural funds.

The quality of applied R&D in healthcare is also conditioned by the evaluation process of project intents financed from the state budget. In this regard, there is a relevant amendment to Act No. 525/2010 Coll. on the Provision of Subsidies under the Scope of the Ministry of Health of the Slovak Republic, reflecting the requirement to enhance the objectivity and transparency of this process by appointing independent international evaluators, which is a standard practice abroad.

An important strategic move is the preparation of a new law aimed at promoting innovation and strengthening technology transfer,[72] based on the reform processes associated with the change in the system of management, evaluation and support of RDI, which the SR has committed to in the Recovery and Resilience Plan. The subsequent adoption of the legislative changes will help resolve the issue of the management structures involved in the implementation of the SK RIS3 2021+ as well as the Summary Report.

As part of the domain transformation, it is necessary to engage in inter-ministerial talks and consequently modify the inadequate legislation concerning the publication of those parts of the application for non-repayable financial contribution that contain confidential information about the project. From the IPR point of view, there is a potential for misuse, in particular of the parts relating to scientific ideas, the substance of inventions, solutions, approaches or setups, etc., which may potentially jeopardise the validity of the IPR protection (patents, utility models, etc.), in particular by generating its own existing state of technology and/or by misuse of the above data by a third party. These changes

[72] Slov-lex: *Act No. 172/2005 Coll. on State Support for Research and Development and on the amendment to Act No. 575/2001 Coll. on the Structure of Government Activities and Central State Administration, as amended*. Available at: https://www.slov-lex.sk/pravne-predpisy/SK/ZZ/2005/172/

are crucial both at national level and for EU-funded projects. It is also important to amend the legislation that at present potentially hinders effective implementation of joint or contractual research between public and private sector in healthcare (e.g. by applying exemptions in the publication of contracts in the Central Register, Register of Public Sector Partners, regulation of publication rules, also in terms of IPR protection, by setting the rules of structural funds financing, etc.).