MINISTRY OF INDUSTRY AND TRADE
OF THE CZECH REPUBLIC

Czech Republic
The Country For The Future

National Research and Innovation Strategy for Smart Specialisation of the Czech Republic 2021–2027

Annex 1

Cards of Thematic Areas

Version 4

(December 2022)

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Introduction

The document of the National RIS3 Strategy for 2021–2027 was approved by the Government of the Czech Republic on 25 January 2021 and subsequently by the European Commission on 19 May 2022. The dynamic developments in the innovation environment and the newly emerging trends and opportunities are reflected in the National RIS3 Strategy through continuous updates to the Annexes to the main document. The following table summarises the process of updates to Annex 1, indicating the dates of their approval.

Process of updating Annex 1 Thematic Area Cards

Version	*Date of approval*	*Source*
Original text	**25 January 2021**	
Following on Chapter 4.3 of the main RIS3 document and using studies and analyses, a basic description of specialisation domains in three dimensions was developed:		
	Topics in KETs[1] and emerging technologies with potential for application in application sectors	analyses
	R&D&I [2]topics in application sectors	analyses
	R&D&I topics in the social sciences and humanities	analyses
The Government of the Czech Republic agreed on the flexibility of the Annexes; their updates will reflect both the dynamic development of the innovation environment and newly emerging trends and opportunities.		
Version 2	**7 October 2021**	
Based on the discussion of stakeholders in the EDP[3] process, in particular innovation platforms and expert groups, strategic themes were identified and 4 clusters were created for the socio-humanities area in each specialisation domain (in bold).		
	Topics in KETs and emerging technologies with potential for application in application sectors	analyses
	Strategic R&D&I topics in application sectors	EDP
	Framework R&D&I topics in the social sciences and humanities	EDP
An introduction to "mission-oriented innovation policy" in R&D&I interventions and a pilot linking of RIS3 missions with selected SDGs was developed.		
Version 3	24 June 2022	
Within the specialisation domains, the definition of KETs was refined based on the EDP, and the strategic themes and SSH themes were slightly restructured. The themes in all three tables were assigned RIS3 criteria codes. Two RIS3 missions responding to current societal challenges in the field of environmental and geopolitical risks were developed.		
Research and innovation specialisation domains		
	Topics in KETs and emerging technologies with potential for application in application sectors	EDP
	Strategic R&D&I topics in application sectors	EDP
	Framework R&D&I topics in the social sciences and humanities	EDP
Societal challenges and RIS3 missions		
	Improving the material, energy and emissions efficiency of the economy	expertise
	Strengthening society's resilience to security threats	expertise
Version 4	23 December 2022	
The description of relevant R&D&I topics in specialisation domain DS03 was partially refined. For both existing RIS3 missions, the Mission Objective Cards were modified based on the EDP and the textual descriptions of the content of the objectives and relevant topics for R&D&I were prepared. The reflection of RIS3 in aid instruments includes a basic methodology for the preparation of interventions.		
Research and innovation specialisation domains		
	Topics in KETs and emerging technologies with potential for application in application sectors	EDP
	Strategic R&D&I topics in application sectors	EDP
	Framework R&D&I topics in the social sciences and humanities	EDP
Societal challenges and RIS3 missions		
	Improving the material, energy and emissions efficiency of the economy	EDP
	Strengthening society's resilience to security threats	EDP
The scope of RIS3 in aid instruments		

[1] Key enabling technologies, also abbreviated as "key technologies".
[2]Research, development and innovation
[3] Entrepreneurial Discovery Process

1. Thematic areas, domains of research and innovation specialisation

The content definition of individual **thematic areas and specialisation domains** corresponds to the focus of the individual National Innovation Platforms. Subsequently, research and innovation specialisation domains are linked to each thematic area, as shown in the following diagram.

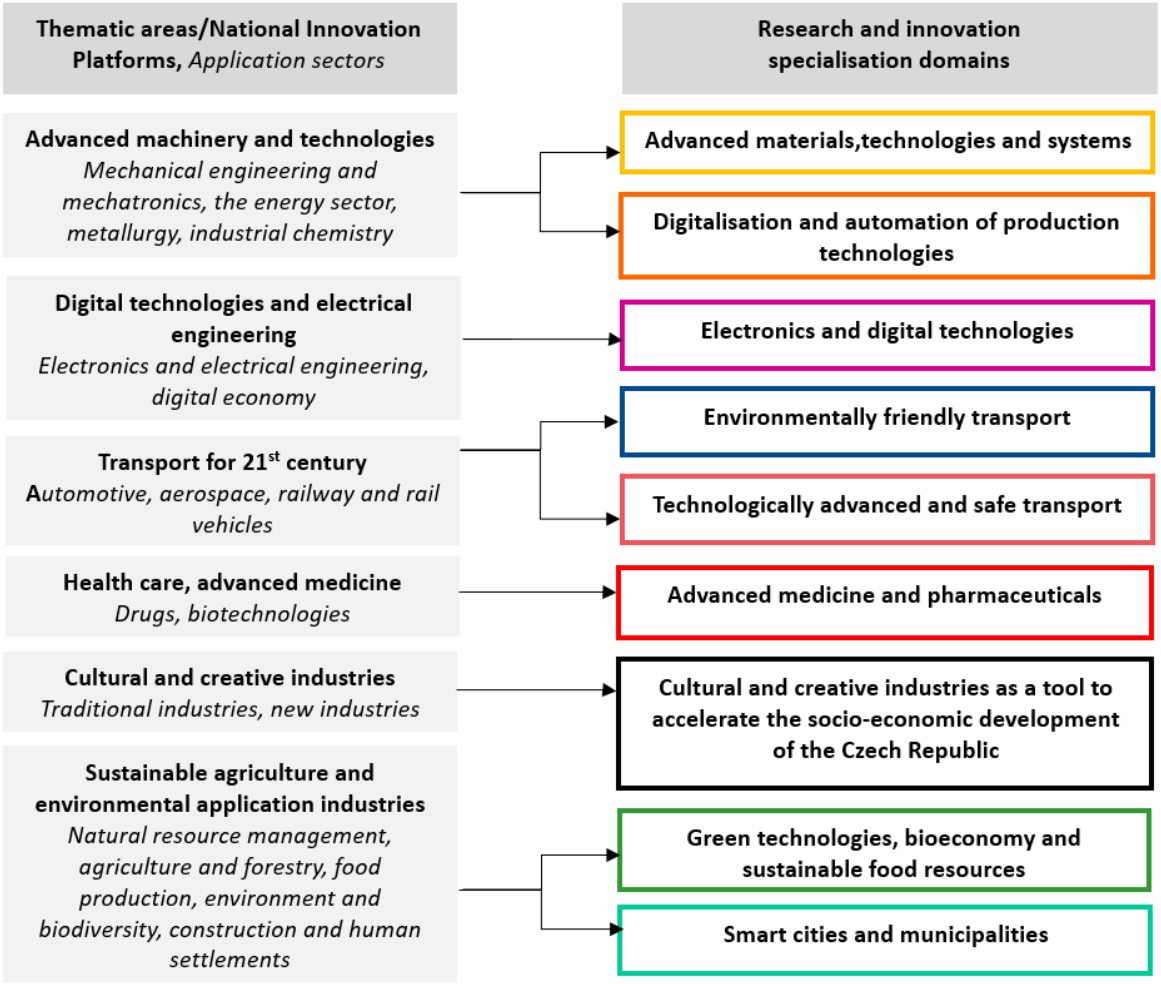


Figure 1 Thematic areas/National Innovation Platforms and specialisation domains

Source: Prepared by the authors

Each thematic area is described in an analogous structure and the following text is made up of "thematic area cards". The cards of thematic areas are the initial framework for discussions at National Innovation Platforms and the Entrepreneurial Discovery Process (EDP), which aims to continuously refine the research and innovation specialisation domains and their detailed focus. Annex 1 also takes into an account the topics emerging from the EDP processes of the different self-governing regions and from input from expert groups.

The focus of the specialisation domains is specified in more detail through the R&D&I topics within each domain. For each specialisation domain, these topics are divided into three dimensions, which are described in the text below:

- Topics in KETs and in emerging technologies with potential for application in application sectors
- R&D&I topics in application sectors
- R&D&I topics in the social sciences and humanities

The different groups of R&D&I topics within the specialisation domains and their focus are described in general terms in the following text. In the specific specialisation domains, illustrative examples of R&D&I topics are provided for all three dimensions; this is not an exhaustive list. For clarity, the RIS3 codes are assigned to the topics (see Chapter 3.1 for more details).

R&D&I topics: 3 dimensions of specialisation domains

The first dimension: **Research topics in KETs and in emerging technologies with potential for application in application sectors**

Based on the analyses prepared and input from the EDP process, in these topics there is potential for the use of R&D in the given research and innovation specialisation domain.

Overview of key enabling technologies (KETs) and emerging technologies and their indicative definition

KET01 **Photonics and micro-/nano-electronics**

This KET covers the very broad field of photonics, microelectronics and nano-electronics, between which there is considerable overlap. **Photonics** is a multidisciplinary field covering light generation, light conduction, light manipulation, and light detection. 'Light' includes not only the visible part of the spectrum, but also the microwave and ultraviolet parts of the spectrum and X-rays. Photonics includes light sources such as light-emitting diodes (LEDs), lasers, conventional sources (e.g. discharge tubes), displays, and many other optoelectronic elements such as light detectors (sensors) and optical modulators. In the field of light guiding, examples include light guides (waveguides), optical fibres, and optical cables. Some quantum technologies can also be included under photonics. Photonic elements enable advances in many technological fields and industries. Examples include solar panels that allow the conversion of sunlight into electricity, cutting and machining of materials with powerful lasers, and a range of optical instruments used for various purposes, such as microscopes (including electron microscopes), spectrometers and others.

Micro/nano-electronics deals with highly miniaturised semiconductor devices, components and electronic sub-systems, and includes the design, fabrication, assembly and testing of these elements from the micrometre to nanometer levels. All areas of electronics with nanometre-scale structure, including components with dimensions where quantum effects are applied, are considered to be nano-electronics. This large group includes semiconductors and semiconductor devices, chips, microprocessors and their integration into larger assemblies, products and systems. It also includes measurement and instrumentation, testing of micro/nano-electronic components and sub-systems, etc.

KET02 **Advanced materials and nanotechnologies**

Advanced materials and nanotechnologies is a broad field with boundaries that are difficult to define. **Advanced materials** are usually defined as new or significantly improved materials that have desirable properties or specific functions. This group includes materials for extreme conditions, lightweight materials, composite materials, advanced metals, polymers, ceramics, protective coatings and resistant materials (against various influences and conditions), smart materials, etc. It also includes materials that have advantages over traditional (conventional) materials. This group includes cost-effective materials replacing traditional materials, innovative materials for use in high value-added products and services, materials reducing energy and material intensity of production, materials enabling recycling, materials reducing carbon footprint, etc.

Nanotechnologies are considered to be technologies for structures with dimensions between 1 and 100 nanometres in at least one dimension. This area includes a wide range of nanomaterials, nanofibres and nanostructures that can be applied in various technological fields and sectors such as manufacturing, health care, energy, environment, agriculture, food production, etc. In addition to nanomaterials, this group also includes the design of these structures, systems for their characterisation (analytical equipment, nanometre-scale testing systems, etc.), and applications of nanometre-scale structures, elements and systems.

KET 03 **Advanced manufacturing technologies**

Innovative and knowledge-intensive technologies enabling the manufacturing of new products and equipment or to significantly improve product and process parameters that can become innovation can be considered advanced manufacturing technologies. They include two types of technologies – process technologies, which are mainly used to produce some of the other advanced technologies (or KETs), and technologies that are based on digital, information and communication technologies.

Process technologies include innovative manufacturing technologies, equipment, systems and processes used to produce specific materials, components and systems. Another group includes technologies for clean industry, such as technologies that reduce production waste, emissions and pollution, innovative technologies that reduce the

consumption of materials and energy (especially non-renewable energy), technologies and processes aimed at making production more efficient, etc.

Technologies based on digital technologies and ICT include automated manufacturing, robotics, additive manufacturing (3D printing), integration of computers into manufacturing (including the use of high-performance computing), technologies using artificial intelligence, manufacturing technologies and processes using virtual/augmented reality, and others. Another group includes technologies enabling efficient production control, such as signal and information processing, production control, machine measurement, control and test equipment, process control, product and equipment testing, modelling and simulation, etc.

KET04 **Biotechnology**

KET Biotechnology includes **industrial ("white") biotechnology** using enzymes and microorganisms for the production of bioproducts and chemical building blocks in sectors such as the chemical industry, material production, energy, food/nutrition, healthcare, textiles and paper industries, and others, mainly in areas where "conventional" processes cannot be used effectively. These include biotechnologies pro industrial processing and the production of chemicals, materials and fuels (biofuels), biotechnologies using micro-organisms or enzymes, technologies to increase production efficiency using enzymes and micro-organisms, research and development of chemicals and building blocks using enzymes and micro-organisms, use of enzymes in food, feed and detergent production, production of biochemicals and biopolymers from agricultural and forestry waste, etc.

Another group is **biotechnology in the medical and life sciences**, which includes technologies in the field of biomedicine, including analytical methods and analytical techniques, bioengineering, bioelectronics, technologies in neuroscience, etc. This group also covers genomics, proteomics, genetic engineering, cell and tissue engineering, including artificial (synthetic) cells, bioactivators, biotechnologies for use in pharmacy, neurotechnology, bioinformatics, and biomedicine (including nanomedicine). Other important groups are systems in analytical technology, such as biosensors and biochips, lab-on-a-chip, and organ-on-a-chip.

KET 05 **Artificial Intelligence**

Artificial intelligence is a branch of computer science dealing with the creation of machines and systems with cognitive functions similar to those of humans, solving complex tasks such as logistics, natural language processing, decision making, processing large volumes of data, etc. This KET covers **software**, which includes artificial intelligence methods and tools enabling cognitive and decision-making functions, algorithms and software, machine learning, neural networks, deep learning, genetic algorithms, high-performance computing, etc.

Another group is **embedded artificial intelligence**, i.e. elements, machines, technologies, processes and other that use artificial intelligence. This group includes for example problem-solving, decision-making and planning systems, systems using big data analytics, intelligent robots, virtual agents and distributed systems. It also includes human-machine interaction issues and devices and processes using virtual and augmented reality. Artificial intelligence also enables the development of autonomous transport (autonomous vehicles and technologies in the field of transport and transport systems).

KET 06 **Digital security and connectivity**

Digital security and connectivity include the **security of IT systems and IT-enabled devices**, information on stored computers and repositories, including the detection and mitigation of risks associated with their use. This group includes, for example, authentication of users of these systems, ensuring data security and storage, preventing data loss, cloud security (cloud storage, cloud computing), security of cyber-physical systems, secure human-machine interfaces, human-computer and robot interaction, technologies for the Internet of Things (IoT), etc.

The field of **connectivity** includes the network infrastructure and the technologies and services that enable end-users to connect to that network, including the security of that infrastructure and communications. It includes secure connectivity and authentication, identity theft prevention, data protection and privacy, cryptography, ensuring the security of communications and communication systems (protection against viruses, malware, etc.), network security (fixed networks and mobile networks, including 5G). Furthermore, it includes technologies related to Internet services such as e-Government, e-Administration, e-commerce, blockchain, etc.

The second dimension: **R&D&I topics in application sectors**

These topics are divided according to the "s**trategic topics**" within the specialisation domains.

Strategic themes are themes with the potential to support fields of activity within the specific domains of specialisation towards better prosperity and increase the competitiveness of the Czech Republic.

The third dimension: **R&D&I topics in the social sciences and humanities**

The innovation process is nowadays commonly understood as a social process that is based on cooperation of a number of actors taking place in the relevant socio-cultural context and is inherently linked to the complex development of society. Research in the social sciences and humanities (SSH[4]), in combination with the natural, medical and technical sciences, can provide further impetus for and a new dimension to innovations. Multidisciplinarity is a prerequisite for research and innovation to have the desired effects, help improve competitiveness, avoid negative impacts and improve people's lives.

The SSH research topics were consolidated to form four framework R&D&I topics that can integrate all existing, previously identified SSH research topics:

SHUV01 **Research on the interrelationships between society, technology and innovation**

> Annotation: Research into the impact of the socio-cultural environment on technological development and innovation and research on the implications of the application of existing technologies. It will further develop existing research topics that have already been approached in the Czech Republic in the past and now need to be addressed in more depth. Innovative applications of existing solutions are also expected to be presented. In terms of the type of the research, it includes e.g. addressing the impacts of climate change, globalisation and other changes that are or may be manifested in relation to people (their psyche, behaviour, perception, etc.) and society (education policy, social system, labour market, management, governance, public administration, etc.) under the conditions existing in the Czech Republic.

Examples: the impact of existing discourses and attitudes on the acceptance of new technologies by different social groups; the effects of digitalisation on human psyche and decision-making; the effect of automation on the labour market; the effects of technology on the increase in inequalities between people, social groups and regions; the effects of technologies on the transformation of communication and media; the links between digitalisation and the concept of power; the gradual development of automation in different areas, etc.

SHUV02 **Addressing 21st century societal challenges associated with emerging technologies**

> Annotation: Research focused on completely new research topics with a high degree of novelty and risk. This mainly includes applied research on global trends, research on the socio-economic opportunities arising from these trends, or possibly arising from experimental deployment of selected technologies. Related issues include eliminating risks, potential threats and societal problems associated with 21st century challenges that our society is facing or will face and that are likely to become more important during the programming period. It places emphasis on new and emerging technologies whose development is still largely unrealised and whose future applications may be radically novel.

Examples: the social, ethical and legal aspects of human genome editing; the ethical and legal aspects of the application of artificial intelligence and robotics; the risk of increasing automation in HW and SW; autonomous transport; the human factor in critical processes in the energy sector and industry; societal threats that are associated with the development of new communication technologies; the (security, psychological) risk of widespread control of the population through technology; the social and cultural framework of environmental threats (e.g. climate change); new energy and climate change, etc.

SHUV03 **Conditions/barriers to the application of innovative technologies and practices**

> Annotation: Research focusing on the regulatory, institutional and policy framework for the systemic and individual adoption of new approaches with predictable consequences, e.g. in law, public administration and public policy. Furthermore, research on barriers to the adoption of innovative solutions, processes and practices across application sectors, at the individual, community or societal level. Research on the digital divide, digital exclusion and mechanisms to prevent it; the effects of open-access in science, education and development on the economic development of the state; the problems of dual use and the potential misuse of technological innovations to the detriment of people and society.

[4] The abbreviation SSH is interpreted as Social Sciences, Humanities and Arts, whereas in the RIS3 strategy the arts are only used in the Cultural and Creative Industries domain.

Examples: Autonomous mobility and the impacts of its introduction on society; interface of technologies for optimal human use; development of the services of the sharing economy; changes resulting from the impacts of innovation policy, social and cultural barriers to the adoption of biotechnologies (e.g. vaccination), etc.

SHUV04 **Security research**

Annotation: Research aimed at eliminating potential security threats caused by new technologies and approaches. Furthermore, research aimed at effectively addressing the consequences of existing threats that are felt in the society at large. One specific area is research in the field of cyber security.

Examples: text and data mining in the security context; crisis management and public health protection; the potential of digital technologies in addressing the security threats of migration crises; non-invasive behavioural and psychophysiological methods in security risk detection; cyber threats and risks of hybrid conflicts that use new communication and military technologies, etc.

The above four framework R&D&I topics define the basic orientation of illustrative examples for research subtopics in the field of social sciences and humanities within the different domains of specialisation and **are always linked to a specific specialisation domain**.

Recommendations for implementing instruments of the National RIS3 Strategy

At the end of the description of the specialisation domain, some recommendations may be proposed for the preparation and implementation of instruments to support R&D&I, which arise from the conclusions of the analyses prepared, the meetings of NIP and expert groups and the linkages to regional RIS3 strategies. Attention is also given to the driving forces and trends that may influence how the given segment will develop in the future ad to which the instruments implemented within the NRIS3 and the Czech Republic's research and innovation specialisation domains should respond.

Thematic areas

Advanced machinery/technologies for strong and globally competitive industry

Introduction

The thematic area of Advanced machinery/technologies for strong and globally competitive industry (abbreviated as Advanced machinery and technologies) covers **four application sectors – Mechanical engineering and mechatronics, the Energy sector, Metallurgy and Industrial chemistry**. The priority thus includes application sectors that form the traditional backbone of the Czech Republic's economy and contribute significantly to generating GDP (Mechanical engineering and mechatronics), as well as sectors that are a prerequisite for the competitiveness of a number of other sectors, as they produce products that are used in those sectors (Metallurgy and Industrial chemistry). The Energy sector plays a key role in keeping the entire economy running. It needs to be understood as a cross-cutting topic that comprises a layer of individual facilities and technological components and a layer of an interconnected energy system

National Innovation Platform I focuses on developing two specialisation domains: *Advanced materials, technologies and systems* and *Digitalisation and automation of manufacturing technologies*.

Drivers of transition in application sectors

R&D&I supported in these domains responds to the following drivers, which will have a major effect on the trends and development in this technological area and which will also be an important factor in maintaining international competitiveness of companies operating in these sectors:

- Requirements for production and products, individualisation, accompanying services, monitoring, diagnostics
- The legislative and regulatory environment, competition, relocation of production and control processes, Industry 4.0, professional knowledge and skills
- The application of the principles of the circular economy
- The need to secure resources and raw materials, the search for their substitutes
- Climate protection, decarbonisation, energy savings, energy efficiency, the environment
- An increase in human healthcare, an increase in investments in human health

1.1 Specialisation domain DS01 **Advanced materials, technologies and systems**

The Advanced materials, technologies and systems domain focuses on R&D&I of advanced manufacturing technologies, advanced materials and industrial biotechnologies. It aims at the use of these technologies in traditional backbone industries of the Czech Republic's economy which contribute significantly to generating GDP. These are industries important for ensuring the competitiveness of the entire economy **(Engineering and Mechatronics, Energy Sector, Metallurgy and Industrial Chemistry).**

The development of the sectors within this domain is influenced by increasing international competition, pressure to reduce costs and increasing demands on manufacturing accuracy, quality, performance and reliability. In addition, the threat of climate change also has significant influence in the form of pressure to reduce negative environmental impacts.

The use of key enabling technologies therefore aims to improve manufacturing efficiency in engineering, increase the value added of products and the competitiveness of businesses operating in the above sectors of this domain. Emphasis is also placed on reducing material and energy requirements, wider use of waste raw materials, as well as recycling and greening of production. The domain deals with strategically important products with high technical demands that normally require systematic research and development for their innovation.

R&D&I topics

Research topics in KETs and emerging technologies with potential for application in application sectors

DS01KET02 Advanced materials and nanotechnologies

Advanced materials and nanotechnology is a broad field with boundaries that are difficult to define. **Advanced materials** are usually defined as new or significantly improved materials that have desirable properties or specific functions. This group includes materials for extreme conditions, lightweight materials, advanced textiles, composite materials, advanced metals, polymers, ceramics, sophisticated organic compounds, protective coatings and resistant materials (against various influences and conditions), smart materials, etc. It also includes materials that have advantages over traditional (conventional) materials. This group includes cost-effective materials replacing traditional materials, innovative materials for use in high value-added products and services, materials reducing energy and material intensity of production, materials enabling recycling, materials reducing carbon footprint, etc.

Technologies for structures with dimensions within the order of nanometres, typically from 1 to 100 nanometres (fibres with diameters smaller than 1 micrometre) in at least one dimension, are considered to be nanotechnologies. This field includes a wide range of nanomaterials, nanolayers and nanostructures that are applied in various technological areas of industry. In addition to nanomaterials, this group also includes the design of these structures, systems for their manufacturing, systems for their characterisation (analytical equipment, nanometre-scale testing systems, etc.), and applications of nanometre-scale structures, elements and systems.

The KETs area "Advanced materials and nanotechnologies" for the application sectors Energy, Metallurgy, Industrial chemistry, Mechanical Engineering and Mechatronics includes research lines and topics, such as:

- Advanced energy storage materials – to achieve storage of substantially higher energy density than today's battery types and to achieve longer life-time of the systems (more cycles, etc.)
- Advanced materials for use in construction to achieve more efficient energy savings
- Materials and technologies for coating and surface treatment (thermal spraying, nano-coating, etc.) to achieve higher reliability and durability of components and systems
- Nanomaterials for high-efficiency filtration of liquids and air, nanomaterials for passive resistance reduction
- Nanomaterial-based membranes for waste gas capture and separation for cascade functional units to reduce waste gas emissions
- Advanced materials for application in membrane reactors increasing the yield and/or conversion of chemical reactions.
- Materials, nanomaterials and technologies for future applications with reduced environmental burden
- Advanced materials for special applications, such as nuclear energy, high thermal, corrosion and force applications, hydrogen transport and storage materials, high strength materials for energy and material reduction, smart materials (e.g. SMA-shape memory alloys), pre-stressing and fire activation)
- New materials for transport (lightweight structural materials, textiles, composites, battery materials, hydrogen, synthetic fuels)
- Alternative materials and technologies (non-toxic environment) to suppress the use of potentially hazardous chemicals (SVHC), materials and technologies for their processing and use.
- Modelling of material degradation, prediction of residual life, prediction of alloy properties using thermodynamic and thermochemical modelling.
- Computational design of nanomaterials and nanostructures
- Advanced fibre-based materials incorporating hybrid textile structures, multifunctional textile structures, energy-generating structures, structures with sensor integration and other electronic components.
- Research and development of nanofibrous scaffolds for growth of microorganisms and cells for broad spectrum applications
- New filter materials and technologies
- New advanced catalytic materials (e.g. microstructured catalysts, multi-functional catalysts, etc.) for advanced chemical transformations, increasing the efficiency of chemical processes and minimising emissions.

DS01KET03 Advanced manufacturing technologies

Innovative and knowledge-intensive technologies enabling the manufacturing of new products, equipment and materials, or significantly improving product and process parameters are considered advanced manufacturing technologies. They can become a driver of innovations . They include two types of technologies – process technologies, which are mainly used to produce some of the other advanced technologies, manufacturing and processing technologies (or KETs), and technologies that are based on digital, information and communication technologies.

Process technologies include innovative manufacturing technologies, equipment, systems and processes used to produce specific materials, raw materials, components, systems and different types of energy. Another group includes technologies for clean industry, such as technologies that reduce production waste, emissions and pollution, innovative technologies that reduce the consumption of materials and energy (namely non-renewable energy),technologies and processes aimed at making production more efficient, etc.

Technologies based on digital technologies and ICT include automated manufacturing, robotics, additive manufacturing (3D printing), integration of computers into manufacturing (including the use of high-performance computing), technologies using artificial intelligence, manufacturing technologies and processes using virtual/augmented reality, and others. Another group includes technologies used for production control, such as signal and information processing, production control, machine measurement, control and test equipment, process control, product and equipment testing, modelling and simulation, etc.

The KETs area “Advanced manufacturing technologies” for the application sectors Energy, Metallurgy, Industrial chemistry, Mechanical Engineering and Mechatronics includes research lines and topics, such as:

- Additive technologies and technologies for processing new and advanced materials for the production of components and parts (e.g. metals and composites, ceramics and inorganics, electronic components, plastics, etc.)
- Highly efficient production of single pieces or small batches of parts; production of extremely complex components; production of components that are no longer available; express production to replace stock and orders from standard suppliers; technologies for refurbishment, reuse; low-cost technologies, rapid prototyping for testing a new range of components; etc.
- Tools and technologies for the primary production of standard, new and advanced materials, nanomaterials and their composites with increased efficiency and reduced environmental burden in the primary production of materials.
- Tools and technologies using standard materials in a new manner, advanced materials and nanomaterials (surface treatments, material cutting, spinning, weaving, creating 3D textile structures, laying, material bonding, additive technologies, machining, material forming and hybrid processes)
- Technologies using hydrogen and other low-emission inputs as part of the decarbonisation of industrial production (e.g. hydrogen reduction of iron ore)
- Increasing the efficiency of manufacturing technologies using material models, process modelling and digital twins involving the interaction of manufacturing equipment, process and material (e.g. optimisation of metallurgical technologies such as casting, forming, heat treatment and others using computer simulation, optimisation of machining and additive technologies using “Process machine interaction” models)
- Smart databases of material properties and technological parameters, data management.
- Waste recycling technologies and their use back into production (including chemical recycling).
- Technologies enabling the practical application of the circular economy concept at the level of materials, components and entire technological plants (e.g. technologies ensuring the required quality of secondary raw materials and wastes for their circular use, designs supporting reparability and disassembly)
- Technologies aimed at renewable resources and saving water, energy and chemicals (There is a need to exploit other sources of raw materials. Searching for alternatives.)
- Water saving and wastewater treatment and recovery technologies
- Advanced flexible automation techniques for the automation of individual machines to the automation of entire productions with the possibility of adaptability from piece to small batch production.
- Digitalisation of production technologies with the possibility of providing a balanced source of data on inputs and outputs, the possibility of advanced production control and lower demands on production staff.
- Advanced technologies and systems for energy management in industry and transport
- Systems for managing the safety and reliability of power supply for production technologies.
- Advanced technologies for the recovery and use of pyrolysis products in the application of the circular economy concept.

DS01KET04 **Biotechnology**
KET Biotechnology includes **industrial ("white") biotechnology** using enzymes and microorganisms for the production of bioproducts and chemical building blocks, mainly in areas where "conventional" processes cannot be used effectively. These include biotechnologies applicable to industrial processing and the production of chemicals, materials and fuels (biofuels), biotechnologies using micro-organisms or enzymes, technologies to increase production efficiency using enzymes and micro-organisms, production of chemicals and building blocks using enzymes and micro-organisms, use of enzymes, production of biochemicals and biopolymers. Another group is **biotechnology in the medical and life sciences**, which includes technologies in the field of biomedicine, including analytical methods and analytical techniques, bioengineering, bioelectronics, technologies in neuroscience, etc. This group also covers genomics, proteomics, genetic engineering, cell and tissue engineering, including artificial (synthetic) cells, bioactivators, biotechnologies for use in the pharmaceutical industry, neurotechnology, bioinformatics, and biomedicine (including nanomedicine). Other important groups are systems used in analytical technology, such as biosensors and biochips, lab-on-a-chip, and organ-on-a-chip.
The KETs area "Life sciences technologies/biotechnologies" for the application sectors Energy, Metallurgy, Industrial chemistry, Mechanical Engineering and Mechatronics includes research lines and topics, such as: - Biotechnology for biomass processing, e.g. solid biomass decomposition, biotechnology for the production of higher generation liquid fuels (e.g. also using algae), methanisation using microorganisms, etc. - Advanced manufacturing equipment that can be used in biotechnologies (bioreactors, gasification, fermentation, plasma technologies, membrane separation, etc.) - Technological processes, machinery and equipment for mastering and implementing biotechnology in industrial application sectors - Biotechnology in relation to textile structures and fibres (e.g. replacement of chemical processes, creation of functional properties of textiles, use of enzymes, use of biopolymer and biomass, replacement of fossil materials) - Process optimization, production and testing of properties of new biopolymers (e.g. high temperature resistant) and cellulose. - Recycling of bio-waste into polymers or raw materials suitable for industry - Special biosensor and their manufacturing technologies

R&D&I topics in application sectors

Strategic R&D&I topics in the application sector of **Mechanical Engineering and Mechatronics**

Strategic topic DS01VVI01 **Manufacturing equipment and technologies (machine tools)**
Illustrative examples of partial R&D&I topics (not a comprehensive list): - R&D&I of new and innovated concepts and improved solutions and products: machine tools, forming machines, material cutting machines, machines for additive technologies and related utility technologies for machining, forming, cutting and adding materials. - R&D&I of techniques for in-process and output inspection - Research on new tools and their materials for manufacturing equipment in mechanical engineering - R&D&I of processes in advanced materials (materials characterisation and imaging, etc.) - R&D&I of solutions for the processing of new metallic and non-metallic materials - R&D&I of advanced and new types of manufacturing equipment in mechanical engineering, e.g. 3D printing, additive technologies, hybrid and multifunctional manufacturing technologies and machines - R&D&I of technologies and equipment responding to the increasing demands on manufacturing and products in terms of the quality parameters (precision, material properties, surface properties, ergonomics, etc.), manufacturing performance, productivity, energy and economic efficiency, functional and process reliability, requirements for customer individualisation and accompanying services in the field of digitalisation, monitoring and diagnostics

- Tool management (a system to supply tools to workplaces, automation of storage, preparation and transport in manufacturing systems, etc.)
- Systems of inter-operation transport with automation of setting and clamping in the machine work area, automation of handling during manufacture and inspection

Strategic topic DS01VVI02 **Manufacturing equipment and technologies for the manufacturing industry**

Illustrative examples of partial R&D&I topics (not a comprehensive list):
- R&D&I of new and innovative concepts and improved machine designs and technology solutions for the manufacturing industry, e.g. textile machines and technologies, machines for the chemical industry, printing machines and technologies, machines and technologies in the food industry, packaging machines and technologies, etc.
- R&D&I of new metallic and non-metallic materials for the design of machinery and equipment in the field of manufacturing equipment for the manufacturing industry

Strategic topic DS01VVI03 **Mechanical equipment and components for the modern energy sector**

Illustrative examples of partial R&D&I topics (not a comprehensive list):
- R&D&I of equipment and components for the energy sector: turbines, heat exchangers, nuclear reactors and other equipment and components for nuclear and non-nuclear energy, electrolysers, fuel cells, etc.

Strategic topic DS01VVI04 **Mechanical equipment and technologies to reduce negative environmental impacts**

Illustrative examples of partial R&D&I topics (not a comprehensive list):
- R&D&I of equipment and technologies to reduce negative environmental impacts (ash, waste heat, waste water, special aggregates and control methods, etc.)
- R&DI&I of recycling technologies and their applications Materials and component recycling, battery recycling, improving the energy balance in metal recycling, polymer recycling, biodegradable materials, automatic sorting systems, advanced reusable packaging materials
- R&D&I of SW green passport (product life cycle and sustainability, improvement of materials in terms of their sustainability and CO2 emission parameters)

Strategic topic DS01VVI05**New and progressive technologies for the manufacture of engineering products**

Illustrative examples of partial R&D&I topics (not a comprehensive list):
- R&D&I of new and progressive technologies and manufacturing processes including related software for manufacturing preparation
- R&D&I of technologies and related equipment responding to the increasing demands on manufacturing and products in terms of the quality parameters (precision, material properties, surface properties, ergonomics, etc.), manufacturing performance, productivity, energy and economic efficiency, functional and process reliability, requirements for customer individualisation and accompanying services in the field of digitalisation, monitoring and diagnostics
- R&D&I of additive manufacturing: graded materials, combinations of material properties, the manufacture of input materials for additive technologies, heat treatment of parts, HIP protection, process parameters of additive technologies

Strategic topic DS01VVI06 **New and innovated materials and surface treatments for mechanical engineering**

Illustrative examples of partial R&D&I topics (not a comprehensive list):
- Research and development of new metallic and non-metallic materials for the design, construction and operation of machinery and equipment.

- R&D&I of reduced-weight structures, metallurgy of reduced-density alloys (bulk materials), special materials with a low volumetric mass density (e.g. foam materials) and applications of advanced composites
- Nanomaterials and nanotechnologies, nanostructured and composite materials, 2D materials (graphene), use of nanoparticles
- R&D&I focusing on surfaces and surface treatments and their applications: abrasion and corrosion resistant treatments, ceramics, enamel, use of powders, new types of surface coatings, the development of coating technologies
- Improvements to known materials and their applications, search for alternative substitute materials
- Materials with specific response (smart materials)
- Highly resistant materials e.g. for product pipelines, hydrogen, high-temperature applications, ionising radiation
- The development of special alloys manufactured by conventional and powder metallurgy for specific loads and stresses
- Joining of materials, advanced welding methods, soldering, joining by plastic deformation and more
- Materials and technology modelling and data management, modelling of material degradation, prediction of residual life, prediction of alloy properties using thermodynamic modelling (CALPHAD, etc.), optimisation of metallurgical technologies (casting, forming, heat treatment) using computer simulations, modelling of technological processes
- Research and development of methods, tests for standardisation purposes and non-standard verification and measurement of the properties of materials and technologies (e.g. for additive technologies)

Strategic R&D&I topics in application sector of the **Energy Sector**

Strategic topic DS01VVI07 **Safe and reliable nuclear energy, the preparation of next generation nuclear sources (nuclear fission and fusion)**

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- Tools and procedures for improving the efficiency and reliability of operations, extending the lifetime of sources and ensuring the safety of nuclear installations, including the preparation of emergency management tools
- The development of next-generation of nuclear fission sources, including small modular reactors Participation in the development of sources based on nuclear fusion, in particular ITER and Demo
- Technologies for decontamination, decommissioning of nuclear sources and for nuclear fuel cycle closure

Strategic topic DS01VVI08 **Renewable sources suitable for the conditions existing in Czech Republic – electricity and heat production**

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- Non-combustion renewable energy sources – advanced photovoltaic sources (including non-silicon cells and solutions as part of structures), wind energy, hydroelectric sources (improving the efficiency of larger sources, small hydroelectric plants), biomass sources (digestion – including biomethane technologies), environmental energy sources (heat pumps) and geothermal sources for heat production
- Renewable energy sources based on combustion processes – sources using biomass (including efficient and environmentally friendly local heating/combustion units) and sources using combustible waste
- Hybrid solutions – combinations of renewable sources and other technologies (e.g. energy storage)

Strategic topic DS01VVI09 **Advanced low-emission fossil fuel-based sources, especially with CCS/CCU**

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- Technologies to reduce emissions (greenhouse gases and pollutants) from operating coal-fired sources – making use of the period until closure of the sources
- Fossil fuel-based sources with a low carbon footprint, especially gas-fired sources, with CO2 capture and storage or recovery (CCS/CCU), or other options for achieving low emissions (e.g. hydrogen addition)

- Gas-based technologies (natural gas, with an increase in biomethane and hydrogen) as an important solution for decarbonising the heating sector and individual heating in the Czech Republic

Strategic topic DS01VVI10 Hydrogen technologies to support the decarbonisation of the energy sector and especially industry

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- Technologies for efficient hydrogen production with a low emission footprint in the Czech Republic (transitionally from fossil sources with CCS/CCU, but especially from renewable or nuclear sources) or technologies enabling the import of hydrogen
- Other necessary technologies for the hydrogen economy – e.g. storage and transport systems
- Hydrogen technologies for energy production – e.g. micro-cogeneration units or hydrogen heating.

Strategic topic DS01VVI11 Smart grids – transmission and distribution systems

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- Preparation of power grids and their components (including control systems) for operation in new conditions – integration of new production and consumption categories
- New elements and equipment to ensure reliable operation of the transmission system
- New elements and equipment for the reliable operation of distribution systems as the systems with the highest rate of change within the power system (progressive “smartisation”).

Strategic topic DS01VVI12 Technologies to support energy system flexibility

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- Technologies and systems to achieve substantially greater energy system flexibility compared to now
- Procedures to expand the output range of larger sources, including nuclear power plants.
- Advanced flexible gas turbines – e.g. enabling hydrogen combustion or based on supercritical CO2.
- Systems for aggregation of smaller sources, energy storage and aggregation of consumption (consumption management)
- Technologies supporting sectoral interconnection (electricity and gas systems) and power-to-X technologies

Strategic topic DS01VVI13 Energy storage with different power and capacity

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- Energy storage technologies as a key element of the future energy system, based on different principles (electrochemical systems, thermal storage, etc.)
- Energy storage systems for energy applications (e.g. advanced pumped storage plants, some types of batteries) and for power applications (e.g. flywheels, capacitors or some types of batteries)
- Hybrid systems with energy and power functions
- Systems for long-term energy storage, including seasonal storage

Strategic topic DS01VVI14 Integral energy solutions on a large and small scale

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- Comprehensive energy solutions at the level of cities (the energy part of the smart cities concept) or parts of cities and districts (low-energy to positive-energy districts), possibly with links to other areas (e.g. transport, waste management, water management).
- Comprehensive energy solutions on a smaller scale – energy communities or based on local distribution systems. Comprehensive energy solutions and technologies for rural environments, especially in combination with water management in the landscape.

Strategic topic DS01VVI15 Systems and technologies for energy saving and energy efficiency

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- Systems and technologies for improving energy efficiency and achieving energy savings in industry (e.g. manufacturing equipment and auxiliary systems with lower energy consumption, frequency converters), in services and non-residential structures (e.g. energy recovery), municipal infrastructure (e.g. energy efficient

lighting systems), the residential sector (e.g. smart meters, smart appliances, overall integration of elements into smart homes) and agriculture (e.g. heat recovery from biogas plants).
- Thermal management (voltage switches)

Strategic R&D&I topics in the application sector of **Metallurgy**

Strategic topic DS01VVI16 **Materials and products in metallurgy and their properties**

Illustrative examples of partial R&D&I topics (not a comprehensive list):
- Steels (stainless steel, etc.)
- Material properties and product properties (mechanical and other)
- Non-ferrous metal alloys (magnesium alloys, micro-alloys, etc.)
- Material treatments (stress relief, corrosion protection, wear protection, etc.)
- New and sophisticated metallic materials and other products (new steels, alloys and composites, superconductors, metallic structures and technological units, biocompatible metallic materials, etc.)
- Ceramic materials for metallurgy
- Nanomaterials (filters, etc.)
- Product portfolio development
- Applications of the above (technologies, tools, processes, etc.)

Strategic topic DS01VVI17 **Technologies and manufacturing processes in metallurgy**

Illustrative examples of partial R&D&I topics (not a comprehensive list):
- Processes in manufacturing in the metallurgy and foundry industry (continuous casting, heat treatment, cooling, etc.)
- The manufacture of specific products (rolled products, cast and rolled blocks, billets and slabs, long, flat products and tubes, respectively sheets, strips, sections, bars, wires, mining reinforcements, pipes, rails, crash barriers, etc.)
- Powder metallurgy
- New and advanced technologies and processes in metallurgy (e.g. the use of hydrogen for iron and steel production, reduction of energy intensity of manufacturing and materials (including insulation), shortening and streamlining technologies, biotechnologies, etc.)
- Artificial intelligence and advanced systems in metallurgy, manufacturing control methods (including links to digitalisation and automation), connectivity and communication, digital impression, modelling and simulation
- Smart factory
- Circular economy (recovery of scrap, sludge, slag, dust, waste energy, other wastes, etc. from manufacturing in metallurgy), CCS/U technologies
- Diagnostic and measuring systems, sensors
- The development of a product portfolio and related manufacturing processes

Strategic R&D&I topics in the application sector of **Industrial chemistry**

Strategic topic DS01VVI18 **Waste management, air and wastewater treatment**

Illustrative examples of partial R&D&I topics (not a comprehensive list):
- R&D&I in the field of efficient operation of technologies with waste minimisation, use of waste for material recovery, e.g. chemical recycling, green chemistry
- R&D&I in the field of efficient use of technologies with waste water minimisation and reuse E.g.: nanofibre filter membranes, nanofibre biomass carriers
- R&D&I in the field of air treatment, e.g. filtration, photocatalytic coatings

Strategic topic DS01VVI19 **New manufacturing technologies for the chemical industry that reduce environmental impacts**

Illustrative examples of partial R&D&I topics (not a comprehensive list):
- R&D&I of new and innovative manufacturing technologies for the chemical industry, including reducing their negative environmental impacts and their energy intensity, e.g. synthetic fuels for decarbonising transport

Strategic topic DS01VVI20 **New advanced non-metallic materials for industrial and consumer applications**
Illustrative examples of partial R&D&I topics (not a comprehensive list): - R&D&I of advanced materials: modern plastics, biomaterials and biodegradable materials, modern catalysts, nanomaterials, nanotechnologies, special fibres, technical textiles, composite materials, fibre composites, viscous fibres, materials for manufacturing technologies and specific applications – 3D printing, insulation materials and others
Strategic topic DS01VVI21 **New and sophisticated organic compounds for various applications**
Illustrative examples of partial R&D&I topics (not a comprehensive list): - R&D&I of new and sophisticated organic compounds for various applications, e.g. microelectronics
Strategic topic DS01VVI22 **Industrial biotechnologies**
Illustrative examples of partial R&D&I topics (not a comprehensive list): - R&D&I of industrial biotechnologies, especially: catalysts, bioreactors, biofuels, ...
Strategic topic DS01VVI23 **New advanced metallic materials for industrial and consumer applications**
Illustrative examples of partial R&D&I topics (not a comprehensive list): - R&D&I of advanced metallic materials and the technologies for their manufacture and processing. Extraction of alkali metals and rare metals
Strategic topic DS01VVI24 **Energy conversion and storage, carbon capture and use**
Illustrative examples of partial R&D&I topics (not a comprehensive list): - R&D&I of materials and technologies for energy conversion and storage, electricity storage (e.g. Power-to-X) and use in hydrogen technologies, carbon capture and use (CCU). For CO_2 conversion, consider low-emission hydrogen and water
Strategic topic DS01VVI25 **Environmentally friendly and efficient methods to produce hydrogen**
Illustrative examples of partial R&D&I topics (not a comprehensive list): - R&D&I of innovative hydrogen production methods using renewable and sustainable energy sources
Strategic topic DS01VVI26 **More efficient separation processes**
Illustrative examples of partial R&D&I topics (not a comprehensive list): - R&D&I of more efficient separation processes (e.g. distillation, membrane separations, filtration nanomaterials)
Strategic topic DS01VVI27 **Elimination, reduction of the use of hazardous chemicals in final products**
Illustrative examples of partial R&D&I topics (not a comprehensive list): - R&D&I aimed at suppressing the use of potentially hazardous chemicals (SVHCs) and replacing them in order to achieve a non-toxic environment

R&D&I topics in the social sciences and humanities

Each of the 4 application areas of this specialisation domain can be examined from the perspective of the social sciences and humanities. Research and innovations in the fields of Mechanical engineering and mechatronics, the Energy sector, Metallurgy and Industrial chemistry offer ample space especially for security research, because these industries present considerable risks associated with the energy resilience of the state and society, chemical accident hazards or negative environmental impacts. The use of nanomaterials and nanotechnologies is associated with a number of legal, ethical and social questions. In general, any research or technological innovation in this specialisation domain may be confronted with the question of how it will affect and impact on individuals, the community, the environment and human settlements or society at large.

DS01SHUV01 **Research on the interrelationships between society, technology and innovation**
Illustrative examples of partial R&D&I topics (not a comprehensive list): - Legal, ethical and social aspects of the use of nanotechnologies and nanomaterials - The effect and impact of technological innovations on society and individuals
DS01SHUV04 **Security research**
Illustrative examples of partial R&D&I topics (not a comprehensive list): - Security research in the energy sector and the energy resilience of the state and society - An analysis of the human factor in processes and critical events in the energy sector
DS01SHUV02 **Addressing 21st century societal challenges associated with emerging technologies**
Illustrative examples of partial R&D&I topics (not a comprehensive list): - Influence and impact of technological aspects of the use of secondary raw materials (such as in the textile industry)

Recommendations for the implementation of NRIS3 instruments

The analysis and the EDP process resulted in the following recommendations for developing instruments to support R&D&I in this specialisation domain:

- In Mechanical engineering and mechatronics, it is recommended to take advantage of the existence of a significant number of domestic businesses, including SMEs, pursuing their own R&D activities, to stimulate further development of the R&D carried out, especially demanding R&D aimed at disruptive innovations (coverage of the entire innovation cycle, including cooperation with ROs)
- In application sectors with low business R&D expenditure and a limited number of companies carrying out R&D (Metallurgy and the Energy sector), businesses should be stimulated to start their own R&D activities and/or cooperate with ROs
- In the application sector of Industrial biotechnologies, businesses should be stimulated to cooperate with public-sector ROs (especially HEIs and public research institutions with strong R&D in this technological area)
- In relevant instruments to support R&D&I, it should be required that all phases of R&D be covered from the development of materials, technological procedures and processes (for more demanding R&D in cooperation between businesses and ROs, especially HEIs) to their application in manufacturing
- Research centres and research infrastructure built with EU funds should be involved in R&D&I projects, especially in projects covering the entire innovation cycle with a potential for disruptive innovations
- When preparing instruments to support R&D at the regional level, the regional sectoral structure of business R&D should be respected.

In addition, it is necessary to take into an account current challenges and trends related to this domain (especially climate change and the Green Deal).

1.2 Specialisation domain DS02 **Digitalisation and automation of production technologies**

The domain of Digitalisation and automation of production technologies focuses on R&D&I in the promising and rapidly developing fields of microelectronics, optics and optoelectronics, digital technologies and artificial intelligence and their applications in key sectors of the Czech economy, especially in mechanical engineering, the energy sector and industrial chemistry. For the key sectors of the Czech economy are transitioning to Industry 4.0. This is also why the domain focuses on the development and implementation of digital technologies, automation of manufacturing processes and gradual replacement of human labour. The aim should be to restructure the Czech economy, increase labour productivity and generally support those sectors that contribute significantly to GDP.

R&D&I topics

Research topics in KETs and emerging technologies with potential for application in application sectors

DS02KET01 Photonics and micro-/nano-electronics

This KET covers the very broad field of photonics, microelectronics and nano-electronics, between which there is considerable overlap. **Photonics** is a multidisciplinary field covering light generation, light conduction, light manipulation, and light detection. 'Light' includes not only the visible part of the spectrum, but also the microwave and ultraviolet parts of the spectrum and X-rays. Photonics includes light sources such as light-emitting diodes (LEDs), lasers, conventional sources (e.g. discharge tubes), displays, and many other optoelectronic elements such as light detectors (sensors) and optical modulators. In the field of light guiding, examples include light guides (waveguides), optical fibres, and optical cables. Some quantum technologies can also be included under photonics. Photonic elements enable advances in many technological fields and industries. Examples include solar panels that allow the conversion of sunlight into electricity, cutting and machining of materials with powerful lasers, and a range of optical instruments used for various purposes, such as microscopes (including electron microscopes), spectrometers and others.

Micro/nano-electronics deals with highly miniaturised semiconductor devices, components and electronic sub-systems, and includes the design, fabrication, assembly and testing of these elements from the micrometre to nanometer levels. All areas of electronics with nanometre-scale structure, including components with dimensions where quantum effects are applied, are considered to be nanoelectronics. This large group includes semiconductors and semiconductor devices, chips, microprocessors and their integration into larger assemblies, products and systems. It also includes measurement and instrumentation, testing of micro/nano-electronic components and sub-systems, etc.

The KETs area “Photonics and micro-/nanoelectronics” for the application sectors Energy, Metallurgy, Industrial chemistry, Mechanical Engineering and Mechatronics includes research lines and topics, such as:

- Advanced types of photovoltaic cells going beyond the characteristics currently used (efficiency, price aspects, etc.) – advanced types of silicon cells, non-silicon cells (based on inorganic or organic compounds), hybrid cells (multilayer, etc.).
- Measuring, monitoring and testing technology with smaller dimensions, lower cost and higher reliability. New sensors, sensors, measurement methods, processing of measured signals and preparation of data for downstream processing to enhance monitoring, diagnosis and control of machines, equipment and processes.
- Optical sources, fibre optics, laser technology with lower energy and cost requirements.
- Photonics and micro/nanoelectronics in relation to textile structures and fibres (transmission of electrical pulses, integration of sensors, provision of data communication possibilities, etc.)

DS02KET05 Artificial Intelligence

Artificial intelligence is a branch of computer science dealing with the creation of machines and systems with cognitive functions similar to those of humans, solving complex tasks such as logistics, natural language processing, decision making, processing large volumes of data, etc. This KET covers **software**, which includes artificial intelligence methods and tools enabling cognitive and decision-making functions, algorithms and software, machine learning, neural networks, deep learning, genetic algorithms, high-performance computing, etc.

Another group is **embedded artificial intelligence**, i.e. elements, machines, technologies, processes and other that use artificial intelligence. This group includes for example problem-solving, decision-making and planning systems, systems using big data analytics, intelligent robots, virtual agents and distributed systems. It also includes human-machine interaction issues and devices and processes using virtual and augmented reality. Artificial intelligence also enables the development of autonomous transport (autonomous vehicles and technologies in the field of transport and transport systems).

The KETs area "Artificial Intelligence" for the application sectors Energy, Metallurgy, Industrial chemistry, Mechanical Engineering and Mechatronics includes research lines and topics, such as:

- Artificial intelligence and machine learning in industrial fields – risk identification, systems for early identification of non-standard conditions in the operation of equipment (early warning systems, prediction of degradation and failures), predictors of weather and climatic conditions, artificial intelligence for controlled systems, artificial intelligence for energy management, etc.
- Advanced mathematical modelling of industrial processes, modelling of processes using new mathematical approaches, use of high-performance computing, interconnection of physical and scientific disciplines in modelling (physics, chemistry, etc.), e.g. modelling of reactor core
- Digital twins as an integral part of the life cycle of complex devices, machines and technologies
- Tools and ICT technologies for the management of complex systems – e.g. the energy sector in the future (large-scale distributed generation, storage, consumption management, etc.)
- New ways of capturing and acquiring data and signals to enable the implementation and application of artificial intelligence technologies and algorithms. Addressing imbalances in the quantity and quality of input and output data.
- Research and development of models (simulation models, digital twins, virtual models) of manufacturing processes, processing technologies and production technologies that can provide computational and simulated data for basic training of artificial intelligence before its deployment on real systems.
- Digitalization and robotization of technologies; autonomous control of production processes; adaptive control of production processes; advanced diagnostics and supervision of technological processes

DS02KET06 Digital security and connectivity

Digital security and connectivity include the **security of IT systems and IT-enabled devices**, information on stored computers and repositories, including the detection and mitigation of risks associated with their use. This group includes, for example, authentication of users of these systems, ensuring data security and storage, preventing data loss, cloud security (cloud storage, cloud computing), security of cyber-physical systems, secure human-machine interfaces, human-computer and robot interaction, technologies for the Internet of Things (IoT), etc.

The field of **connectivity** includes the network infrastructure and the technologies and services that enable end-users to connect to that network, including the security of that infrastructure and communications. It includes secure connectivity and authentication, identity theft prevention, data protection and privacy, cryptography, ensuring the security of communications and communication systems (protection against viruses, malware, etc.), network security (fixed networks and mobile networks, including 5G). Furthermore, it includes technologies related to Internet services such as e-Government, e-Administration, e-commerce, blockchain, etc.

The KETs area "Digital security and connectivity" for the application sectors Energy, Metallurgy, Industrial chemistry, Mechanical Engineering and Mechatronics includes research lines and topics, such as:

- Advanced tools for safe interconnection of energy systems, especially for maintaining the functionality of critical infrastructure elements or rapid recovery of systems after their failure (human or technical error, intention, natural disaster)
- Protection of critical and high-risk production infrastructures (e.g. petroleum refining)
- Secure and robust connectivity for Industry 4.0. E.g. protection of industrial production equipment against hacking and data theft
- Protecting operators and the production process from digital attacks that can cause damage and degradation of production and production equipment, or injury or other harm to human operators.
- Using VR in training and training applications.
- Ensuring traceability of products, components and products throughout the entire production and, where appropriate, consumption chain (e.g. using blockchain) and handling of used products (e.g. for textiles)
- Advanced methods for system safety assurance, including risk assessment tools and ensuring continuity of production, processes and business.

R&D&I topics in application sectors

Strategic R&D&I topics in the application sector of **Mechanical engineering and mechatronics**

Strategic theme DS02VVI01 **Measurement, diagnostics, control, software and data processing for improved and new functions of engineering products**
Illustrative examples of partial R&D&I topics (not a comprehensive list): - R&D&I of sensors, measurement systems, measurement techniques, signal evaluation technologies, diagnostics, predictive diagnostics, load analysis, improvements to reliability and lifetime, data acquisition and analysis - New and innovated systems for in-process and post-process measurement of manufacturing results and using the data for further optimisation - Data infrastructures usable in mechanical engineering - Advanced control systems at all levels, development of software for manufacturing and products in mechanical engineering - R&D&I of the applications of machine learning and artificial intelligence techniques in mechanical engineering (agent systems, self-learning systems, human-machine interaction, neural networks, deep learning, genetic algorithms, software technologies, problem solving, decision making, planning, intelligent robots, virtual agents, distributed systems, etc.) - Harnessing the potential of cloud computing and data storage
Strategic topic DS02VVI02 **Automation, robotisation and digitalisation of manufacturing**
Illustrative examples of partial R&D&I topics (not a comprehensive list): - R&D&I focused on advanced robotics, automation for mass and job production, digitalisation of manufacturing for monitoring, control, optimisation, individualisation of manufacturing and broader connectivity - R&D&I focused on advanced robotics for new industrial areas – space, medicine, agriculture, construction, nuclear energy, chemistry, rescue work - R&D&I focused on miniaturisation of mechanical robots for applications in the micro and nano world - The use of data from interconnected systems and the increased capabilities of automated decision-making mechanisms in industrial practice
Strategic topic DS02VVI03 **Cyber-physical systems for mechanical engineering**
Illustrative examples of partial R&D&I topics (not a comprehensive list): - R&D&I of techniques for linking virtual cyber and real environments in manufacturing in mechanical engineering, and for more productive use of equipment in and products of mechanical engineering - R&D&I of the virtualisation of products and entire manufacturing systems both for the development phase and the product use phase (mathematical models of machines, tools and technologies including control and process, Process Machine Interactions, cyber-physical forms of product created from scratch, digital twins, optimisation techniques, model reduction methods, etc.)

Strategic R&D&I topics in application sector of the **Energy Sector**

Strategic topic DS02VVI04: **Modern information and communication technologies in the energy sector**
Illustrative examples of partial R&D&I topics (not a comprehensive list): - Advanced sensorics, preparation of tools for big data processing, advanced analytics for decision making and process control, applications of machine learning and artificial intelligence, development of the Internet of Things, digital twins, blockchain technologies, etc. in the energy sector

Strategic topic DS02VVI05 **Digitalisation and automation in energy generation, energy transmission and distribution, energy accumulation, for energy savings support, to achieve more efficient energy use in transport and for integral solutions in the energy sector**
Illustrative examples of partial R&D&I topics (not a comprehensive list): - Development of specific solutions in energy generation, energy transmission and distribution, energy storage, to support energy savings, to achieve more efficient energy use in transport and for comprehensive solutions in the energy sector

Strategic R&D&I topics in the application sector of **Industrial chemistry**

Strategic topic DS02VVI06 **Applying the Industry 4.0 Concept in the Chemical Industry**
Illustrative examples of partial R&D&I topics (not a comprehensive list): - R&D&I for implementing the Industry 4.0 concept in the chemical industry R&D focused on operational and computer security in connection with digitalisation and automation of manufacturing

R&D&I topics in the social sciences and humanities

Digitalisation and automation in manufacturing will have a significant impact on the labour market, because operating a digitalised workplace requires completely different skills from the person and affects their perceptions, behaviour and social ties. Communication with robots and automated systems has impacts on the psyche and actual interpersonal communication. Automated manufacturing requires a different way of managing and organising work and raises a number of legal and ethical issues. Digitalised and automated manufacturing must be resilient to cyber-attacks. The involvement of artificial intelligence in decision-making and management processes is associated with ethical issues. These aspects should be examined alongside the development of new technologies and their application in real-life practice. In this specialisation domain, the social sciences and humanities can be a useful complement to the purely technical research.

DS02SHUV01 **Research on the interrelationships between society, technology and innovation**
Illustrative examples of partial R&D&I topics (not a comprehensive list): - The impact of digitalisation and automation on the labour market, people and society (research on the ethical, psychological, economic and social aspects of digitalisation and automation and the impacts on education and the social system) - The impacts of digitalisation of manufacturing technologies on work organisation, management and productivity - The readiness of society for global trends
DS02SHUV02 **Addressing 21st century societal challenges associated with emerging technologies**
Illustrative examples of partial R&D&I topics (not a comprehensive list): - The effects of digitalisation on interpersonal communication, the human dimensions of new technologies - The effects of digitalisation on the functioning of the organisation and individual well-being
DS02SHUV03 **Conditions / barriers to the application of innovative technologies and practices**
Illustrative examples of partial R&D&I topics (not a comprehensive list): - Communication with robots and automated systems in the manufacturing environment, cooperation between humans and intelligent machines - A behavioural and psychophysiological analysis of the risks of digitalisation and automation

Recommendations for the implementation of NRIS3 instruments

The analysis and the EDP process resulted in the following recommendations for developing instruments to support R&D&I in this specialisation domain:

- In Mechanical engineering and mechatronics, it is recommended to take advantage of the existence of a significant number of domestic businesses (including SMEs) pursuing their own R&D activities, to stimulate further development of R&D, especially demanding R&D implemented in cooperation with ROs and aimed at disruptive innovations that use promising digital technologies and artificial intelligence
- To take advantage of the development of R&D in the public sector in the field of artificial intelligence and cybernetics and further strengthen R&D in ROs aimed at developing AI capabilities and its applications in manufacturing in mechanical engineering, the energy sector and other sectors
- To use existing research centres that were built using resources from the EU Funds and that focus on digital technologies and artificial intelligence as well as other ROs with experience in such R&D in order to implement more demanding R&D projects, especially in cooperation with domestic businesses that will use the R&D results
- Given that most of the patent applications that focus on artificial intelligence and cybernetics and that were co-created by Czech workers are filed by foreign companies and, in turn, knowledge is still largely draining abroad, it is recommended to strengthen the establishment of start-ups that are based on R&D results (especially from ROs) and to create conditions for their further development in the Czech Republic
- To take advantage of the well-developed international linkages of domestic research teams working mainly in the field of artificial intelligence and to stimulate their further involvement in international R&D, especially in major initiatives and instruments implemented at the EU level (e.g. with ties to the global challenges to European society in the area of security).

When preparing instruments to support R&D&I, it is necessary to take into an account the objectives and priorities of the National Artificial Intelligence Strategy in the Czech Republic and other relevant strategic and policy documents (especially Industry 4.0). This area also presents a significant opportunity to strengthen businesses' international competitiveness and to restructure this traditional sector of the economy in the context of the impact of the Covid-19 pandemic and the European Green Deal on the Czech economy.

Digital technologies and electrical engineering

Introduction

The Digital technologies and electrical engineering thematic area includes two application sectors – Electronics and Electrical Engineering and Digital Economy. These sectors have been developing dynamically and, in the future, they will play a significant role in ensuring the international competitiveness of businesses operating in many sectors of the Czech economy. Corporate costs on R&D is very high in both application sectors. Both application sectors are also among the most dynamically developing ones in the Czech Republic.

Since electronics and digital technologies cannot be strictly separated, there is one specialisation domain in this thematic area – Electronics and digital Technologies. In public research, there is a strong knowledge base in computer science, cybernetics, informatics and mathematics, as well as in physical sciences for this domain. There are also research centres operating in the Czech Republic that were built using resources from the EU Funds, that carry out R&D&I in the field of material sciences, electrical engineering and electronics, digital technologies, ICT and artificial intelligence and that have high-quality research infrastructure and professional capacities.

In businesses that operate in both application sectors and that are active in research, there is sufficient absorption capacity for R&D results generated in the public sector. In R&D projects, businesses often cooperate with ROs. In this area, there are therefore also suitable conditions for implementing projects that cover all phases of the innovation process from basic research to the implementation of R&D results into new technologies and products.

Drivers of transition in application sectors

In the future, the trends and developments in this thematic area and its application sectors will be influenced e.g. by the following drivers:

- Improvement in the performance, speed and reliability of electronic and optoelectronic components
- Expanding application of electronic and optoelectronic components and systems in all sectors of the economy
- The development of digital technologies, including artificial intelligence, and their wider application in manufacturing processes and technologies, management and other areas of the economy (Industry 4.0), public administration (eGovernment) and in products used in everyday life
- Automation of manufacturing processes and substitution of human labour (also in the context of the expected impacts on the Czech Republic)
- The development of information and communication technologies and their use in manufacturing processes, services and households (including the Internet of Things, IoT)
- Wider application of the principles of the sharing economy in society
- Growing threats in the area of cyber security
- The demands of natural science research on the design of sophisticated instruments where the key components include electronics, digital equipment or optical components
- An increase in the share of manufacturing of highly sophisticated high-tech electronic and optoelectronic devices and instrument subsystems with a high level of value added

1.3 Specialisation domain DS03 **Electronics and digital technologies**

The domain Electronics and digital technologies includes electronics and electrical engineering and digital economy, i.e. an area that uses digital technologies to generate products and services. A strong knowledge base and quality research infrastructure in artificial intelligence, computer science, cybernetics, IT, electrical and electronic engineering, digital humanities and physical sciences support the development of this area.

The areas that are covered by the domain are currently developing dynamically and, in the future, they will play a significant role in ensuring the international competitiveness of businesses operating in many sectors of the national economy. The application of electronic and optoelectronic components and systems is increasing in all sectors of the economy, and there is pressure to improve their performance, speed and reliability. Also, digital technologies are accelerating their development and application in companies, public administration and in products and services for the general public. Another influential trend is the wider spread of the sharing economy in society, and the increasing threats in the area of cyber security.

There is significant development potential within the specialisation domain, especially in R&D&I of new and progressive materials and manufacturing technologies and their application in electronics, optoelectronics and electrical engineering. The key driving force within the domain will be R&D focused on the promising and

intensively developing area of digital, information and communication technologies and their implementation into various sectors of economy.

The development of the digital economy has societal implications, and its impacts also carry significant risks. Therefore, the domain will also address the socially sustainable development of the digital economy and develop measures to eliminate the risks of its impacts. This is done by involving research in the social sciences and humanities (sociology, psychology, law, ethnology, political science, etc.). In this context, the digital humanities, such as the field of information extraction from textual sources and data, are becoming new areas of research.

R&D&I topics

Research topics in KETs and emerging technologies with potential for application in application sectors

DS03KET01 **Photonics and micro-/nano-electronics**
This KET covers the very broad field of photonics, microelectronics and nano-electronics, between which there is considerable overlap. Photonics is a multidisciplinary field covering light generation, light conduction, light manipulation, and light detection. 'Light' includes not only the visible part of the spectrum, but also the microwave and ultraviolet parts of the spectrum and X-rays. Photonics includes light sources such as light-emitting diodes (LEDs), lasers, conventional sources (light bulbs, discharge tubes, etc.), and many other optoelectronic elements such as light detectors (sensors) and optical modulators. In the field of light guiding, examples include light guides (waveguides), optical fibres, and optical cables. Some quantum technologies and electron optics (including electron microscopes) can also be included in photonics. Micro/nano-electronics deals with the development of highly miniaturised semiconductor devices, components and electronic sub-systems, and includes the design, fabrication, assembly and testing of these elements from the micrometre to nanometer levels. All areas of electronics with nanometre-scale structure, including components with dimensions where quantum effects are applied, are considered to be nano-electronics. This large group includes semiconductors and semiconductor devices, chips, microprocessors and their integration into larger assemblies, products and systems. It also includes measurement and instrumentation, testing of micro/nano-electronic components and sub-systems, etc.
Illustrative examples of partial R&D topics (not a comprehensive list): - Research and development of electronic and micro-nano mechanical components, systems and devices - Research and development of optical sources, and sensors of electrical and non-electrical quantities - Research and development of materials and components for communication (fibre optics, light guides, sources, receivers, etc.) - Research and development focused on methodology and technologies for the development of sophisticated instrument units and subsystems - Safe and radiation hardened nanoelectronics - Research and development of advanced optical systems and thin films - Research and development of quantum and HPC technologies
DS03KET02 **Advanced materials and nanotechnologies**
Advanced materials and nanotechnology is a broad field with boundaries that are difficult to define. Advanced materials are usually defined as new or significantly improved materials that have desirable properties or specific functions. Nanotechnologies are considered to be technologies for structures with dimensions between 1 and 100 nanometres in at least one dimension. This area includes research into a wide range of nanomaterials, nanolayers and nanostructures that are applied in various fields and industries such as electronics, optoelectronics and digital technologies. In addition to nanomaterials, this group also includes the design of these structures, systems for their characterisation (analytical equipment, nanometre-scale testing systems, etc.), and applications of nanometre-scale structures, elements and systems. These include research and development into new electronic and optoelectronic components, new areas of micro- and nanomechanics, and the development of new materials for additive manufacturing with applications in electronics and electrical engineering.
Illustrative examples of partial R&D topics (not a comprehensive list): - Research and development of technologies for the manufacture of advanced materials and nanomaterials that can be used in electronics, optoelectronics, electrical engineering, digital technologies and ICT and their

modification and processing (material deposition, etching, passivation, cutting, grinding, surface protection of materials, etc.)
- Research and development of advanced manufacturing technologies for the manufacture of electronic, optoelectronic and micro-nano mechanical components and devices
- Research and development of technologies and equipment (instrumentation, etc.) for measurement, diagnostics, control and metrological purposes in electronics, electrical engineering, micro-nano mechanics and ICT

DS03KET03 Advanced manufacturing technologies

Innovative and knowledge-intensive technologies that can be used in the manufacturing of new products and equipment or to significantly improve product and process parameters that drive innovation can be considered advanced manufacturing technologies. They include two types of technologies – process technologies, which are mainly used to produce some of the other advanced technologies (or KETs), and technologies that are based on digital, information and communication technologies.

Process technologies include innovative manufacturing technologies, equipment, systems and processes used to produce specific materials, components and systems. This involves the research and development of technologies, processes and procedures that will subsequently make the production of advanced materials more efficient, e.g. in electronics, optoelectronics and electrical engineering.

Technologies based on digital technologies and ICT include automated manufacturing, robotics, additive manufacturing (3D printing), integration of computers into manufacturing (including the use of high-performance computing), technologies using artificial intelligence, manufacturing technologies and processes using virtual/augmented reality, and others. Another group includes technologies used for production control, such as signal and information processing, production control, machine measurement, control and test equipment, process control, product and equipment testing, modelling and simulation, etc.

Illustrative examples of partial R&D topics (not a comprehensive list):
- Research and development of technologies for the manufacture of advanced materials and nanomaterials that can be used in electronics, optoelectronics, electrical engineering, digital technologies and ICT and their modification and processing (cutting, grinding, surface protection of materials, etc.)
- Research and development of advanced manufacturing technologies for the manufacture of electronic, optoelectronic and micro-nano mechanical components and devices
- Research and development of technologies and equipment (instrumentation, etc.) for measurement, diagnostics, control and metrological purposes in electronics, electrical engineering, micro-nano mechanics and ICT
- Research and development of technologies for wireless transmission in production.

DS03KET04 Biotechnology

KET Biotechnology includes industrial (“white”) biotechnology using enzymes and microorganisms for the production of bioproducts and chemical building blocks in sectors such as material production, mainly in areas where “conventional” processes cannot be used effectively.

An important group includes bioelectronics and systems used in analytical technology, such as biosensors and biochips, lab-on-a-chip, and organ-on-a-chip. The research deals with the use of electronics and optics (i.e. optical methods) in biotechnologies (especially optical and electron microscopy, devices for analysis and diagnostics, monitoring, etc.).

Illustrative examples of partial R&D topics (not a comprehensive list):
- Research and development of biomaterials and their use in electronics and electrical engineering (biosensors, etc.)
- Research and development of technologies, systems and equipment that can be used in biotechnologies and the natural sciences

DS03KET05 Artificial intelligence

Artificial intelligence is a branch of computer science dealing with the creation of machines and systems with cognitive functions similar to those of humans, solving complex tasks such as logistics, natural language processing, decision making, processing large volumes of data, speech and speaker recognition, person identification, etc. This KET deals with software development which includes artificial intelligence methods and tools enabling cognitive and decision-making functions, algorithms and software, machine learning, neural networks, deep learning, genetic algorithms, high-performance computing, etc. In addition, it also addresses the development of a system for problem solving, decision making and planning, big data analytics, improving

intelligent robots, virtual agents and other distributed systems. It involves human-machine interaction, the development of devices and processes using virtual and augmented reality, and the use of mathematical and statistical methods and numerics, which are the basic system of AI operation. Key to this issue is the sharing of big data, which allows AI systems to be developed and trained, and on which these systems can be built.

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- Research and development of artificial intelligence and AI-enabled technologies and devices
- Applications of artificial intelligence in technologies, devices, manufacturing processes, etc.
- Powerful and large-scale data storage for processing and storing datasets

DS03KET06 Digital security and connectivity

Digital security and connectivity include the security of IT systems and IT-enabled devices, information on stored computers and repositories, including the detection and mitigation of risks associated with their use. This group includes, for example, authentication of users of these systems, ensuring data security and storage, preventing data loss, cloud security (cloud storage, cloud computing), security of cyber-physical systems, secure human-machine interfaces, human-computer and robot interaction, technologies for the Internet of Things (IoT), etc.

The field of connectivity includes the network infrastructure and the technologies and services that enable end-users to connect to that network, including the security of that infrastructure and communications. It includes secure connectivity and authentication, identity theft prevention, data protection and privacy, cryptography, ensuring the security of communications and communication systems (protection against viruses, malware, etc.), network security (fixed networks and mobile networks, including 5G). Furthermore, it focuses on technologies related to Internet services such as e-Government, e-Administration, e-commerce, blockchain, etc.

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- Connectivity, communication, communication control, communication security, etc.
- Defence against cyber threats, identity protection, protection of critical infrastructure, industry, citizens/consumers, etc.
- The impacts of the development of AI on cyber security and the security of AI-enabled technologies

Strategic R&D&I topics in application sectors

Digital technologies

Strategic topic DS03VVI01 Advanced computing systems

This theme deals with methods of information processing and the means that can be used for this purpose The area of interest ranges from the study of the properties of information, algorithms, languages and computational and information processes to the practical issues of implementing computing systems in terms of both software and hardware. Without intensive research support and development, the application potential of artificial intelligence, computer graphics, computer security, theoretical computer science, and database systems and software engineering cannot be further developed. This is a relatively new area where many Czech businesses are at the world level and this area offers completely new applications in traditional Czech industry. However, what is important is the level of knowledge and work, and because of that, it is necessary to assign a high priority to the development of this field, as it will significantly help to shift the production of the entire economy. Otherwise, the competitiveness of production and output in the Czech Republic could be reduced, as both EU countries and other international market players are aware of the importance of data and are investing funds in research, support and education in this field. All themes include the required software development.

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- Information theory, coding theory, algorithms, programming languages
- Cognitive computing – Audio and video recognition and transmission, Natural language processing

Strategic topic DS03VVI02 Application of HPC

The use of high-performance computing (HPC) is a pre-requisite for the digital transformation of our society. It is a driving force for a data-driven economy, with the potential to enable key methods and technologies such as artificial intelligence, data analytics, numerical simulations or cyber security to seize the potential of big data processing or the realisation of challenging complex computational simulations (such as the digital twin technology). HPC provides many sectors with the opportunity to innovate and move to more valuable products,

processes and services, which is also a preparation for the development of new industrial applications together with other advanced digital technologies. HPC applications and infrastructure are essential in almost all areas of research, from basic physics to biomedicine, as they enable deeper scientific understanding and breakthroughs. It is also an essential tool for designing solutions to major societal challenges, from climate change to smart and green development and sustainable agriculture to personalised medicine and crisis management. HPC makes it increasingly possible to replace the experiment phase, significantly shorten the development process and reduce costs and negative environmental impacts.

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- HPC infrastructure and access to its services
- HPC technologies: hardware architectures and their components (including new processors, quantum computers and software tools)
- HPC applications (support for research challenges, support for innovation in industry)

Strategic topic DS03VVI03 **Use of artificial intelligence (AI)**

Artificial intelligence can be considered the next level of automation. Its application in industry is broad and thanks to its use, we can achieve more efficient production processes, reduce costs and increase competitiveness. Machine learning methods can be used to process image, audio or multimedia data in areas where the level of their use in the Czech Republic is still low: healthcare, material engineering, agriculture and other. The application of AI in institutions and projects for which machine learning methods have not yet been available for capacity or financial reasons. There are also opportunities to exploit synergies with other advanced technologies such as 3D printing, where the use of AI methods will lead to a bigger efficiency and competitiveness.

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- AI-enabled technologies (image analysis, machine learning, big data, data mining, etc.)
- Applications of artificial intelligence in technologies, devices, manufacturing processes, etc.
- Predictive diagnostics, SW models based on real data, incl. AI (automotive, engineering, aerospace, instrumentation)
- Artificial intelligence / machine learning / SW engineering (HW design and AI, aviation, gas & flame detection, warehouse automation, worker safety, healthcare, predictive diagnostics in automotive, management of highly complex systems with thousands of nodes, image and data mining, video, data mining from electric vehicles)
- Cognitive Cloud: AI-enabled computing continuum from Cloud to Edge

Strategic topic DS03VVI04 **Applications of quantum computing and technology**

Quantum computing speeds up classical algorithms and brings completely new ways to model solutions. The development of this technology is still at its early stage and it is very important to develop it. The most famous example is the use of cryptography, where a properly designed quantum computer can break most ciphers. It can also be used in machine learning due to the ability of a quantum computer to process a large number of numerical operations. This is an area with great potential for the Czech Republic.

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- Quantum protocols and algorithms for secure and efficient communication
- Quantum algorithms for data processing
- Quantum simulations
- Non-informatics quantum technologies – quantum sensing and quantum metrology
- Quantum technologies for computing and communication – HW
- SW for quantum technologies

Strategic topic DS03VVI05 **Cybersecurity**

With the introduction of the Internet of Things, digital technologies are expanding into many areas, connecting billions of devices to the Internet that may have previously operated offline. We must be prepared for this change. The development of new technologies and constant system updates are essential, as it is important that the network infrastructure security testing toolkit takes into an account current technologies and current threats. It is important to strengthen network connectivity, to increase the resilience of the critical information infrastructure environment of the connected nodes against Distributed Denial of Service attacks. The growing number and intensity of such attacks represents a significant threat to the Czech cyberspace. It is necessary to

develop technologies that will protect against DDoS attacks and provide high-speed cleaning and filtering of unwanted network traffic. The Czech Republic has a lot to build on, from traditional electrical engineering to quantum technologies to cybersecurity with artificial intelligence. All themes include the required software development.

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- Cyber security and cryptography
- Digital technologies in security research
- Defence against cyber threats, identity protection, protection of critical infrastructure, industry, citizens/consumers, etc.
- Cyber security and the use of these technologies
- Cyber security, zero trust security (administration of highly complex systems with thousands of nodes combined with the need for their autonomy (using AI/ML), vertical and horizontal system security (across disciplines and applications)

Strategic topic DS03VVI06 **Data-driven economy**

Data are the basic information unit and their processing generates information and knowledge. Effective governance, data exploitation and the use of decentralised technologies will lead to the further digitalisation of services and promote a more open and free internet. Thanks to the development and popularisation of the benefits of collective storage, data management and interaction, traditional industrial, commercial and public institutions became interested and started to adapt this idea to their own needs. An example is the BDLT protocol, which creates a digital book of unmistakable records of all activities performed in a given system. Such a database is much more resilient to attacks and does not require an administrator to oversee the creation, storage and transfer of information and digital values. They are secured by cryptographic algorithms that do not allow records to be altered or reused multiple times.

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- Interconnection of public and private data centres, interconnection with edge computing and IT security (IT and across the industries that use them)
- IoT (Internet of Things) – only sensors and SW
- Long-range, low-energy wireless communications across the spectrum from NFC to Lora, Sigfox, including security; MESH and hybrid systems (across industries)
- Big data + data mining, storage and compression
- Data analytics, data storage and data management, including sharing and using data from public registries in a publishable format (e.g. data from health registries that, if shared, would make it possible to share good practice in treatment), using blockchain to anonymise such data (IT and across the industries that use them)
- Cloud computing
- Digital twins, static and dynamic-simulation
- DLT (e.g. blockchain)
- eXtended Reality (VR, AR, MR)
- The use of IT digitalisation and automation of corporate and industrial processes

Electronics and electrical engineering

Strategic topic DS03VVI07 **Electronic devices and instrument subsystems with a high level of value added**

Electronics and related technologies have not played a dominant role in the Czech industry, but they have survived global competition and are currently becoming scarce on global markets (such as the car chips). Therefore, their development may be crucial for the sustainability of the Czech industry. Combined with traditional skills in engineering, completely new application areas are opening up. These include new electronic and optoelectronic components, new areas of micro- and nanomechanics, and the development of new materials for additive manufacturing with applications in electronics and electrical engineering. These new technologies may be decisive for the competitiveness of Czech industry's products on world markets.

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- New materials and technologies for electronics and their applications, including nanomaterials and nanotechnologies
- New electronic and optoelectronic components and elements, including the use of nanotechnologies
- Technologies for the manufacture of optical elements and their applications

- Technologies for testing optical materials and components for resistance to laser radiation under extreme and precisely controlled conditions
- Laser sources and optic systems for high-tech industry and space applications
- Luminaires, lighting equipment, warning lighting devices, light sources (especially LED)
- New detection, imaging and diagnostic methods and techniques for the development of new advanced instruments and instrument subsystems
- Functional electronics for green and circular economy
- Cyber-physical systems (except mechanical engineering, metallurgy, the energy sector, industrial chemistry)
- Nanomaterial-assisted sources of quantum states of light for quantum communication and quantum detection, the development of ultrasensitive sensors on this basis – applications in metrology for intelligent devices and location

Strategic topic DS03VVI08 **Electronics and digital technologies for Industry 4.0**

The electric and electronic sectors are one of the most stable pillars of the Czech economy thanks to its wide portfolio of end customers and other manufacturers for which it serves as a subcontractor. It includes for example improving the efficiency of industrial processes, introducing predictive maintenance, making data available to the digital twin, using autonomous control and reducing the risk of failure. It is a field with ever new principles and applications. Therefore, its development is promising. Since the Czech economy is based on industrial production, the development of robotics is of enormous importance to the Czech Republic. This will solve the shortage of human resources, increase efficiency, process stability while also reducing defective production.

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- Sensors and actuators, fibre optic technologies and sensors, methods of processing sensor data, etc.
- Diagnostics for industrial processes, including the use of artificial intelligence
- Automation and robotics
- Smart Systems integration tools
- Applications of laser technologies
- MEMS (microelectromechanical systems) – HW, instrumentation, analytical devices
- Electric drives including their control
- Advanced sensors and detectors, including connectivity to local infrastructure and cloud and security (urban air mobility, space, cockpit systems, warehouse automation, worker safety, imaging and detection devices, personalised medicine)
- Edge computing, especially battery and thermal management of devices, optimisation of computing power, limited autonomy = end devices without cloud connectivity, AI & edge computing, scalability (communication networks, urban air mobility, cockpit systems, warehouse automation, autonomous driving, worker safety, healthcare)
- Field programmable gate arrays, FPGA (HW design)
- Industry 4.0. automation, rotary actuators, end-to-end solutions including SW, simulation modelling (precision instruments, aerospace, automotive)
- Digital business services with an emphasis on automation and digitalisation
- Innovative semiconductors, special semiconductor components, e.g. for use in optical, detection and analytical equipment
- Communication technologies and their applications (fibre optics, wireless communication, superfast internet, 5G and 6G internet, etc.)
- (Ultra)-low-power, secure processors for edge computing
- Advanced Photonic Integrated Circuits

R&D&I topics in the social sciences and humanities

Digitalisation permeates all areas of human activity and its impacts on people and society are significant. Research and innovations in this area should never neglect the human, social and security dimensions and should always thoroughly assess the risks associated with the introduction of digital technologies into different areas of people's lives. Digitalisation affects psychological and cognitive processes, triggers changes in people's behaviour and alters established social relationships. The introduction of artificial intelligence raises ethical issues and is likely to require legal regulation. Research in the field of the digital humanities covering a combination of digital technologies and the humanities may reveal new dimensions of the use of digital resources in the humanities and the analysis of

their application. Digital content and information sources disseminated through new communication channels pose security threats to individuals, companies, communities, municipalities, public institutions and others.

DS03SHUV01 Research on the interrelationships between society, technology and innovation

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- The impact of digital technologies on people and society and the labour market (including research on the ethical, psychological, economic and social aspects of digitalisation and automation and the impacts on education and the social system)
- Information and data literacy in the context of new technologies
- Reducing the risk of digital exclusion

DS03SHUV02 Addressing 21st century societal challenges associated with emerging technologies

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- Human-machine communication system
- Artificial Intelligence (legal, ethical and other implications of AI development)
- Dehumanisation of the decision-making process
- Common perception / sharing of reality in society as a whole

DS03SHUV03 Conditions / barriers to the application of innovative technologies and practices

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- Digital humanities, research and development of the integration of digital technologies with the social sciences and humanities with applications in industry, knowledge economy, services and society
- The societal impacts of the sharing economy and other changes in patterns within the economy
- Ethics, law and societal aspects of digital technologies
- Trust and data sovereignty on the internet
- Socio-economic research into communication, media, perception of misinformation, subjective interpretation of this information and ways of obtaining information.
- Transformation of education systems and individual education institutions (including the system of science management organisation and digital education system)

DS03SHUV04 Security research

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- The use of digital technologies to address the priorities of security research
- Text and data mining in a security context, language, speaker and social network identification
- Analysis of fake news in text and speech, extraction of information from sources of security interest, protection of companies' strategic information and personal data and misuse of illegally obtained information
- Perception and detection of disinformation and hoaxes using advanced digital technologies including artificial intelligence, methods for early warning and remedial action in the event of a disinformation campaign
- Analysis of social networks and new forms of communication in relation to the threat of terrorism and political extremism, including the perception of this information by society
- The potential of digital technologies for addressing the security threats of migration crises
- Researching and protecting against the misuse of digital technologies
-

Recommendations for the implementation of NRIS3 instruments

The analysis and the EDP resulted in the following recommendations for developing instruments to support R&D&I:

- In relevant instruments to support R&D&I, it should be required that all phases of R&D be covered from the development of materials, technological procedures and processes (for more demanding R&D in cooperation between businesses and ROs, especially HEIs) to their implementation into new technologies and products

- Research centres and research infrastructure built with EU funds should be involved in R&D&I projects, especially in projects covering the entire innovation cycle with a potential for disruptive innovations
- Given that electronic and optoelectronic components and systems and digital technologies (including artificial intelligence) are increasingly applied in many sectors of the economy, there is a need to coordinate instruments supporting R&D&I with those that are implemented in other thematic areas
- Since ROs that are active in photonics and micro/nano-electronics are involved in international R&D, it is also appropriate to support activities at the transnational level (e.g. with ties to societal challenges and threats in the field of cyber security).
- Given that in Artificial intelligence and Digital security and connectivity, there is intensive use of R&D knowledge that was co-produced by Czech workers in foreign or foreign-controlled businesses (knowledge "drain"), it is necessary to stimulate the establishment of new companies that are based on R&D knowledge (especially from public research) and their initial development in the Czech Republic (also in the context of the high share of foreign-controlled businesses operating in both application sectors of this thematic area)
- When preparing instruments to support R&D at the regional level, the regional sectoral structure of business R&D should be respected
- An emphasis should be placed on research and development focused on hi-tech final, end products, especially technologically advanced devices, which should be preferred over R&D of components or sub-components

In addition, it is necessary to take into an account current challenges and trends related to this domain, such as robotisation, digitalisation and the use of digital technologies (including artificial intelligence) in manufacturing industries and in the life of society, the growing cyber threats, etc.

Transport for the 21st century

Introduction

The thematic area of **Transport for the 21st century** comprises three application sectors, namely Automotive, Aerospace industry and Rail transport, and it is divided into two specialisation domains: **Environmentally friendly transport** and **Technologically advanced and safe transport**.

The **Automotive** sector (often referred to as the automotive industry) can be defined as an industry within the secondary sector engaged in the development, manufacture, marketing, sale, maintenance and disposal of on- and off-road motor vehicles and their accessories. For the purposes of the RIS3 strategy, this sector includes on-road and off-road passenger and freight vehicles, buses, electric buses and trolleybuses, trailers and motorcycles. R&D of companies operating in the automotive industry mainly focus on the use of energy in transport by improving the operational efficiency of powertrains by means of their innovative configuration and optimisation, reduction of driving resistance by decreasing the weight and aerodynamic drag of vehicles, advanced materials and their use (such as light metals, composites, thin films, additive and other energy- and waste-saving technologies in the production, maintenance and recycling of vehicles, advanced robotics of manufacturing to ensure consistent quality), measurement and control technologies (sensors, metrology, testing, calibration, standards, control algorithms and their implementation in hardware), especially with regard to vehicle integration into the transport system, emissions and air pollution, vehicle safety, light sources, batteries and other vehicle components and their interaction with the transport infrastructure and after-sales services (servicing, inspection and recycling activities) in both the material and information domains.

In the **Aerospace industry**, research activities are mainly focused on R&D&I of aircraft components such as aircraft engines (turbines), leading edges, compressors, wheels, brakes, etc., as well as aircraft structure (design) and construction. Another important area of R&D is the technologies and materials used in aircraft manufacturing (e.g. precision casting, composite materials, surfaces and their processing, etc.). The R&D is also focused on air traffic management and the integration of new airspace users (e.g. unmanned systems and related services – the "U-Space"), alternative propulsion systems, fuels (or energy) and consumption, safety, etc. In the space industry, research in the Czech Republic is focused on mechanical and electromechanical systems, the design and manufacture of flight HW and SW, inertial sensors, electrical power supply and control systems, ground SW, simulations and testing, avionics and on-board computers, laser technologies, optical elements and structures for satellite payload, multi-constellation GNSS receivers, satellite telecommunication terminals, structural parts for launch vehicles and propulsion systems, applications of special materials, surface treatments, etc. The Czech Republic's space activities include the construction of small satellites and the ground infrastructure necessary for their operation, data centres, computing and dissemination platforms using cloud computing and artificial intelligence, and many diverse applications of remote sensing, satellite navigation and telecommunications.

Research activities in the **Rail transport** application sector are focused on R&D of locomotives and rail vehicles (including trams) and their components (seats, motors, axles, chassis, doors, etc.). The R&D also addresses technologies and materials for the manufacture of these vehicles (welding, composites), numerical and computational methods, safety (crash tests), climatic conditions, fuels and their consumption, etc.

The **knowledge base** for transport R&D is mainly available at technically oriented HEIs, certain institutes of the CAS and certain application-oriented research institutes in the government sector as well as research-oriented entities in the business sector. Knowledge-based R&D focuses on the area of materials science, photonics and micro/nano-electronics, digital technologies, artificial intelligence and digital security.

Drivers of transition in application sectors

In the future, the trends and developments in this thematic area and its application sectors will be influenced e.g. by the following drivers:

- Emphasis on transport as an integrating element of society that has a significant socio-economic effect and reflects the principles of sustainable development (including the inclusion of non-motorised transport)
- Emphasis on improving the safety, efficiency and fluidity of traffic (including control processes) and increasing transport accessibility
- Pressure to reduce the negative environmental impacts of transport
- Increased use of progressive materials and technologies (including digital technologies and artificial intelligence) in transport equipment and its manufacture, transport infrastructure and in transport as a whole

- Increased demand for space systems' data and services and for space transport, in this context there is pressure to prepare cost-effective, flexible, yet highly reliable solutions for satellite systems and launch vehicles. Pressure for increased commercialisation in the area of space activities
- The development of new and alternative drives and propulsion units, the development of electromobility, the use of alternative fuels (e.g. hydrogen), etc.
- The expanding use of automated and autonomous vehicles and unmanned systems, intelligent transport systems, cooperative intelligent transport systems and new modes of transport including a broader concept of mobility as a service

1.4 Specialisation domain DS04 **Environmentally friendly transport**

Based on the initial analyses carried out, it can be concluded that within the domain of **Environmentally friendly transport** there is a potential for the use of the results of R&D focused on Advanced materials and nanotechnologies, Advanced manufacturing technologies and Life sciences technologies/biotechnologies, which can contribute to improving the use and properties of vehicles, improving their parameters and reducing the manufacturing complexity, as well as to reducing the negative environmental impact of transport.

R&D&I topics

Research topics in KETs and emerging technologies with potential for application in application sectors

DS04KET02 **Advanced materials and nanotechnologies**
The **Advanced Materials** group for the Environmentally friendly transport domain includes in particular materials for extreme conditions, lightweight materials, protective coatings and resistant materials (against various influences and conditions). These include innovative materials that reduce the energy and material intensity of production, materials that enable recycling, materials that reduce the carbon footprint, etc. It is necessary to focus on research and development of materials with new properties, which for aerospace structures should have a superior ratio of properties to specific weight. Materials that can resist corrosion (airframes), high temperatures (engine components), non-flammable materials (interior), materials with sliding properties (motion parts), materials with anti-icing properties, materials that reduce aerodynamic surface friction, materials capable of absorbing high energy (landing gear), materials with programmable and intelligent properties, etc. are needed. In the automotive and rail transport sectors, there is also a general need to develop new materials with higher durability, safety and, consequently, more environmentally friendly properties, and to adapt the design, production technology, service and recycling of vehicles to them. These include new materials with higher strength, energy absorption and corrosion resistance (bodywork, chassis). The application of these new materials will find use in vehicle construction and interiors. These materials should provide a technological advance in reducing emissions and the propagation of noise and vibration in road and rail traffic. Developments in the field of materials with new properties can be suitably applied, for example, to materials for railway wheels and axles with increased durability and operational safety for urban and suburban rail transport. One of the directions of research and development in the field of **nanotechnology** for environmentally friendly transport is, among other things, the use of materials with nanofibres and nanofillers. In addition to the nanomaterials themselves, this includes the design of nanostructures, systems for their characterisation (e.g. analytical devices, nanometre-scale testing systems, catalysts, or nanocatalysts, which are applied in emission reduction, fuel cells and batteries, and synthetic fuel production), and applications of nanometre-scale structures, elements and systems.
Illustrative examples of partial R&D&I topics (not a comprehensive list): - R&D of new and advanced materials (including nanotechnology-based materials) and their use in transport equipment, transport, transport infrastructure and space systems (e.g. metallic materials and their alloys, ceramic materials, polymeric and other organic materials, composites, fibre and textile materials, nanomaterials and intelligent materials, etc.)

DS04KET03 Advanced manufacturing technologies

Advanced process technologies in the field of green transport include in particular technologies for clean industry, such as technologies that reduce production waste, emissions and pollution, innovative technologies that reduce the consumption of materials and energy (especially non-renewable energy), technologies and processes aimed at making production more efficient, etc.

Advanced manufacturing technologies for green transportation include, among others, new technologies and optimisation tools for progressive assessment of aerospace structures in the areas of fatigue and durability, limit states, fatigue failure and refinement of residual life prediction. In the field of advanced manufacturing technology, it is necessary to investigate the possibilities of efficient and safe use, e.g. various modifications of new composite technologies, joining of structural parts and production of integral structures.

Advanced **manufacturing technologies based on digital technologies and ICT** for green transport include semi-automated design of vehicles and power units for new operational requirements and energy carriers, parts made of new materials, automated manufacturing, robotics, integration of computers into manufacturing (including the use of high-performance computing), technologies using artificial intelligence, manufacturing technologies and processes using virtual/augmented reality and others.

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- R&D of advanced manufacturing technologies for the manufacture of transport equipment, transport and space systems (e.g. precision casting, advanced surface treatments, grinding, the use of foils, laser technologies, vacuum technologies, surface hardening and surface treatments, etc.); including their recycling
- Additive manufacturing, 3D printing
- The R&D of vehicle design processes with new power units for new energy carriers such as batteries, the use of hydrogen technology and synthetic fuels

DS04KET04 Biotechnology

KET Biotechnology in the field of green transport mainly includes **industrial ("white") biotechnology** using enzymes and micro-organisms for the production of bioproducts and chemical building blocks. These include biotechnologies for the industrial processing and production of fuels (biofuels) and research and development of biotechnologies to help address the negative environmental impacts of transport.

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- R&D of biotechnologies that contribute to reducing the negative environmental impacts of transport and environmental burdens (technologies for removing pollutants and cleaning polluted water and air, etc.)
- R&D of biofuels and their use in newly developed power units
- R&D of biomaterials for use in transport equipment and transport

Within the entrepreneurial discovery process (EDP), members of the National Innovation Platform for Transport for the 21st Century (representatives of industry and academia, research organisations and the ministries concerned) and expert teams from the MIT identified the following strategic research topics and social science research topics for the domain of Environmentally friendly transport:

R&D&I topics in application sectors

Strategic topic DS04VVI01 Low-emission mobility

The topic of low-emission mobility encompasses all of the above R&D&I topics and reflects the main strategic areas that are identified in documents such as the Transport Policy of the Czech Republic for 2021–2027 with a view to 2050 or the National Action Plan for Clean Mobility and that are also contained in the EU's transport strategies emphasising low-emission mobility and its development and support for related research, development and innovations. The area of transport is part of a wider effort to transform economies and societies to achieve climate-friendly solutions with reduced air pollution in many areas. In order to find the

optimal combination of solutions, a technology-neutral approach must be taken, i.e. the goal is not to prescribe technical solutions, but their desirable parameters, from a product life-cycle perspective.
Illustrative examples of partial R&D&I topics (not a comprehensive list): - Drive trains for vehicles (new concepts, technologies and materials, alternative drives using new energy carriers and high efficiency, weight reduction, research on simulation and virtual reality techniques for parametric product optimization) - Reducing the negative impacts of transport - Vehicle design (new concepts, integrated and hierarchical vehicle control systems, energy storage, weight reduction, passive safety using new materials and production technologies, materials processing and their use in vehicles and transport (nanotechnologies and multifunctional materials, advanced materials – composites, thin films), recycled materials, reduction of the energy intensity of vehicles and manufacturing technologies, research on simulation and virtual reality techniques for the parametric optimisation of products) - Transport infrastructure (modern traffic control, systems for the optimal use of data on the energy-related possibilities for charging electric and hybrid vehicles, reduction of the energy intensity of transport infrastructure, the use of new materials and recycled materials with lower energy intensity in their life cycle, reduction of emissions and pollution) - Measurement technologies (sensors, metrology, testing, calibration, standards) - Light sources, batteries and other components for vehicles and roads - Energy for transport and related infrastructure, including alternative fuels (hydrogen infrastructure, electromobility, fuel distribution, operating models) and their use in the different modes of transport - Batteries and battery energy management (automotive – charging of EVs from own PV (design of charging equipment, reversibility: charging of a vehicle from the grid vs. supply to the grid from the car battery), aerospace, mobility) - High speed (rpm) electric machines, electric drives (120k/min), including SW - Fuel cells of different concepts - Design, construction and structure of aircraft, satellites and launch vehicles – aerodynamics, thermomechanics and flight mechanics - Aircraft components – aircraft engines (including turbines), leading edges, compressors, wheels, brakes - Propulsion systems – aircraft engines (including turbines), propulsion systems for launch vehicles and satellites - Alternative aircraft propulsion systems and control elements – hybrid and fully electric aircraft propulsion units, optimisation of the on-board network, actuators for moving parts of aircraft (flaps, rudders – still mostly hydraulic), on-board energy storage, possibilities of electrical taxiing on the ground (using wheel drives rather than turbines) - Technologies and materials for aircraft manufacturing and for the needs of satellite systems and launch vehicles (composite materials, precision casting, surfaces and their treatment, nanotechnologies, electrification and decarbonisation of aircraft and drones) - Low-emission aircraft propulsion, including Power Train technologies, controllers and other technologies for air and ground movement - Thermal management (cockpit systems, automotive) - Fuel, synthetic fuels to decarbonise transport - Locomotives and rail vehicles (including trams) and their components (seats, engines, axles, chassis, doors) - Technologies and materials for the manufacture of rail vehicles (technologies reducing noise, emissions and energy consumption, advanced materials, composites, welding) - Increasing the environmental friendliness of rail transport – fuels and their consumption, integration of renewable sources, optimisation of charging and energy consumption, use of batteries and hydrogen - The development of methods in testing, technical tests, certifications and standardisation - Climatic conditions – R&D of materials and components resistant to extreme climatic conditions

R&D&I topics in the social sciences and humanities

In this domain, there is considerable potential for the application of research in the SSH area, especially in the area of human behaviour in connection with the provision of mobility and transport mode choice. In addition to technological solutions oriented towards more environmentally friendly (sustainable) transport, e.g. the development of CO_2-neutral technologies, the mode of transport that ensures the mobility of the population is also crucial. In other words, the best results in providing environmentally friendly (sustainable) transport, with the potential to have a positive impact on climate change, will be achieved if modern environmentally friendly

technologies are available and if the population uses sustainable modes of transport responsibly. Application of the sharing economy also offers ample opportunities – in addition to its economic consequences, it has (or can have) a positive impact on the environment, yet it also raises a number of questions relating to interpersonal relationships and impacts on the community. In addition, the issue of the effects of environmentally friendly (sustainable) transport on the transformation of human settlements and the sustainability of transport services also warrants examination. Security aspects are another separate issue, e.g. electromobility raises new questions regarding the protection of persons and property and the behaviour of citizens.

DS04SHUV02 Addressing 21st century societal challenges associated with emerging technologies

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- Transport mode choice towards sustainable mobility and transport
- Transport mode choice in the context of organisational outcomes
- Promoting the use of public transport to ensure mobility
- Strengthening acceptance and purchasing behaviour in terms of higher penetration of electric vehicles in the Czech environment
- The sharing economy in transport and environmental impacts
- Socio-economic aspects of the development of environmentally friendly (sustainable) transport, including the transformation of settlements:
    - charging of electric vehicles from own PVPP
    - transport fuels (electricity, CNG, hydrogen, etc.) will increasingly be used in local electricity generation

DS04SHUV03 Conditions/barriers to the application of innovative technologies and practices[5]

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- Legal aspects of the use of spent batteries from electric vehicles in the energy sector (most car companies currently follow the rule that batteries from electric vehicles cannot be used in stationary mode; electric vehicles have high-capacity batteries, but their warranty is void if they are used stationary; disposal costs)
- Legal aspects of safety and readiness of environmentally friendly means of transportation (e.g. electric vehicles) in the MoD, MoI and MoFA in terms of ensuring reliable mobility in emergency situations

DS04SHUV04 Security research

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- Safety research on electromobility from the perspective of the Fire Rescue Service of the Czech Republic (fire prevention and protection, repressive grounds for procedures in emergency situations with the presence of an electric, hydrogen or hybrid vehicle)
- Safety and readiness of environmentally friendly means of transportation (e.g. electric vehicles) in the MoD, MoI and MoFA in terms of ensuring reliable mobility in emergency situations
- Second Life for car batteries (secondary use in stationary local PV plants; vehicle with unknown history; ignition protection)

Recommendations for the implementation of NRIS3 instruments

The analysis and the EDP resulted in the following recommendations for developing instruments to support R&D&I:

- Given that R&D results from multiple KETs are applied within the application sector, support should also be provided to projects of a multidisciplinary nature, especially those involving public-sector ROs
- Stimulate the involvement of domestic businesses that do not yet carry out R&D to start their own R&D activities or to carry out R&D in cooperation with public-sector ROs
- Given that R&D expenditure of domestic businesses operating in the application sectors of this thematic area are low compared to foreign-controlled companies, it is recommended to stimulate the establishment of new companies that are based on knowledge obtained from public R&D and to create the conditions for their initial development

[5] Necessary modification of the codebook in MS2021 (4Q/2022-1Q/2023).

- Stimulate the involvement of research centres that were built using resources from the EU Funds and that operate in the field of advanced materials, manufacturing technologies and biotechnologies in R&D&I projects implemented in cooperation with domestic businesses, especially in projects of a multidisciplinary nature with the potential for disruptive innovations
- Stimulate the use of data and services of satellite systems to reduce the environmental burden resulting from transport

In addition, it is necessary to take into an account current challenges and trends related to this domain (climate change and the Green Deal).

1.5 Specialisation domain DS05 **Technologically advanced and safe transport**

The domain of **Technologically advanced and safe transport** is focused on the automotive industry, or possibly the aerospace and unmanned aerial vehicles industry, and research, development and innovation in the field of the manufacture of rail vehicles. The aim is to improve the reliability and safety of road, air and rail transport and traffic. The domain focuses on the use of modern technologies, especially advanced electronic and optoelectronic components and systems, digital technologies, ICT and AI-enabled technologies in transport equipment, in monitoring, controlling and ensuring transport/traffic safety and other areas related to transport. In addition to autonomous driving systems and sensors, safe transport is also about integrated safety.

Mobility as a service – transport is facing fundamental changes resulting from the changing behaviours of the population, which also leads to different needs in terms of the provision of transport services (transport of people and goods) – people will more often work from home, they will not want to own a car, they will make greater use of home delivery of food and shopping, which will eventually necessitate changes so that city centres are not overwhelmed by couriers (it can be expected that cities will have to start regulating entrance, which means additional potential for research in the field of traffic management).

In space activities, it mainly includes the use of artificial intelligence (and the results of R&D in this area) in the autonomous control of individual satellites (or robotic probes) and satellite systems; the processing of satellite navigation signals, signal correction in satellite telecommunications and the automated processing of satellite images from Earth observation. Artificial intelligence is also widely applied in scientific data processing. Digital security is key to the reliability of operation of and the provision of data and services by satellite systems.

R&D&I topics

Research topics in KETs and emerging technologies with potential for application in application sectors

DS05KET01 **Photonics and micro-/nano-electronics**
Photonics is of particular relevance to the field of technologically advanced and safe transport, with a focus on light sources, such as light-emitting diodes (LEDs), lasers, conventional sources (light bulbs, discharge tubes, etc.), and many other optoelectronic elements such as light detectors (sensors) and optical modulators. In the field of light guiding, examples include light guides (waveguides), optical fibres, and optical cables. **Micro-/nano-electronics** is mainly concerned with highly miniaturized semiconductor devices, components and electronic subsystems. Nano-electronics cover a wide range of semiconductors and semiconductor devices, chips, microprocessors and their integration into larger assemblies, products and systems. It also includes measurement and instrumentation, testing of micro/nano-electronic components and sub-systems, etc.
Illustrative examples of partial R&D topics (not a comprehensive list): - Electronic components, systems and equipment for use in transport equipment, transport, satellite systems and launch vehicles - Optical sources, imaging systems and sensors for use in transport equipment, transport and satellite systems - Elements and systems for communication (light guides, fibre optics, etc.) to be used in transport equipment, transport and satellite systems

DS05KET02 Advanced materials and nanotechnologies

Advanced materials for technologically advanced and safe transport include e.g. materials for extreme conditions, lightweight materials, protective coatings and resistant materials (against various influences and conditions), smart materials, etc.

In the field of space activities, research and development mainly focuses on new mechanisms with driving systems based on shape memory alloys (SMA), new mechanism designs with high mechanical and thermal properties, as well as the use of new materials such as AlBeMet and materials with improved properties for space applications.

The use of **nanotechnologies** in the field of technologically advanced and safe transport focuses mainly on the spectrum of nanomaterials, nanolayers and nanostructures that are important in the protection of surfaces, where their anticorrosive, self-cleaning, abrasion-resistant and other properties can be used.

Illustrative examples of partial R&D topics (not a comprehensive list):

- R&D of the methodologies for an accurate determination of the lifetime of advanced materials
- R&D of materials resistant to long-term stress and thermal or chemical exposure
- R&D of smart materials to enable the early detection of damage
- R&D of materials whose boundaries are difficult to define, including advanced metallic materials, advanced synthetic polymers, advanced ceramics, novel composites

DS05KET05 Artificial Intelligence

For the needs of technologically advanced and safe transport, this KET covers **software**, which includes artificial intelligence methods and tools enabling cognitive and decision-making functions, algorithms and software, machine learning, high-performance computing, etc. Another group is **embedded artificial intelligence**, i.e. elements, machines, technologies, processes and other that use artificial intelligence. This group includes for example problem-solving, decision-making and planning systems, systems using big data analytics, intelligent robots, virtual agents and distributed systems. It also includes human-machine interaction issues and devices and processes using virtual and augmented reality.

Artificial intelligence enables, among other things, the development of autonomous transport, especially in the area of vehicle control and communication systems as part of the transport infrastructure, taking into account the safety and reliability of systems and equipment and the interaction of the elements of the human-machine system (these include, among other things, research, development and implementation of driver assistance systems, as well as research, development and implementation of autonomous driving systems.

The basis for effective solutions to the challenges associated with technologically advanced and safe transport is, among other things, simultaneous engineering (based on the integrated use of modelling by simulation and experimentation) coupled with the systematic use of previous experience stored in knowledge bases. It is therefore necessary to develop R&D instruments (simulation methods at different levels, including virtual reality or knowledge and data storage methods) and to validate these instruments in short-term oriented experimental development and to use them for strategic applied research of innovative concepts.

Virtual development includes research into simulation and virtual reality techniques for parametric optimisation of products, for conceptual optimisation of higher-order innovations, virtual reality for accelerating the preparation of the production phase in the production chain, etc.

Artificial intelligence generally includes the fields of machine learning, deep learning, reinforcement learning, natural language processing, computer vision, robotics, algorithmic game theory, neuromorphic engineering, recommender systems, and the Internet of Things.

Illustrative examples of partial R&D topics (not a comprehensive list):

- Research and development (of new concept vehicles) based on simulations verified by experiments, via digital twins
- Research and development of methods for creating digital twins
- Digital twins, numerical simulations of violations
- Decision-making, control and monitoring processes in transport equipment, transport systems and satellites
- Advanced processing of traffic data, elimination of risk factors in transport and optimisation of transport flows and traffic; satellite navigation signal processing, automation in the processing of Earth observation data

- Automated and autonomous vehicles and their system architecture
- Mobility as a service – the provision of transport services using modern digital technologies and services, the creation of mobility models within smart city, forecasting in the area of mobility, models of operation: mobility operators, models for the optimisation of transport infrastructure coherence and communication of vehicles with their environment, multimodal mobility, connectivity and data sharing, cyber security of data transmission and services, the legal environment for shared services, the use of autonomous vehicles and drones
- Big data analytics, machine learning, neural networks, deep learning, algorithms, software technologies, problem solving, decision making, planning, intelligent robots, virtual agents, distributed systems, autonomous vehicles, etc.

DS05KET06 Digital security and connectivity

The security of information systems and IT-enabled devices for technologically advanced and secure transport is mainly about authenticating users of these systems and ensuring data security. Ensuring **connectivity** in this area includes, inter alia, the network infrastructure and the technologies and services that enable end-users to connect to that network, including the security of that infrastructure and communications. This area includes secure connections and authentication, identity theft prevention, data protection and privacy, cryptography, ensuring the security of communications and communication systems (protection against viruses, malware, etc.), network security (fixed networks and mobile networks).

The focus is on maximising safety, including research and development of technologies for active and passive vehicle safety and for measures to ensure the safety of the entire transport system, such as cooperative systems for sharing information between participants and other elements included in the transport system. Security also includes on-board data/communication security and system reliability. In addition, systems for the optimal use of data on the road network, traffic and travel, as well as energy options for charging electric and hybrid vehicles and energy storage, including the interaction of charging systems with the energy network.

A wide range of detection, diagnostic, information, control and safety systems based on intelligent transport systems (ITS), global navigation satellite systems (GNSS) and earth observation systems are currently being built in transport, and proposals using satellite telecommunications and blockchain technologies are also emerging. Research and development of technologies in the field of digital security and connectivity enables, among other things, the development of the individual systems mentioned above and their combination and/or integration with conventional ground technologies. Research and development of these technologies will also enable interoperability of the systems, ensuring their compatibility and continuity at local, regional, national and European levels. The development of standardised interfaces between individual systems, subsystems and applications, the specification of individual links between applications and the specification of requirements for individual link interfaces will enable the harmonised development of these systems.

In the field of rail control systems, it is necessary to focus on the development of full automation of traffic control, including interfacing to rail vehicles (SW, HW). Integration with other technological units in rail vehicles. Optimisation of automatic rail transport control in terms of efficient management of energy resources. Development of stationary infrastructure for the automation of vehicle driving control, including on-line data transmission. These activities should involve the application of satellite localisation in signalling technology with a focus on ETCS, increased safety on regional lines, telematic applications, including diagnostics, etc.

In terms of aviation safety and development, these include advanced cockpits and ensuring the safety and continuity of air traffic (technical systems for the provision of air traffic services, including technology for their remote provision, aeronautical information and communication technologies, detection equipment for unmanned aerial vehicles in the vicinity of large airports, including detection equipment for unmanned aerial vehicles in the vicinity of large airports, detection systems for the detection of interference and jamming of GNSS systems, transmission and sharing of large volumes of design data between remote users).

In the field of space activities, research and development may also include on-board and SW systems, automated and robotic systems, open and secure communication protocols.

Illustrative examples of partial R&D topics (not a comprehensive list):

- Secure communication in transport and satellite systems
- Secure communication between transport vehicles with each other and between transport vehicles and transport infrastructure
- Research and development of IoT methods (inside products from transport equipment manufacturing to facilitate product calibration during manufacture and maintenance)

- Authentication, secure connection, secure communication, identity theft prevention, data protection and privacy, Internet of Things (IoT), data security
- Manufacturing systems and related services, processes, operations and equipment for other KETs, including automation, robotics, measurement systems, signal and information processing, production control and other processes

Within the EDP process, members of the National Innovation Platform for Transport for the 21st Century and expert teams from the MIT identified the following strategic research topics and social science research topics for the domain of Technologically advanced and safe transport:

R&D&I topics in application sectors

Strategic topic DS05VVI01 **Autonomous mobility**

The strategic theme "Autonomous mobility" covers a wide range of technical, systemic and socio-economic aspects related to the further development of the autonomous mobility trend. The related R&D&I activities and innovation support in this strategic theme will help accelerate the transition from the development to the implementation phase and will allow to strengthen the competitiveness of the Czech Republic in this area, which will be crucial in the further development of transport. The benefits associated with the gradual introduction of vehicles with advanced assistance systems into operation are mainly related to increased traffic safety, improved transport serviceability and accessibility of transport, and user- and environment-oriented services and concepts. The strategic theme also includes development in the field of rail transport using autonomous systems, possibly in other modes of transport (waterway transport). Through cooperation between research institutions and the private sector, it is possible to achieve progress in this area and also to strengthen expert capacity building to deliver results that contribute to the development of systemic solutions and the commercialisation of technological outputs.

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- Autonomous transport equipment and cooperative intelligent transport systems
- Distributed and central infrastructure elements (edge, cloud) for traffic management
- Virtual development and testing and integration into the transport system and applications in the concepts of Mobility as a Service and Smart Cities/Smart Regions
- Advanced materials and their applications (composites, thin films)
- Components of autonomous systems, i.e. AI algorithms, detection and sensing technologies, communication components and technologies for their measurement and verification (including conformity assessment and certification)
- Technologies improving active and passive vehicle safety, elimination of risk factors, including data and communication security – advanced electrical and electronic systems of vehicles
- Measurement technology (certification – conformity assessment, safety, sensors, metrology, testing, calibration, standards)
- Numerical and simulation methods
- Methods for designing and testing transport equipment with enhanced passive, active and integrated safety (including autonomous traffic control systems)
- Autonomous driving systems for road vehicles (cars and trucks)
    - vehicles – cooperative systems for online information sharing between vehicles and other modes of transport and between the vehicle and their environment
    - Infrastructure – systems for optimal use of road network, traffic and travel data
- Autonomous systems in rail transport – automatic train operation (ATO)
- Low-speed vehicles with automated driving systems (with a predefined route)
- Tools for advanced planning of transport capacity
- Integrated safe transport

Strategic topic DS05VVI02 **Unmanned systems (drones) and U-Space**

The field of unmanned systems (drones) and related services is a dynamically developing sector, which brings a number of potential benefits and challenges, but also societal risks. Applications can be seen in both the private and public sectors. The development of technologies, procedures and infrastructure and the creation of an

optimal environment for the advanced and efficient operation of drones in the Czech Republic, including U-Space services, will enable the full potential to be exploited while gaining the tools to control risks. At the same time, it will enable the Czech Republic and its entities to be competitive in the European and global context. This can bring considerable societal and economic benefits.

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- Technologies, processes and infrastructure for the development and introduction of U-Space services for highly automated traffic/operation of unmanned systems
- Design, construction and structure of aircraft and unmanned aerial vehicles and their applications
    - Aircraft UAV components – aircraft engines (including turbines), leading edges, compressors, wheels, brakes
    - Technologies and materials for aircraft manufacture and safe air transport (precision casting, surfaces and their treatment, composite materials)
    - Mapping, construction, agriculture, forestry, protection of critical infrastructure
- Aircraft and air transport safety – source distribution systems, motion control, control systems and algorithms, data communication
- Methods for designing and testing transport equipment with enhanced passive, active and integrated safety (including autonomous traffic control systems)

Strategic topic DS05VVI03 **Technology for satellites and vertical constellations**

The field of space technology and applications has been undergoing dramatic development in the last few years. The rapidly increasing demand for satellite data and services has accelerated the emergence of private investment in space activities, giving the entire sector a whole new dynamic. There are undoubtedly multiple factors, including the declining costs of satellite launches, rapidly increasing performance and overall developments in ICT, miniaturisation, and technology evolution. In addition to the rapid growth in interest from private users, there has also been a steady increase in interest from government institutions in areas such as satellite telecommunications, satellite navigation and Earth observation. As the number of small satellites in orbit is increasing, there is also a trend towards non-orbital high atmosphere platforms (HAPS) that can serve an area the size of a smaller region. Both small satellites and HAPS are promising technologies with a high commercialisation potential, which, in combination (vertical constellation), can provide even more interesting and desirable solutions.

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- Preparation of system architecture
- Design, construction and structure of high-altitude platform stations (HAPS) and space systems (including materials and the methods for their manufacture, treatment and processing, including additive manufacturing; the development of platforms)
- Components of high-altitude platform stations (HAPS), satellites and probes – solar panels, gyroscopes, on-board computers and avionics, communication systems, electric and ion engines and power systems, radiation detectors, special optics, microelectronics, satellite payload
- Flight software and mission subsystem control software
- Numerical and simulation methods
- Testing of HW and SW components
- Algorithms, data communication, secure communication, compression algorithms
- Preparation of technologies and components for the ground segment, including communication systems and robotic antenna systems
- Processing of data provided by satellite systems, including machine learning, AI and other advanced technologies
- The use of space technologies in security research
- R&D of hardware components and software for automated ground observatories

R&D&I topics in the social sciences and humanities

Mobility that is provided through transport is one of the key indicators of the quality of human life and, in turn, has an impact on lifestyles, social relationships, public and individual health and safety. Research on new

technologies and materials to be used in transport must be accompanied by SSH research on the impacts on people and society, e.g. in order to enhance the acceptance of new solutions or possibly to strengthen the appropriate use of new technologies (eliminate negative side effects).

Examples of topics include: the acceptance of new technologies in transport, the impacts of the introduction of autonomous transport on individuals and society, new modes of transport within the concept of smart cities and regions, security and cyber security issues.

DS05SHUV01 **Research on the interrelationships between society, technology and innovation**
Illustrative examples of partial R&D&I topics (not a comprehensive list): - Issues concerning ergonomics and the acceptance of new transport technologies that assume human interaction - Transport technologies for the provision of mobility in smart cities/smart regions - The human factor in transport and the societal acceptance of new technologies - Ethical issues relating to autonomous mobility - Research on methods for education, awareness and traffic education in the field of autonomous mobility - Social and ethical implications of digitalisation in transport
DS05SHUV03 **Conditions / barriers to the application of innovative technologies and practices**
Illustrative examples of partial R&D&I topics (not a comprehensive list): - Autonomous mobility and the impacts of its introduction on people and society - Legal and safety aspects of the development of new technologies in transport, especially from the perspective of autonomous mobility - Incentives for the transition from extensive transport development to conceptual multimodal mobility
DS05SHUV04 **Security research**
Illustrative examples of partial R&D&I topics (not a comprehensive list): - Cyber security and the impacts on the behaviour of transport system participants (changes in processes and procedures in connection with measures to eliminate cyber risks in transport)

Recommendations for the implementation of NRIS3 instruments

The analysis and the EDP resulted in the following recommendations for developing instruments to support R&D&I:

- In the context of domestic businesses' low R&D expenditure, especially in the Automotive application sector, it is recommended to stimulate the involvement of domestic businesses that do not yet carry out R&D to start their own R&D activities or to carry out R&D in cooperation with public-sector ROs
- Given that R&D results from multiple KETs are applied within the application sector, support should also be provided to projects of a multidisciplinary nature, especially those involving public-sector ROs
- Stimulate the involvement of research centres that were built using resources from the EU Funds and that operate in the field of materials research, electronics, digital technologies and ICT in R&D&I projects implemented in cooperation mainly with domestic businesses, especially in multidisciplinary projects and projects covering the entire innovation cycle that will lead to disruptive innovations
- Stimulate the establishment of new companies that are based on the results of public R&D, especially in the field of digital technologies and AI-enabled technologies, where there is a significant "drain" of knowledge abroad, and create the conditions for their initial development
- Stimulate space technology companies to collaborate on the preparation of complete systems for use in satellites or entire small missions

In addition, it is necessary to take into an account current challenges and trends related to this domain (climate change and the Green Deal, robotisation, digitalisation and the use of digital technologies, including artificial intelligence).

Health care, advanced medicine

Introduction

The thematic area of Healthcare, advanced medicine has only one application sector – Pharmaceuticals, biotechnology, medical devices and life sciences (abbreviated as Pharmaceuticals, biotechnologies). Business R&D expenditure in this application sector is relatively high and increasing. However, the increase is lower than in other sectors. As in other application sectors, more than half of the expenditure is implemented in foreign-controlled businesses, and their share in the implementation of R&D is increasing. Business research is concentrated in several self-governing regions – Prague and the South Moravian, Moravian-Silesian and Central Bohemian Regions. In the other self-governing regions, business R&D expenditure is significantly lower.

The advantage of the thematic area is the strong knowledge base in medical sciences, especially in the field of clinical medicine. By international comparison, R&D is of very high quality and both R&D focus on this area and its quality are increasing. Research institutes/organisational units carrying out R&D with this focus are mainly at HEIs, government-sector research institutes and some other government and business sector organisations operating in the field of healthcare. These ROs also receive very high support in projects that are supported under R&D&I programmes. The projects address R&D for a number of diseases such as cancer, diabetes, heart disease, metabolic disorders, Alzheimer's disease, etc. Diagnostic methods and devices (magnetic resonance imaging, medical devices, early diagnostics, cytometry, etc.) are another important field of R&D. R&D is also focused on stem cells, risk factors, molecular genetics, gene expression and other medical methods and approaches in healthcare.

For the implementation of instruments to support R&D&I, it is convenient that ROs have well-established links with the application sector and at the same time have the potential to produce applied results that are usable in business innovations. This, together with the broad knowledge base in fields such as material science, biotechnology, computer science and ICT, and the high number businesses from other sectors that are active in research and that may participate in R&D&I within this thematic area, creates suitable conditions for the implementation of instruments to support R&D&I, the results of which will contribute to further development in the field of healthcare and medical technology as well as to improvement of medical care quality. In the Czech Republic, there are also a significant number of research centres that operate in medical and biological sciences as well as in optoelectronics, advanced materials and computing, which creates conditions for the implementation of demanding R&D, the results of which will have the potential for disruptive innovation.

Drivers of transition in application sectors

In the future, the trends and developments in this thematic area will be influenced e.g. by the following drivers:

- Wider use of advanced materials, advanced technologies, electronic and optoelectronic components/systems in diagnostics, medical technology, pharmaceuticals and treatment procedures, etc.
- The development of digital technologies and their wider use in healthcare and medical and non-medical care (including artificial intelligence, robotics and communication) and in nursing and care
- The development of new treatments and pharmaceuticals and vaccines (also in the context of the Covid-19 pandemic)
- An improvement in the quality, availability and efficiency of health care
- Increasing life expectancy and population ageing
- The development of information and communication systems, wider application of the principles of delivering healthcare and medical care at a distance, personalised medicine
- Increasing cyber threats in healthcare (operation of information systems and databases, telecare, etc.)

The thematic area of Healthcare, advanced medicine includes only one application sector that concerns the rather specific issue of healthcare and pharmaceuticals. Therefore, only one specialisation domain has been proposed for this thematic area – Advanced medicine and pharmaceuticals.

1.6 Specialisation domain DS06 **Advanced medicine and pharmaceuticals**

The domain of Advanced medicine and pharmaceuticals focuses on R&D in medicine, diagnostic equipment and medical devices that use advanced materials, electronic and optoelectronic components and progressive digital technologies, including artificial intelligence. Another R&D&I area is R&D on innovative pharmaceuticals and their use in medicine. R&D results from all KETs can find applications in this specialisation domain. Especially the results of R&D focused on Life sciences technologies/biotechnologies, which have applications mainly in new advanced pharmaceuticals and treatments for diseases (cancer, diabetes, etc.), have the highest potential. There is also considerable potential for the application of the results of this R&D in materials for medical purposes (e.g. surface treatments), implants, materials for additive manufacturing and medical equipment. Current R&D also focuses on stem cells, genetics, immunity, DNA, biomarkers, tissues and other areas that have significant potential in the future. The results of R&D focusing on Advanced materials and nanotechnologies, Advanced manufacturing technologies and Photonics and micro-/nano-electronics also have a high potential for application in this domain. The result of R&D in advanced materials and nanomaterials of various nature (metallic, composite, ceramic, polymer, textile and other materials) has applications mainly in the field of medical devices such as implants, including their surface treatments and special surfaces (bone implants and dental implants), materials used in diagnostic devices (magnetic resonance imaging) or in special technologies such as additive manufacturing. The results of R&D in photonics and micro-/nano-electronics are mainly applied in products such as sensors and light sources, light guides, imaging equipment and diagnostic equipment. The results of R&D in Advanced manufacturing technologies mainly have potential for application in additive manufacturing, medical orthoses, prostheses, etc. Progressive digital technologies such as Artificial Intelligence and Digital security and connectivity are increasingly being applied in diagnostic equipment and treatment procedures. Current R&D&I projects of businesses operating in the application sector Pharmaceuticals, biotechnology, medical devices in healthcare and life sciences addressing AI issues focus on machine learning, digital data (image) analysis and home care. While the number of such projects is not yet very high, the strong knowledge base in medical sciences and computer and technical sciences, together with the high number of businesses that are active in research in electronics and ICT, creates the conditions for these progressive technologies to find wider application in health equipment and medical care, for example in telemedicine, robotic and smart systems and in information and communication systems in healthcare or in the field of secure communication and biodata protection.

R&D&I topics

Research topics in KETs and emerging technologies with potential for application in application sectors

DS06KET01 Photonics and micro-/nano-electronics

This KET covers the very broad field of photonics, microelectronics and nano-electronics, between which there is considerable overlap. **Photonics** is a multidisciplinary field covering light generation, light conduction, light manipulation, and light detection. 'Light' includes not only the visible part of the spectrum, but also the microwave and ultraviolet parts of the spectrum and X-rays. Photonics includes light sources such as light-emitting diodes (LEDs), lasers, conventional sources (light bulbs, discharge tubes, etc.), and many other optoelectronic elements such as light detectors (sensors) and optical modulators. In the field of light guiding, examples include light guides (waveguides), optical fibres, and optical cables.

Another group is the use of photonics in various applications. An important area of application is the conversion of solar radiation into electricity (solar cells and panels). It also includes the use of photonics in a number of industrial areas such as laser cutting and material processing, lighting technology, and lighting systems. Applications include optical devices used for various purposes, imaging technologies (displays), and technologies such as quantum technologies and electron optics (including electron microscopes).

Micro/nano-electronics deals with highly miniaturised semiconductor devices, components and electronic sub-systems, and includes the design, fabrication, assembly and testing of these elements from the micrometer to nanometer levels. All areas of electronics with nanometre-scale structure, including components with dimensions where quantum effects are applied, are considered to be nano-electronics. This large group includes

semiconductors and semiconductor devices, chips, microprocessors and their integration into larger assemblies, products and systems. It also includes measurement and instrumentation, testing of micro/nano-electronic components and sub-systems, etc.

Illustrative examples of partial R&D topics (not a comprehensive list):

- Sensors, optical detectors
- Imaging and diagnostic equipment
- Light sources
- Fibre optics
- Biosensors
- SW for quantum technologies

DS06KET02 Advanced materials and nanotechnologies

Advanced materials and nanotechnologies is a broad field with boundaries that are difficult to define. **Advanced materials** are usually defined as new or significantly improved materials that have desirable properties or specific functions. This group includes materials for extreme conditions, lightweight materials, composite materials, advanced metals, polymers, ceramics, protective coatings and resistant materials (against various influences and conditions), smart materials, but also advanced biocompatible materials or various types of innovative implants, etc.

Nanotechnologies are considered to be technologies for structures with dimensions between 1 and 100 nanometres in at least one dimension. This area includes a wide range of nanomaterials, nanolayers and nanostructures that are applicable in various technological fields and industries, including health care. These include, in particular, new innovative types of forms of pharmaceuticals. Nanocrystals, solid dispersion formulations, solid phase-liquid and solid phase-solid phase carrier systems for solid medicine administration. Self-emulsifying systems and other nanoparticle systems for liquid phase medicine administration. Designing the above delivery systems in a targeted manner based on knowledge and characterisation of properties and mechanistic principles. The use of systems to reduce the administered dose or extend the duration of action, processing of a highly soluble medicine into a solid dosage form, personalised medicinal products, combination products, or products with improved stability.

Illustrative examples of partial R&D topics (not a comprehensive list):

- R&D of advanced materials and nanomaterials with applications in healthcare (metal, composite, ceramic, polymer, textile and other materials)
- Implants, including their surface treatments and special surfaces (bone implants and dental implants), organ replacements
- R&D of materials for diagnostic devices and special technologies
- Advanced biocompatible materials
- Advanced technologies for the production of dosage forms (in particular using advanced materials and leading to nano- and micro-structured products with improved performance)
- R&D of materials and innovative ways of their use for drug delivery
- Innovative drug formulations using new materials, combinations of materials, new principles, or enabled by advanced materials characterization

DS06KET03 Advanced manufacturing technologies

Advanced manufacturing technologies are based on the use of new principles, as well as existing principles, but optimised based on mechanistic ideas and computational models for bigger efficiency and flexibility. Technology leading to savings in energy, production time, costs based on optimised design based on knowledge of the processes and behaviour of the materials being processed. Technologies designed to convert production processes to continuous mode of production and batch release. Approaches to enable more efficient production scheduling of multiple fixtures on a shared facility.

They include two types of technologies – process technologies, which are mainly used to produce some of the other advanced technologies (or KETs), and technologies that are based on digital, information and communication technologies. **Process technologies** include innovative manufacturing technologies, equipment, systems and processes used to produce specific materials, components and systems. **Technologies based on digital technologies and ICT** include automated manufacturing, robotics, additive manufacturing (3D printing), integration of computers into manufacturing (including the use of high-performance computing), technologies using artificial intelligence, manufacturing technologies and processes using virtual/augmented reality, and others. Another group includes technologies used for production control, such as signal and information

processing, production control, machine measurement, control and test equipment, process control, product and equipment testing, modelling and simulation, etc.

Illustrative examples of partial R&D topics (not a comprehensive list):

- Advanced manufacturing technologies in medicine and healthcare (3D printing and more)
- Advanced technologies for the production of pharmaceuticals (especially those based on the QbD (quality by design) principle and technologies designed for continuous production)
- Manufacture of prostheses, orthoses and replacements
- Integration of computers into production (including the use of high-performance computing)

DS06KET04 **Biotechnology**

KET Biotechnology includes **industrial ("white") biotechnology**, i.e. the application of biotechnology for the industrial processing and production of bioproducts and chemical building blocks in sectors such as the chemical industry, material production, energy, food/nutrition, healthcare, textiles and paper industries, and others, mainly in areas where "conventional" processes cannot be used effectively. These include biotechnologies applicable to industrial processing and the production of chemicals, materials and fuels (biofuels), biotechnologies using micro-organisms or enzymes, technologies to increase production efficiency using enzymes and micro-organisms, production of chemicals and building blocks using enzymes and micro-organisms, use of enzymes in food, feed and detergent production, production of biochemicals and biopolymers from agricultural and forestry waste, etc.

Another group is **biotechnology in the medical and life sciences**, which includes technologies in the field of biomedicine, including analytical methods and analytical techniques, bioengineering, bioelectronics, technologies in neuroscience, etc. This group also covers genomics, proteomics, genetic engineering, technology of production of medicines for advanced ATMP therapy, cell and tissue engineering, including artificial (synthetic) cells, bioactivators, biotechnologies for use in the pharmaceutical industry, neurotechnology, bioinformatics, and biomedicine (including nanomedicine). Other important groups are systems used in analytical technology, such as biosensors and biochips, lab-on-a-chip, and organ-on-a-chip.

Illustrative examples of partial R&D topics (not a comprehensive list):

- Technologies of new advanced pharmaceuticals and biopharmaceuticals, their use and manufacture
- Genomic, proteomic and metabolomic technologies
- Advanced Therapeutic Medicinal Products Manufacturing Technology (ATMP)
- Genetic engineering technology
- Stem cells, cell and tissue engineering (production of tissue and organ replacements)
- Bioinformatics and the use of artificial intelligence in medicine
- Bioengineering, bioelectronics, biosensors and biochips
- Analytical methods and analytical techniques in diagnostics

DS06KET05 **Artificial Intelligence**

New methods and software tools for understanding biological data and large and complex data (big data). Novel approaches, methods combining connections between bioinformatics, biology, computer science, information engineering, mathematics and statistics to analyse and interpret biological data, software data modelling and case development using bio data.

Machine learning in the processing of complex and large datasets (big data) evaluated by artificial intelligence tools for diagnosis in precision medicine, such as in oncology, cardiac surgery or internal medicine, or in imaging methods (radiomics).

Illustrative examples of partial R&D topics (not a comprehensive list):

- Machine learning, digital data (image) analysis
- Home care
- Visualisation equipment
- Computer modelling
- Advanced bioinformatics and its use in precision medicine
- The use of artificial intelligence in imaging methods (e.g. radiomics)

DS06KET06 **Digital security and connectivity**

Digital security and connectivity include the **security of IT systems and IT-enabled devices**, information on stored computers and repositories, including the detection and mitigation of risks associated with the use of a computer. This group includes, for example, authentication of users of these systems, ensuring data security and storage, preventing data loss, cloud security (cloud storage, cloud computing), security of cyber-physical

systems, secure human-machine interfaces, human-computer and robot interaction, technologies for the Internet of Things (IoT), etc.

Another group is the issue of **interconnectivity**, covering the network infrastructure and the technologies and services that enable end-users to connect to that network, including the security of that infrastructure and communications. It includes secure connectivity and authentication, identity theft prevention, data protection and privacy, cryptography, ensuring the security of communications and communication systems (protection against viruses, malware, etc.), network security (fixed networks and mobile networks, including 5G). Furthermore, it includes technologies related to Internet services such as e-Government, e-Administration, e-commerce, blockchain, etc.

Illustrative examples of partial R&D topics (not a comprehensive list):

- Intelligent systems and information and communication systems in healthcare
- Telemedicine
- Secure communication
- Biodata protection

R&D&I topics in application sectors

The proposed topics are aligned with the Czech Republic's strategic materials and objectives in the field of healthcare and the healthcare system, including R&D&I objectives. These are the most important directions that have long-term potential.

Strategic topic DS06VVI01 **Personalised and precision medicine**

The field of personalised and precision medicine is very broad. It covers the field of highly individualised diagnostics and individually formulated therapeutic products. In the Czech Republic, this area is very important both historically and from an industrial perspective. The Czech Republic has the ability to develop products and to take them to the stage of products used in the healthcare system.

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- New diagnostic procedures, SW and devices and products for personalised medicine
- Predictive biopharmaceutical and pharmacological methods
- Molecular genetics, gene expression
- New and innovative pharmaceuticals (human and veterinary)
- New materials, biomaterials, tissue and organ replacements
- Medicinal products for modern therapy (products for somatic cell therapy, tissue engineering and gene therapy)
- The use of innovative tools in psychodiagnostics and psychotherapy
- Multidisciplinary medicine, working with data

Strategic topic DS06VVI02 **Telemedicine, eHEALTH and AI**

Telemedicine is an important progressive area of contemporary medicine. In the context of the Covid pandemic19 , it has become more important as patients were not able to see a physician in the standard way (check-ups, prevention, etc.). The Czech Republic has an infrastructure dedicated to developments in this field. The area is also significant in the historical context. eHealth is a broader concept. The field of AI represents the application of artificial intelligence.

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- Expert systems and the use of AI in diagnostics, therapy and healthcare personalisation
- Information and communication systems to improve the health and well-being of the population (eHealth and mHealth)
- Communication devices for remote patient monitoring, smart housing elements in home care, etc.
- Data collection, availability and storage, data sources
- Medical diagnostics (e.g. molecular diagnostics, smart sensors and AI)

Strategic topic DS06VVI03 **Medical devices**

Medical devices are a big theme. In this respect, the Czech Republic is a country with a functioning industry that supplies Czech hospitals in a significant way. This area has a history that has put the Czech Republic in a good position compared to other countries.

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- Innovative medical instruments, materials and implants made of new materials, including the use of nanomaterials and nanotechnologies
- New and innovative medical devices (devices and equipment for healthcare, home care, etc.)
- Progressive imaging systems and systems for non-invasive applications in medicine
- Robotic systems, intelligent systems and devices for diagnostics and therapy, and other devices and systems to be used in healthcare
- Medical and other healthcare methods and healthcare approaches
- Modern sensors for diagnostic applications and wearable or embedded sensors for Dx applications (medicine, biotech)

Strategic topic DS06VVI04 **Innovative products and solutions for the pharmaceutical and biotechnology industry**

This field includes innovative products as well as technological solutions for the pharmaceutical and biotechnology industries.

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- R&D of the solid-phase chemistry of drugs
- Continuous pharmaceutical processes
- Advanced drug formulation and drug delivery systems
- Digitalisation and robotisation in pharmacy
- Protein engineering in drug development – vaccines, biologics, biosimilars
- R&D of special-purpose food and dietary supplements based on special nutrition
- R&D for a new indication
- Green pharmacy

Strategic topic DS06VVI05 **Prevention, public health and health system resilience**

In the context of the Covid pandemic19 , the importance of prevention, public health and health system resilience has increased. Anticipation of future threats of a similar nature is required. This theme resonates significantly across the National Recovery Plan as one of its objectives. Epidemiology and prevention of the most serious threats, typical multi-factorial diseases of civilisation (diabetes mellitus, etc.), management of biological threats, and protection from addictive substances including counterfeit drugs are major areas of focus in health protection.

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- Epidemiology and prevention of the most serious diseases, risk factors
- Cancer, diabetes, heart diseases, metabolic disorders, Alzheimer's disease
- Neurodegenerative diseases as a major health risk to the ageing population
- Prevention and diagnosis of behavioural addictions
- Dealing with biological threats (epidemics/pandemics and deliberate misuse of biological agents)
- Protection against addictive substances, counterfeit medicines and the excessive use of digital technologies
- The use of information and communication systems in prevention and resilience building
- Age-related diseases, health risks associated with the ageing of the population; new disinfectants; new antidotes for the treatment of poisonings, including industrial poisonings

R&D&I topics in the social sciences and humanities

This specialisation domain is directly related to people, which is why research in the field of new drugs, therapies and diagnostics offers a wide scope for the application of SSH topics. For example, human genome research raises a number of legal, ethical and social questions. Likewise, research in the field of artificial intelligence applied in medicine also has legal and ethical aspects that need to be explored and subsequently reflected in the regulatory system. Medicine will also address the societal topic of population ageing, which, in addition to purely medical topics, also offers the topic of the impact on the health and social system, public budgets, human settlements, housing, mobility, etc. The topic of cyber security will be highly relevant in the context of healthcare digitalisation and robotisation.

Research on the interrelationships between society, technology and innovations
Illustrative examples of partial R&D&I topics (not a comprehensive list): - Language and medicine – the comprehensibility of treatment procedures and drug applications to patients - Equality/inequality in access to medical procedures and drugs, freedom of choice, alternative approaches - The ability to adapt to organisational and societal change in the context of health protection measures
Addressing 21st century societal challenges associated with emerging technologies
Illustrative examples of partial R&D&I topics (not a comprehensive list): - Legal, social and ethical aspects of human genome editing - Artificial intelligence in medicine (legal and social aspects) - Reflection on complex legal and ethical issues in medicine, including new nanotechnologies and trends (including e.g. issues and aspects of personal data processing for the purposes of scientific research in healthcare) - Societal impacts of population ageing - The impacts of health and organisational measures on well-being
Conditions of / barriers to the application of innovative technologies and practices
Illustrative examples of partial R&D&I topics (not a comprehensive list): - Legal and ethical aspects of personalised medicine/assistive technologies (telemedicine) - Social and cultural barriers to new technologies in medicine - Organisational and legal framework for medicine and healthcare (establishing a basic legal framework for medicine, for national health policies, including threats such as Covid19) - Friendly, fast, reliable and successful public administration in healthcare
Security research
- Crisis management and public health protection

Recommendations for the implementation of NRIS3 instruments

The analysis and the EDP resulted in the following recommendations for developing instruments to support R&D&I:

- Support domestic businesses (especially SMEs) operating in the field of medical equipment, healthcare and other related sectors to start their own R&D activities
- Stimulate the establishment of new companies that are based on R&D knowledge (especially from public research) and that have the potential for application in the healthcare sector and medical care (including the implementation of progressive materials and technologies that use artificial intelligence and ICT)
- Encourage businesses that do not yet carry out R&D to participate in R&D projects in cooperation with public-sector ROs (especially at the regional level)
- Research centres and research infrastructure that was built using resources from the EU Funds (centres operating in the field of healthcare and biotechnologies as well as centres focused on materials R&D, photonics, electronics and digital technologies) should be involved in R&D&I projects, especially in projects covering the entire innovation cycle with a potential for disruptive innovations
- Although in some regions there are a limited number of businesses that are active in R&D and that operate in this application sector, there are businesses that carry out R&D in other sectors. These businesses together with ROs working in medical fields should be involved in R&D projects that will focus on R&D of products with applications in medical equipment and healthcare
- In the case of medical devices, the introduction of new medical devices into practice has become significantly more complicated, expensive and requires more time due to the EU Medical Device Regulation (MDR). The certification process is extremely complex, long and thus extremely expensive. Know-how in this area is limited and not easily available. Therefore, greater support should also be provided for activities aimed at supporting the placing on the market of new or innovated devices.

In addition, it is necessary to take into an account current challenges and trends related to this domain, such as population ageing.

Cultural and creative industries

Introduction

The domain Cultural and creative industries as a tool to accelerate the socio-economic development of the Czech Republic focuses on the cultural and creative industries (hereinafter "CCI"). On the one hand, the domain includes technology-based application sectors such as mechanical engineering, the glass industry or the textile industry ("traditional" CCIs), in which a wide range of materials, technologies and manufacturing processes find application. On the other hand, there are areas such as media, cultural heritage, audiovisual production, etc. ("new" CCIs), where progressive digital technologies, including artificial intelligence, are used extensively.

In the Czech Republic, linking the CCIs with technology and traditional industry has the potential to shift the Czech economy towards generating products and services with high value added and to improve their competitiveness in foreign markets. In this respect, design plays an important role – today, design creates a key comparative advantage or helps to create customised solutions in many sectors. However, the domain focuses not only on design as one of the product parameters, but also on other applications of design and the Design Thinking method in high value-added services.

The domain also focuses on the application aspects of R&D in key enabling technologies in the traditional CCI sector, where it builds on the Czech Republic's strong industrial and craft tradition. Above all, it is about the application of advanced technologies in the design and manufacturing process and in materials research. In addition to this traditional focus, the domain also emphasises CCIs related to new technologies and the digital economy. This combination often gives rise to new industries and markets, which are currently developing dynamically and where companies from the Czech Republic are able to reach world-class levels (e.g. the gaming industry). In connection with the progressive development of the sector, it is also necessary to take into an account the consequences in terms of legal regulation, intellectual property, cultural policy and the transformation of business models of R&D results in the CCIs.

The focus of the CCIs is on humans and their quality of life. The domain therefore envisages a deeper interconnection between the technical sciences and the social sciences, humanities and arts in order to build the desired synergies.

Drivers of transition in application sectors

In the future, the trends and developments in this thematic area and its application sectors will be influenced mainly by the following drivers:

- The development of advanced materials and technologies and their applications in a variety of fields, including traditional craft techniques, art, design, heritage conservation and other cultural and creative professions
- The use of natural, renewable and recycled materials, environmental impact reduction
- The development of digital technologies (including ICT and artificial intelligence) and their wider use in all areas, including media production, the gaming industry, performing arts, architecture, archives, libraries and other cultural and creative industries
- Open access to data, databases and other information
- The development of the innovative potential of the creative and cultural industries based not only on technologies but also on other, non-material sources
- The development of a multidisciplinary approach and activities aimed at interconnecting actors and networking

1.7 Specialisation domain DS07 **Cultural and creative industries as a tool to accelerate the socio-economic development of the Czech Republic**

CCI areas can – also based on many foreign good practice examples – act as a tool to accelerate economic and societal development. Without creativity, there can be no quality research or innovation, and creative industries can move traditional industry and services towards higher added value. Innovation and creativity often helped companies survive the crisis caused by the Covid 19 pandemic. CCIs can therefore be the next driving force for the

Czech Republic's recovery. New technologies provide room for creative problem solving in many areas and can improve the quality of the economic and social dimensions of human life.

Research and development in the business sector is driven by opportunities for applications of advanced manufacturing technologies, nanomaterials, biotechnologies, immersive technologies and artificial intelligence combined with design. R&D expenditure is therefore gradually increasing. The segment is generally represented by small and medium-sized enterprises with extensive research potential, as well as start-ups and, to a lesser extent, research organisations focused on industrial and product design, digital and audiovisual production. In the CCIs, there are also many self-employed persons, so-called "creatives", who are able to apply new research findings and development results in specific practice. The application of creative techniques in process and service innovation is developing. Last but not least, creative approaches are also applied in the social sciences, humanities and arts.

Entities that do research operate in all regions of the Czech Republic – the highest R&D expenditures and the resulting outputs and results are statistically significant for Prague, the Central Bohemian and the Zlín Regions.

Application sectors are specified as "Traditional CCIs" (industrial applications of design in mechanical engineering, architecture, technologies, etc.) and "New CCI" (audiovisual applications, digital creation, game design, smart textiles, etc.). CCIs cut across many CZ NACE sectors, from the manufacture of textiles, clothing, glass, porcelain, furniture, book publishing to software publishing including video games, data processing, digital archives and advertising.

R&D&I topics

Research topics in KETs and emerging technologies with potential for application in application sectors

DS07KET01 Photonics and micro-/nano-electronics

Photonics covers light generation, light conduction, light manipulation, and light detection. Optoelectronic elements such as light-emitting diodes (LEDs), lasers, conventional sources (light bulbs, discharge lamps, etc.) and others can be targeted, for example, in the design and implementation of lighting technology, lighting systems, display technology (displays, 360° video, light advertising). Combined with artistic creativity (glass production, architecture, building design, urban lighting, solutions for video mapping, etc.), unique innovations can be created that have a high potential for profitability in global markets. Examples include unique chandeliers, video mapping productions, smart streetlights, etc.

Another area of photonics is the conversion of solar radiation into electricity (solar cells and panels). Here, CCI can look for new solutions, such as how to incorporate solar panels on the roofs of historic buildings in urban conservation areas.

Micro-/nano-electronics addresses highly miniaturised semiconductor devices, components and electronic subsystems that can find applications in many fields of CCIs, such as smart textiles, wearable electronic devices, sensors and transducers for controlling lighting systems, etc.

Illustrative examples of partial R&D topics (not a comprehensive list):

- The use of optical materials, light sources and light guiding technologies in CCI production, such as glass technology, LED and laser light sources, 3D scanning, etc.
- Sensors, optical detectors, miniature electronic devices (wearables), light control systems and effects
- Visualization technologies, immersive technologies and imaging technology (360°video sequences, new solutions using virtual and augmented reality, holography)
- Techniques and technologies for animation, game development and visual effects
- Conversion of solar radiation into electricity for incorporation into artworks, historical buildings, human settlements and other objects produced by CCI

DS07KET02 Advanced materials and nanotechnologies

Advanced materials have specific properties that can be an important inspiration for innovations in CCI. Materials for extreme conditions, lightweight, composite, durable or smart materials can find applications in products and services with high added value because they contribute to reducing energy and material intensity of production and carbon footprint, give products new properties and new use value, enable recycling, etc. Thanks to the creativity of researchers, developers and practitioners, the use of these materials will make it possible to achieve a real transformation of many sectors, from engineering to artistic creation.

Nanotechnology encompasses a wide range of nanomaterials, nanolayers and nanostructures that are applicable in various fields, including CCI. Some applications have been used, such as nanomaterials serving as protective layers in the conservation of monuments, woven and non-woven nanotextiles, liquid glass, etc. The development in this field is very dynamic and further opportunities for innovation are opening up

Illustrative examples of partial R&D topics (not a comprehensive list):

- New applications of advanced materials and nanotechnologies in traditional CCI, such as custom engineering, development of synthetic polymer systems, development of new composites, production of glass, ceramics, textiles with special properties, metal and wood production.
- New applications of advanced materials and nanotechnologies in new CCI, such as audiovisual applications, game design, publishing (magnetic quantum dots), etc.
- New tools, work procedures and technologies using advanced materials (surface treatment, preservation, cutting, grinding, welding, micro-machining, etc.)

DS07KET03 **Advanced manufacturing technologies**

Innovative and knowledge-intensive technologies that can be used in the manufacturing of new products and equipment or to significantly improve product and process parameters that drive innovation can be considered **advanced manufacturing technologies**. CCIs are mainly linked to **process technologies**, where they can use the Design Thinking method to find new models of production processes and achieve, for example, more efficient production.

Technologies based on digital technologies and ICT will also find application in CCI, especially in the field of additive manufacturing (3D printing), integration of computers into production, use of artificial intelligence, edge computing and virtual/augmented reality. They can also be used to train employees, test their competence (simulators), and coordinate distributed work teams.

Illustrative examples of partial R&D topics (not a comprehensive list):

- The incorporation of advanced manufacturing/process technologies into the pre-production and production phases of manufacturing (e.g. prototyping technologies, dynamic modelling of production processes)
- New applications of additive manufacturing (replacing traditional manufacturing), virtual and augmented reality (e.g. in prototype testing, product demonstration, functional verification, etc.)
- Using edge computing to streamline work processes, improve field team collaboration and remote customer support, and enhance people skills.

DS07KET04 **Biotechnology**

Biotechnologies (especially **“white” industrial biotechnologies**) using biological processes, enzymes and living organisms to produce or modify products or processes for specific applications will also find applications in CCIs, especially in the design of biodegradable materials (textile and paper industries) and in the circular economy. It can also be applied to the design of new processes and innovative modelling of services and processes (Design Thinking).

Another important group consists of systems used in analytical technology, such as biosensors and biochips, which can be used, for example, in the development of new wearable devices and smart materials.

Illustrative examples of partial R&D topics (not a comprehensive list):

- Biomaterials and biotechnology with links to new CCIs (e.g. production of designer packaging from biodegradable materials, biosensors for wearables)
- The use of biotechnology in the circular economy, design of new process models in manufacturing and services

DS07KET05 **Artificial Intelligence**

Applied research and experimental development in **Artificial Intelligence** focused on cognitive and decision-making functions and algorithms, machine learning, neural networks, deep learning, genetic algorithms and high-performance computing can serve as a source of innovation for traditional manufacturing such as engineering, automotive, glass, porcelain, furniture, etc. There is also a large field of application in video game production, digital archive services, authentication of artworks, creation of digital galleries, XP digital marketing, etc.

Embedded artificial intelligence includes elements, machines, technologies and processes that use artificial intelligence. In CCI they will be used for big data analysis, creation of intelligent robots, virtual agents and

distributed systems. Research should also focus on human-machine interaction and the implications of virtual and augmented reality processes.

Illustrative examples of partial R&D topics (not a comprehensive list):

- Artificial intelligence in automatic/autonomous devices and means in traditional CCIs (e.g. evaluation of big data and nuances of production processes, diagnostics of technological processes, defect detection, failure prevention, etc.)
- Artificial intelligence in new CCIs (e.g. scanning tools to validate the authenticity of works of art, valuation of cultural heritage using Digital Humanities tools, etc.).
- Machine learning for the analysis of digital data, e.g. speech, visual objects, etc.
- Advanced processing of data on visitors, users, clients, customers and business partners for innovative service and process modelling (Design Thinking)

DS07KET06 Digital security and connectivity

Digital security and connectivity include the **security of IT systems and IT-enabled devices**, information on stored computers and repositories, including the detection and mitigation of risks associated with their use. These technologies are essential for cultural and creative content (CCC) as they can serve, among other things, to authenticate users of information systems, ensure the security of stored data and, in particular, prevent the loss and misuse of such data. In CCC, "data" are mostly copyrighted works, which in digital form are very often subject to piracy and illegal exploitation.

Technologies related to **connectivity** include the network infrastructure, technologies and services that enable end-users to connect to that network. Secure access to digital cultural and creative content that is created and protected by copyright is also very important for CCC. Applied research and experimental development should bring new solutions for CCC to ensure secure connections and authentication, prevent identity theft and protect data and privacy. It is also important for CCI to provide technologies, instruments and methods for the long-term preservation of digital content, often very complex and composed of many types of data and different formats (e.g. multimedia, dance performances, interactive 3D presentations, computer games, etc.). In addition, this KET can be incorporated into various Internet services, such as e-commerce of artworks for CCC.

Illustrative examples of partial R&D topics (not a comprehensive list):

- Digital communication and remote forms of cooperation (e.g. cyber security of remote access to databases of artworks, remote study of collections, identification and authorisation of artists in cloud systems, etc.)
- Cryptographic methods to prevent piracy, illegal use of copyright works and identity theft
- Business models for e-commerce of artworks and other objects created by CCI
- Technologies, tools and methods for long-term preservation of digital content

Note: A number of the above KETs are expected to be used for applications in both the private and public sectors.

R&D&I topics in application sectors

Strategic topic DS07VVI01 Progressive product design

Design offers the opportunity to add further value added to products as early as the product design, conceptualisation and prototyping stage. In addition to the efforts to convey a visually attractive impression, to capture attention and please, design must also be wedded with the utility and functionality of the product, whether it is an industrially manufactured product intended for the end consumer (product design) or a product, such as a machine, intended for other manufacturers (industrial design). Design cannot be understood only superficially, as a change in the colour of a product or packaging, but much more broadly – as an overall approach to the product, its technical design or the use of new materials and technologies. Design provides objects with additional value added that determines their marketability and can help make a product more attractive, not only useful but also beautiful and, as a result, more competitive in the market. It is a marketing tool that combines utility, practicality and aesthetics. It is a multiprofessional (multidisciplinary) activity, where the designer cooperates with other experts, such as ergonomists, material specialists, psychologists or sociologists.

Progressive product design will contribute to domestic producers' shift within international supply chains and increase the competitiveness of Czech products based on applied product/industrial design (aspiration to Tier1 supply), including digital exports.

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- New materials (including nanomaterials) and their use in design in traditional CCIs and crafts and for use by other manufacturers
- New non-wovens and smart textiles, smart apparel with sensing functions
- Design of peripherals and communication devices
- Bodywork design for motor vehicles, ships, boats, aircraft and other transport equipment
- Design of furniture and other utility objects for different user segments (e.g. the disabled)
- The application of product and industrial design for end consumer or manufacturer use
- The application of new technological processes in creating new products with high value added (e.g. production prototyping, additive manufacturing, test before invest)
- The application of R&D results and technologies/technological processes in the conservation of national cultural heritage and national identity (e.g. in the surface treatment of artefacts, restoration, etc.)
- Smart industrial applications (e.g. environmentally friendly manufacturing processes/implementation of the circular economy and upcycling)
- The application of new technological processes in creating new products with high value added (e.g. production prototyping, 3D scanning and reverse engineering, additive manufacturing, test before invest).

Strategic topic DS07VVI02 **Application of the Design Thinking approach for innovative service and process modelling**

Design Thinking is a user-centred method of problem solving. It starts with understanding users' needs, continues with exploring innovative solutions and ends with rapid prototyping. The methodological framework of Design Thinking is based on a detailed analysis of the end-user of the product, their thoughts, needs and wishes. The method is very effective in designing products, websites, mobile and computer applications, as well as manufacturing processes, communication with customers or setting up internal processes. The actual design of the service/process is preceded by socio-economic research of the needs in the different user and customer segments and the subsequent customisation of the processes and services offered, i.e. in several prototype versions for testing. The aim is to achieve greater utility for the end user/customer and, secondarily, higher value added, including software, digital and information activities. Often, multidisciplinary cooperation is used, where experts from different fields collaborate on the design of a service/process.

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- Innovative approaches to creating media content creation, media production
- Digitalisation of data processing, book collections and other resources
- The use of 3D technologies in audiovisual production
- The use of digital technologies and artificial intelligence in architecture and performing arts
- New directions in the gaming industry (game design)
- The application of artificial intelligence in modelling customised services
- The application of numerical simulations, mathematical models and artificial intelligence in analysing big data from textual sources (e.g. databases, digital libraries, archives, etc.)
- Digital distribution services/new forms of remote distribution of intangible goods
- Infrastructure for multimedia content sharing (i.e. remote access services for libraries, museums, galleries, theatres, etc.)
- Innovative methods for memory fund restoration and archiving
- A new approach to services in marketing and creating customised solutions for differentiated customer/consumer/influencer segments
- Urban planning and modern architecture
- The application of Design Thinking in internal processes of businesses and organisations

R&D&I topics in the social sciences, humanities and arts

Cultural and creative industries are directly related to people, their lifestyle, quality of life and culture. People themselves with their creative abilities are the main driving force in this domain. Research in the social sciences, humanities and arts is therefore an integral part of most research and innovation activities in the cultural and creative industries. Expertise in sociology, psychology, law, design, media studies, arts and other disciplines, especially in the field of cultural research, is absolutely crucial for appropriately approaching, applying and maximising the economic benefits of the services/activities/products that make up the CCI segment. For example, research on new service delivery models is directly dependent on socio-economic research in the different customer segments.

The key research questions in this domain include e.g. formulating the definition of the value added of creative input in economic activities/products. This question is a fundamental constant in discussions on the CCIs as a tool for accelerating the socio-economic development of the Czech Republic. In addition, it is necessary to investigate the social benefits of CCI activities within communities (primarily within excluded areas) and the related research on the role of the CCIs in the revitalisation of areas affected by the decline of traditional economic sectors in order to prevent the deepening of social inequality and unemployment and, by extension, to help start alternative socio-economic development in such affected areas, instead of the expected decline that then affects the overall situation in the Czech Republic.

The segment of new media and the downstream distribution channels for the distribution of cultural and entertainment content – and the associated change in the perception of cultural content and in audience behaviour – is extremely powerful and economically profitable.

Examples in the field of technology include research and development of new smart clothing with sensor functions, which cannot be done without cooperation with scientists in the fields of psychology, ergonomics or medicine. Research may focus, for example, on the influence and impact of immersive technologies on human perception, the involvement of creativity in education, research into the socio-economic determinants of creativity, the implications of the digitalisation of cultural content for the market and the economy, the impacts of public policies and legal regulation on the cultural and creative industries.

DS07SHUV01 Research on the interrelationships between society, technology and innovation

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- The effects of the CCIs on education (e.g. research on the impacts of long-term use of immersive technologies on human perception in cognitive processes)
- The application of creativity, entrepreneurship and research tools to the educational curriculum at all educational levels (including the pre-primary level)
- The potential of (the measurement and use of) the digital export of Czech cultural production

DS07SHUV03 Conditions / barriers to the application of innovative technologies and practices

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- Socio-economic determinants of the development of creative potential
- The impacts of legal regulation and cultural policy on the cultural and creative industries in the Czech Republic (analysis of consequences and model scenarios)
- The socio-economic and creative potential of shared portfolios of creatives/authors/designers

DS07SHUV04 Security research

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- Cyber security in the processing of digital content and other data (including the ethics of working in cyberspace)

Recommendations for the implementation of NRIS3 instruments

The analyses and the EDP process resulted in the following recommendations for developing instruments to support R&D&I:

- Multidisciplinary approach – given that R&D results from all KETs are applied in the application sectors, R&D project proposals should be submitted with multidisciplinary overlaps between SSH disciplines and technological applications
- Research centres that were built using resources from the EU Funds and that operate in all relevant technological areas can be involved in R&D projects in this specialisation domain, especially in the above-mentioned multidisciplinary projects and projects covering the entire innovation cycle that may have a potential for disruptive innovations
- Expand the potential for networking between the social sciences, humanities and arts with technological applications (expanding the potential of endogenous R&D into businesses and organisations that have not yet engaged in this activity)
- Encourage domestic businesses (especially SMEs) to start their own R&D activities
- Stimulate the establishment of new companies that are based on the results of public R&D (especially in digital technologies and AI-enabled technologies and thus prevent the “drain” of this know-how abroad)
- Link research topics in the CCIs with research topics in the areas of advanced machines and advanced technologies for a strong and globally competitive industry

Sustainable agriculture and environmental sectors

Introduction

The thematic area of **Sustainable agriculture and environmental application sectors** comprises five application sectors – Sustainable management of natural resources (abbreviated as Natural resource management), Sustainable agriculture and forestry (Agriculture and forestry), Sustainable food production (Food production),Ensuring a healthy and quality environment, biodiversity and ecology of natural resources (Environment and biodiversity) and Sustainable construction, human settlements and technical environmental protection (Construction and human settlements).

The strategic topics – Bioeconomy, Smart farming, Global changes, Digitalisation and systemic interconnection of infrastructure and the natural environment, Sustainability and decarbonisation, Resilience, which belong to the thematic area of "Sustainable agriculture and environmental application sectors" build on the R&D&I topics in the application sectors as listed above (described in the annex to the National RIS3 Strategy document in Annex 1 – Card of Thematic Areas").

The objective of defining strategic R&D&I topics was to build a more general "superstructure" overarching the domain and the more detailed R&D&I topics (i.e. to respond to trends, opportunities, drivers, in sectors, etc.), to merge/cluster the more detailed R&D&I topics under strategic topics (can be used for support programmes), to focus on R&D&I topics in application sectors and increase the transformation potential of the given strategic sectors.

In the application and strategic R&D&I sectors that focus on agriculture and the environment, the number of businesses that are active in research is limited and their R&D expenditure is not high, it is lower than in other application sectors, which is related to the nature of the R&D carried out and the applications of the results. R&D expenditure is mainly implemented in domestic businesses. Most businesses cooperate with ROs and this is linked to the high potential of the implementation of joint R&D&I projects and the use of the results. However, new themes associated with the implementation of the Green Deal for Europe provide an opportunity to create new solutions and grow new businesses.

There is a relatively strong knowledge and research base for this sector in ROs under the Ministry of Agriculture, in ROs under the Ministry of the Environment as well as in HEIs and some ROs in the business sector.

Cooperation between HEIs and businesses seems to be promising in terms of cooperating in the field of R&D&I of digital technologies, ICT and artificial intelligence, robotics, because most businesses operating in the application sectors within this thematic area do not have sufficient experience with new IT technologies.

The implementation of R&D&I projects should involve not only research centres that were built using resources from the EU Funds and that operate in the field of agricultural and environmental sciences, but also centres operating in the field of digital technologies, computer equipment and artificial intelligence, robotics and biotechnology, or life sciences.

Drivers of transition in application sectors

In the future, the trends and developments in this thematic area and its application sectors will be influenced e.g. by the following drivers:

- The expanding application of advanced technologies (including biotechnologies) and materials (including biomaterials and nanomaterials) in agriculture, food production, environmental protection and other sectors
- The development of digital technologies (including ICT and artificial intelligence) and their use in all application sectors within this thematic area
- The trend of expanding implementation of systems using automation, autonomous systems and robotics of agricultural activities (Agriculture 4.0, precision agriculture);
- Climate change and the impacts of a changing climate on the landscape, cities and municipalities, management, use of natural resources and the environment
- Sustainable development, the use of materials from renewable sources, pressure on the circular economy, decreasing availability of minerals, use of renewable materials and secondary raw materials, minimisation of negative impacts of human activities on the environment
- Energy consumption reduction and optimisation and altering the energy mix; using the potential of bioeconomy and the circular economy

- Increasing demands for food safety and quality, expanding applications of new digital technologies (including artificial intelligence and robotics) in food production and delivery
- Increasing urbanisation, the application of the concept of intelligent and energy independent regions, cities, municipalities and buildings

Given the nature of the application sectors and their role in the national economy, this thematic area is divided into two specialisation domains:

- Green technologies, bioeconomy and sustainable food resources
- Smart cities and municipalities

Both specialisation domains and their links to KETs are described in more detail in the following chapters.

1.8 Specialisation domain DS08 **Green technologies, bioeconomy and sustainable food resources**

The ***Green technology, bioeconomy and sustainable food resources*** domain includes sustainable management of natural resources, sustainable and smart agriculture and forestry, sustainable food production, ensuring a healthy and high-quality environment and biodiversity development, and nature conservation as an opportunity to use ecosystem services. The domain reflects the need for innovation in the areas of natural resources, agriculture and food. In terms of maintaining the resilience of the Czech Republic, this is a critical area necessary to prevent risks (sustainability of development, security and resource sufficiency) that may threaten the long-term prosperity of the economy and society. As before, in this domain the strategy aims to apply key enabling technologies in agriculture, food production and environmental protection. In this respect, biotechnologies have the highest potential, but there are also applications for advanced manufacturing technologies, advanced materials or R&D results focused on artificial intelligence, robotics and digital security and connectivity, which can be used e.g. in smart farming and smart landscape management.

R&D&I topics

Research topics in KETs and emerging technologies with potential for application in application sectors

DS08KET01 **Photonics and micro-/nano-electronics**
Photonics includes advances and developments in R&D in the fields of light generation, light management, light manipulation, detection, amplification and use in applications, and other forms of radiant energy such as (light emission, transmission, detection by optical components, lasers, fibre optics,etc.).The quantum unit is the photon. Micro-/nano-electronics technology includes progress and developments in R&D in the fields of highly miniaturised semiconductor components and electronic subsystems, including their integration into larger systems and products (chips, computer microprocessors) where their quantum mechanical properties are applied. Nano-electronics is considered to include all areas of electronics with a structure at the level below 100 nm. Technological progress and R&D development in technologies under the specialisation domain, "Green technologies, bioeconomy and sustainable food resources" are most significantly reflected in the application sectors "Agriculture and Forestry" and "Food Production". Overall, advanced manufacturing technologies fall under the strategic theme of "Smart farming"
Illustrative examples of partial R&D topics (not a comprehensive list): - R&D focused on the development and progress of electronic and optoelectronic systems and methods in agriculture and food production (electrochemical methods, electrocoagulation, transport, lighting, fluorescence, miniaturisation of sensors, chips for measuring plant nutritional status, health status, chips/sensors for monitoring food quality and safety parameters, etc.) - R&D focused on the development and progress of the energy sector (energy consumption, energy storage, photovoltaics, agri-photovoltaics, autonomous decision-making, integrated signal processing and wireless transmission, navigation, information technology, data storage and interpretation, etc.)

DS08KET02 Advanced materials and nanotechnologies

Advanced materials involve progress and development in R&D in the fields of materials with difficult-to-define boundaries. These are materials where progress and R&D development is based on smart and advanced materials (including advanced metals, advanced synthetic polymers, advanced ceramics, new composites, advanced biopolymers, protective coatings, smart materials, new materials resulting from the reprocessing of end-of-life products and others) that reduce energy and material intensity and enable recycling to reduce the carbon footprint.

Nanotechnologies include progress and developments in R&D in the fields of structure technologies with dimensions from 1 to 100 nanometres in at least one dimension (nanomaterials, nanolayers, nanostructures, carbon fibres, graphenes, quantum dots).

Technological progress and R&D developments in advanced materials and nanotechnologies in the specialisation domain, "Green technologies, bioeconomy and sustainable food resources" are most significantly reflected in the application sectors "Environment, and Biodiversity", "Natural Resource Management", "Agriculture and Forestry".

Overall, advanced manufacturing technologies fall under the strategic topics of "Smart farming", "Bioeconomy", "Global changes"

Illustrative examples of partial R&D topics (not a comprehensive list):

- R&D focused on the development and progress of advanced materials and their use in agriculture, food production (nutrients) and ecology (bioactive substances, polymers, polymer carriers, polycarbonates, nanomaterials, bioactive substances, nano carriers for active substances and nutrition, smart food packaging)
- Research into agro- and geotextiles with gradual/controlled nutrient release/controlled lifetime and protective (biological) components in conservation and intensive agriculture

DS08KET03 Advanced manufacturing technologies

Manufacturing systems and related services, processes, operations and equipment for other KETs, including automation, robotics, measurement systems, signal and information processing, production control and other processes. These includes R&D reflected in progress in technologies based on digital knowledge and ICT, "clean" manufacturing technologies enabling physical conversion of materials, supporting technologies, computer modelling and simulation of manufacturing processes, "soft" activities – manufacturing process innovation, additive manufacturing (3D printing), automation, robotics, signal and information processing, integration of computers into manufacturing, technologies using artificial intelligence, virtual augmented reality and other processes, and more).

Technological progress and R&D developments in technologies in the specialisation domain of "Green technologies, bioeconomy and sustainable food resources" are most significantly reflected in the application sectors "Agriculture and Forestry", "Environment, and Biodiversity", "Food Production". Overall, advanced manufacturing technologies cut across all three strategic topics of "Bioeconomy", "Smart farming" and "Global changes"

Illustrative examples of partial R&D topics (not a comprehensive list):

- R&D focused on the development and progress of advanced and production technologies in agriculture and forestry (grading, inspection, transportation, modern crop technologies, precision farming, means of transport, animal welfare, low-emission farming technologies, storage and application of manure, livestock feed for livestock, and other)
- R&D focused on the development and progress of advanced and production technologies (including nanotechnologies) in natural resource management, environmental protection and biodiversity conservation and ecology (technologies contributing to sustainable landscape development, reducing negative environmental impacts, waste treatment and disposal, wastewater treatment, ammonia reduction, production of greenhouse gases and volatile organic compounds, POPs, etc.)
- R&D focused on the development of advanced and production technologies (including nanotechnologies) in food production for animal food quality/technology, food production, specialty foods, progressive production processes, compositional analysis and food quality, food safety, technologies for processing small volumes of raw materials, development of advanced technologies in the field of drinking water treatment and quality control
- R&D focused on the development and use of recycled packaging materials to ensure a high level of food safety in food production
- R&D focused on the development and progress of advanced and production technologies (including nanotechnologies) in the production of specialty foods for consumers with health and ethical constraints

- R&D focused on the development of innovative production processes (3D printing, biotechnology, etc.) and environmentally friendly procedures in food preservation (pulsed electric field, high pressure, cold plasma, etc.)
- R&D aimed at increasing the nutritional value of food (UV treatment of food, etc.)
- R&D focused on the development of laboratory control methods for production technologies for the purpose of quality and safety control of agricultural products and foodstuffs

DS08KET04 **Biotechnology**

Biotechnology includes progress and development in R&D in technical applications or processes using microorganisms or enzymes for industrial processing and production of bioproducts in sectors where R&D is advancing and progressing, such as chemical, food/nutrition, healthcare, textiles and paper, materials, energy, genetic engineering, medical and life sciences, synthetic biology, biosensors, bioactivators, Lab on CHip, neurotechnology and other.

Technological progress and development of R&D developments in the specialisation domain of "Green technologies, bioeconomy and sustainable food Resources" are reflected in the application sectors "Agriculture and Forestry", "Food Production", "Environment and Biodiversity", "Natural Resource Management",

Overall, advanced manufacturing technologies span across all three strategic topics of "Bioeconomy" (GMOs, Smart farming, Global changes)

Illustrative examples of partial R&D topics (not a comprehensive list):

- R&D focused on the development and progress of biotechnology and its application in food production (production processes, composition and quality analysis, food safety and quality, enzymes in food processing, production of bioproducts, biologically active substances, nutraceuticals, processing of agri-food sector by-products, biotechnology using micro-organisms)
- R&D focused on the development and progress of biotechnology and its application in agriculture and forestry (forest plantation, agricultural crops, breeding and other technologies in plant and animal production - GMO – transgenic plants/food, gene editing, bacterial strains used for composting, production of feed and detergents, cultivation technologies for non-food purposes)
- R&D focused on the development and advancement of biotechnology and its application in natural resource management and environmental protection (e.g. waste and wastewater management, biodegradation of hazardous waste, removal of pollutants and atmospheric pollution, technologies for water management and water recycling, production of biochemicals and biopolymers from agricultural and forestry wastes, conversion of biomass to biofuels, remediation of polluted soil/bioremediation or phytoremediation, etc.)
- R&D focused on the development and application of alternative protein sources
- R&D focused on the development of innovative technologies in livestock production with an emphasis on reducing greenhouse gas emissions

DS08KET05 **Artificial Intelligence**

Artificial intelligence includes progress and development in R&D in the fields of software, embedded artificial intelligence, human-machine interaction (physical-robotic systems), virtual and augmented reality processes (big data analytics, machine learning, neural networks, deep learning, genetic algorithms, software technologies, problem solving, decision making, planning, intelligent robots, virtual agents, distributed systems, autonomous vehicles, drones, intelligent traffic management systems, etc.).

Technological progress and R&D advance in technologies in the specialisation domain "Green technologies, bioeconomy and sustainable food resources" are reflected in the application sectors of "Agriculture and Forestry", "Food Production", "Environment, and Biodiversity".

Overall, advanced production technologies cut across all three strategic themes of "Smart farming", "Bioeconomy" and "Global changes"

Illustrative examples of partial R&D topics (not a comprehensive list):

- R&D focused on the development and progress of robotic and automated devices and their use in food production, food supplements and the creation of higher quality proteins in food supplements
- R&D aimed at the development and progress of automatic devices and their application in the field of water quality control
- R&D aimed at development and advancing technologies for Agriculture 4.0 (smart farming) mobile techniques, expert systems, satellite farming, site specific crop management, precision farming, drones, GPS-based systems – recording systems
- R&D focused on the development and progress of technologies for the environment, landscape design and nature and biodiversity conservation, analysis of environmental information sets for innovative solutions
- R&D focused on the implementation of intelligent warehouse management in food production

DS08KET06 **Digital security and connectivity**
Digital security covers progress and development in R&D in the fields of security of information systems and IT-enabled devices, interconnectivity involving network infrastructure and technologies and services - Authentication, secure connectivity, secure communications, identity theft prevention, data protection and privacy, Internet of Things (IoT), data security, human-machine interfaces, human-computer and robot interaction, 5G, e-Government, e-Administration, cyber-physical systems security, blockchain and others Technological progress and R&D developments in the specialisation domain "Green technologies, bioeconomy and sustainable food resources" are reflected in the application sectors of "Agriculture and Forestry", "Food Production", "Environment and Biodiversity". Overall, advanced production technologies cut across all three strategic themes of "Smart farming", "Bioeconomy" and "Global changes"
Illustrative examples of partial R&D topics (not a comprehensive list): - R&D focused on the development and progress of agriculture is in the fields of precision agriculture, sensor networks for crop and livestock monitoring, environment, mobile technology management, digital farm management programmes, unmanned aerial vehicles, satellite navigation systems, etc. - R&D for the development and progress of food production, digital thermometers - R&D aimed at developing digital solutions, reducing food waste and food resources throughout the agri-food chain - R&D aimed at developing innovative and digital approaches to the adulteration of food, ensuring food safety - R&D aimed at developing simplified nutritional and environmental labelling schemes for food

R&D&I topics in application sectors

Strategic topic DS08VVI01 **Bioeconomy**
The bioeconomy (hereafter BE) is an interdisciplinary field whose results help the different sectors to transform the current economy towards sustainable development and can help not only reduce the impacts of climate change, but also contribute to the impact of human activity on the climate, reduce the use of non-renewable raw materials, increase the value added from biomaterials in parallel with reduced energy consumption, use nutrients and energy from waste and by-products as additional end products and optimise the value and benefits of ecosystem services to the economy. Bioeconomy should be seen as a transformation of society towards a more sustainable development using biological resources across sectors such as agriculture, forestry, aquaculture, food industry, energy, bioenergy, bio-based production of products, chemical industry, biotechnology sector, and pharmaceuticals). BE can be seen as a multidisciplinary economic sector whose development is conditional upon quality research, development and innovations.
Illustrative examples of partial R&D&I topics (not a comprehensive list): - The circular economy, waste and sediment recovery, sewage sludge and biowaste, pollutants, waste air and industrial water and their treatment - Development of modern biotechnologies in agriculture, forestry, food sector and their application - The use of non-traditional protein sources (novel food) - Reclamation/revitalisation after mining activities (particularly lignite and non-energy minerals) - Safe technologies for agricultural emergency response - Genetics (molecular genetics), genomics - R&D focused on non-food production (biomass, recycled and degradable materials) - Bioeconomy research and development in connection with the circular economy - Research into recycling processes and recycling technologies to ensure circularity, material reduction and waste prevention, with emphasis on biological materials, difficult-to-recycle wastes, critical raw materials and new materials - Development of digitalisation in waste management and SMART waste management, digitalisation of material flows - R&D of consumer awareness and education on food and food waste
Strategic topic DS08VVI02 **Smart agriculture**
Smart farming refers to all agricultural activities such as livestock farming, crop production, forest eco-systems, forestry, revitalisation, new cultivation systems and food activities, where digitalisation, automation, robotics, precision farming and the use of sensors (IoT) are applied to enable targeted use of heterogeneity to optimise

activities and intervention while minimising negative impacts on nature and the landscape. In the historical sequence of qualitative changes, the term Agriculture 4.0 has also been introduced. Agriculture 4.0 differs from the previous degrees of innovation, which primarily affected production techniques and technologies on farms or in businesses, in that it affects all parts of the value chain in agriculture, including off-farm. The role of the farmer will undoubtedly require more knowledge in information technology and data analysis. Hand in hand with this, the role of agricultural research will grow, opening up a new dimension even in fields that were inherent to industrial activity.

The combination of the Agriculture and IT domains will increase efficiency and precision in the agricultural sector and respond flexibly to the variability of conditions related to climate change, agri-environmental measures and the market environment in order to meet the challenges of the Green Deal for Europe (e.g. the strategic objectives of a Europe without chemicals, Farm to Fork, Nature back into our lives)

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- Smart and sustainable agriculture, Agriculture 4.0, low-carbon technologies
- R&D focused on precision agriculture, including the use of remote sensing, satellite imagery, etc.
- Land management technologies, monitoring and reducing soil erosion, soil degradation and solutions to meet the European soil strategy
- Agricultural mechanisation – machines for sorting and harvesting, especially hop harvesting, other machinery for agriculture and forestry
- Technologies and biotechnologies for food production and storage and analytical methods for the food industry (including the use of nanotechnologies, physical technologies and methods, etc.)
- Transport, delivery and storage of food using new “non-chemical” techniques (e.g. intelligent packaging systems)
- Planting material (seeds), crops, forest and forest crops and their protection and regeneration
- R&D of sustainable production of wholesome and quality food with a focus on food composition and its effects on human health, nutraceuticals (increasing the safety and quality of food, extending its shelf life)
- Food products – new products for population groups with special nutritional requirements (gluten-free foods, nutrition for the elderly)
- R&D focused on crop and animal production including the plant health sector and animal welfare
- Forest ecosystems and silviculture, agroforestry
- Sustainable agriculture on arable land and permanent grassland
- Use of composts and digestates on agricultural land
- R&D aimed at promoting aquaculture and aquaponics

Strategic topic DS08VVI03 **Global change**

Global changes in the biosphere are increasingly affecting, and to some extent threatening, the further development of global human society. The agricultural sector, including forestry, and natural resources (biodiversity, water, soil) are among the most threatened areas. The contribution of human activities is decisive in some aspects (desertification, erosion, water resource management), and in others it is assumed to be significant (climate change).

The agricultural and forestry sector is exposed to the effects of global climate change in the first instance. On the other hand, it has considerable potential for adaptation to climate change and enables mitigation measures. There is a scientific and political consensus that climate change is significantly influenced by the increasing greenhouse gas concentration in the atmosphere from anthropogenic activities. The issue of tackling and preventing the effects of climate change is therefore a major focus of research, which is more concerned with diversity and the management of basic natural resources and genetic resources.

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- Water retention in the landscape, water resources, surface water protection
- R&D focused on genetic resources
- R&D focused on climate change adaptation and new mitigation measures
- R&D focused on environmental protection, biodiversity, conservation of protected ecosystems, nature conservation and landscaping and the promotion of ecosystem services
- Sustainable landscape development, prediction of negative natural changes, environmental security, including flood protection and measures to eliminate drought
- R&D focused on ensuring a nutritionally valuable diet for the population, research on food as a prevention of disease, reduction of civilisation diseases and malnutrition

R&D&I topics in the social sciences and humanities

This domain is directly related both to the individual and to the entire human society. Research in the SSH can help uncover the implications of introducing innovations and new technologies for workers in the application sector, how the bioeconomy and green technologies contribute to the transformation of society, how perceptions of sustainable development are changing in different social groups, and what economic benefits may result from introducing innovations in the sector. Environmental education is essential, the content and forms of which are changing with advancing knowledge and available tools Global changes, and climate change in particular, have complex impacts on society, so research on the impacts of climate change will be important for preventing and avoiding negative consequences for people, the economy, public services and public policies, and society as a whole. Research, among other things, into genetic interventions in organisms will open up issues relating to law, ethics, psychology and sociology. The introduction of digitalisation and automation into the agri-food chain will place new demands on the workforce, requiring new ICT and data skills.

DS08SHUV01 **Research on the interrelationships between society, technology and innovations**
Illustrative examples of partial R&D&I topics (not a comprehensive list): - The effects and impacts of consuming different food categories/types on a person's health, economic situation and quality of life, tools to eliminate negative impacts (e.g. promotion and education) - The influence and impact of healthy lifestyle education systems on children and young people - Research into changing farmers' way of life in the context of new technologies
DS08SHUV02 **Addressing 21st century societal challenges associated with emerging technologies**
Illustrative examples of partial R&D&I topics (not a comprehensive list): - Social and economic impacts of climate change, (people's behaviour and mitigation measures affecting the consumption) - Transition to a sustainable circular economy - R&D into consumer awareness and education on food, food waste and waste recovery
DS08SHUV03 **Conditions / barriers to the application of innovative technologies**
Illustrative examples of partial R&D&I topics (not a comprehensive list): - Legal, social and ethical aspects of genetic interventions in agriculture (GMO, targeted mutagenesis) - Perceptions of the topics of bioeconomy and the circular economy in different social groups, identification of barriers and tools to remove them (e.g. awareness raising)

Recommendations for the implementation of NRIS3 instruments

The analysis and the EDP process resulted in the following recommendations for developing instruments to support R&D&I:

- Given that R&D expenditure is low in most sectors, it is necessary to stimulate businesses to start R&D activities
- Take advantage of the well-developed cooperation between businesses and ROs (including ROs under the Ministry of Agriculture and ROs under the Ministry of the Environment) in order to address more demanding R&D&I projects
- Stimulate businesses that do not yet carry out R&D to start their own R&D activities or to implement projects in cooperation with ROs
- Support multidisciplinary projects involving multiple KETs and application sectors, where demanding R&D will be carried out in collaboration between ROs (including centres that were built using resources from the EU Funds) and businesses aiming to implement disruptive innovations (e.g. the use of digital technologies and artificial intelligence in agriculture and the environment)
- Stimulate collaboration between the public sector (including public administration) and companies to formulate themes for R&D, new solutions and the creation of new companies
- Address the public administration – municipalities, cities and regions, cooperate on the development of sustainable agriculture, agro-energy, agro-tourism, technologies and techniques for the protection of nature, landscape and climate

It is also necessary to take into an account current challenges and trends related to this domain, such as climate change and mitigation, sustainable development, with the Green Deal for Europe providing the basis for efforts to promote development and R&D in this domain.

1.9 Specialisation domain DS09 **Smart cities and municipalities**

The **Smart cities** domain is focused on R&D&I of new and advanced materials and technologies, including digital technologies, ICT and artificial intelligence, and their use in civil engineering or the creation of public spaces in the inner city. The domain focuses on the use of key enabling technologies for smart solutions in the field of buildings, human settlements and their connectivity. Given the increasing urbanisation, it is increasingly necessary to take account of the principle of sustainable development and the impacts of climate change, i.e. the efforts to reduce its impacts on people, society and nature. Therefore, the focus of the domain includes R&D&I topics oriented towards energy efficient buildings, the use of materials from renewable sources or new advanced materials. Attention is also paid to waste (wastewater, air pollution, MSW) and its treatment. It is essential that the domain is oriented not only towards energy, building or transport sub-solutions, but also towards complex solutions that combine multiple effects aimed at improving the quality of life and sustainability.

R&D&I topics

Research topics in KETs and emerging technologies with potential for application in application sectors

DS09KET01 **Photonics and micro-/nano-electronics**
These are advances and developments in working with light such as the generation, conduction, manipulation or detection of light (photonics). Light means the part visible to the human eye as well as the microwave and ultraviolet part of the spectrum and X-rays. Highly miniaturised semiconductor devices, components and electronic sub-systems including the design, fabrication, assembly and testing of these elements from the micrometer to nanometer levels are covered by the micro-/nano-electronics sector. Within the Smart cities domain, these technologies have various application areas, which include building and communications construction, home, security and monitoring systems, cable and other line components, energy SmartGrid (e.g., microGrid), and many others. In the energy sector, this industry can contribute with energy optimization up to the stage of complex energy systems and help in the evaluation of sustainable development indicators (ESG indicators).
Illustrative examples of partial R&D topics (not a comprehensive list): - R&D of electronic and electrotechnical components, systems and equipment for use in buildings, urban space development, and construction - R&D of optical sources and lighting equipment for buildings, municipalities and regions - R&D of sensors of electrical and non-electrical quantities with applications in buildings and construction, including transport solutions - R&D of photovoltaic cells and systems for use in buildings and human settlements
DS09KET02 **Advanced materials and nanotechnologies**
This is a broad area with difficult-to-define boundaries. The advanced materials sector typically includes materials that are considered new or significantly improved and have desirable properties or specific functions. These include extreme conditions of use, recyclability of materials, composites, etc., used especially in the construction of buildings, roads and landscaping. If the dimension (at least in one direction) is between 1 and 100 nanometres, the material is classified as nanotechnology. Examples include materials that can protect buildings from the climate or vandals, (e.g. they perform an air and climate quality absorption function called “cleaning plasters”), as well as applications for the energy sector, urban infrastructure, environmental design, food, etc.
Illustrative examples of partial R&D topics (not a comprehensive list): - R&D of new and advanced materials (including nanomaterials) for use in construction technologies in buildings and in the development of public space in the inner city (concrete with specific properties, durable materials, special polymers and composites, advanced structural materials, etc.) - R&D of technologies that use advanced materials and nanotechnologies and their implementation into construction of buildings and necessary infrastructure
DS09KET03 **Advanced manufacturing technologies**
This sector deals with innovative and knowledge-intensive technologies that enable the production of new products and equipment or for the substantial improvement of product and process parameters. They generally

include two types of technologies – process technologies (production of other advanced technologies) and general technologies (based on digital, information and communication technologies).

Examples include innovative manufacturing technologies, equipment and other systems and processes used to produce specific materials, etc. This sector includes technologies that reduce production waste, increase production/processing efficiency and more. We also include automated or additive manufacturing, the use of virtual/augmented reality, models, etc. Models of future developments are linked to knowledge graphs that can show the interrelationships and use of material combinations in construction.

For this domain, these are mainly construction and renovation – the use of new and more efficient procedures, modelling not only buildings but also their surroundings and wider units, connections and influences on all subjects, technologies for energy used in cities and municipalities, technologies for repairs and renovation.

Illustrative examples of partial R&D topics (not a comprehensive list):

- R&D of advanced technologies to help improve the efficiency of construction and reduce negative environmental impacts
- R&D of advanced technologies that reduce the negative environmental and climate impacts of technologies, help improve the environmental safety and quality of construction processes (additive manufacturing and 3D printing, manufacturing technologies for special construction materials, energy-efficient technologies in buildings, etc.)

DS09KET04 Biotechnology

For the Smart Settlements domain, these are mainly applications for small-scale crop production in or on buildings. This means, for example, growing in home gardens and community gardens and growing on the roofs of buildings, such as green roofs and facades with multiple functions. In particular, micro-organisms are used here that have a beneficial effect on crop growth. Other uses include the processing of various types of waste and water management, for example. Again, it is important to interconnect systems so that they work together and do not duplicate each other unless necessary. A good tool for testing new solutions include for example living labs.

Illustrative examples of partial R&D topics (not a comprehensive list):

- R&D of biotechnologies contributing to environmental protection (wastewater treatment, air pollution, etc.) and reduction of the negative impacts of construction (e.g. waste management)
- R&D of biotechnologies with applications in environmentally friendly technologies, contributing to sustainable landscape development, etc.

DS09KET05 Artificial Intelligence

Artificial intelligence plays a vital role in the development of smart settlements. This field addresses neural networks, machine learning, genetic algorithms, etc. that help to solve complex and difficult tasks in various areas of life of municipalities, cities and regions. It is an efficient way to process large volumes of data. For this domain, it is one of the most comprehensive solutions which enables, for example, modelling settlements and modifying their parameters, including the actual construction of buildings or infrastructure, layout, etc., as well as the usability of materials, the impact of the sun, energy efficiency and more. Digital twins are not just the domain of industry, but an important tool for territorial development. AI is associated with virtual agents that help the system and humans define problems and propose solutions in a given location. This is further helped by knowledge graphs of the systems, which show the interconnections between the individual sub-systems. The implementation of new solutions in this sector will be reflected in the assessment of ESG targets and climate commitments.

Illustrative examples of partial R&D topics (not a comprehensive list):

- R&D into artificial intelligence and its use in construction, human settlements – municipalities, cities and regions (intelligent systems of buildings and public spaces, modelling of urban and municipal development, monitoring of buildings and their security, image analysis with use in identification of persons and recognition of human activity, etc.).
- R&D focused on digital twins in the public sector (digital twin can simulate different situations and help decision-making).

DS09KET06 Digital security and connectivity

This sector is primarily concerned with securing information systems and minimising the risks associated with the use of information technology. A minor example is the authentication of users of systems and settlements – for example, the authentication of people in a building. This includes cloud security, cyber-physical systems,

IoT technologies, etc. Connectivity is a key feature for users, allowing them to access a network and information that must be sufficiently secure.

For the domain of smart settlements, e-Government is an important component, which can be performed electronically with high convenience for the user. This sector also includes knowledge graphs, which help users with data and information interconnectivity, because they can see the individual connections between systems and make more informed and effective decisions. The main incentive for new solutions is the implementation of Act 12/2020 Coll., on the Right to Digital Service. It provides a significant boost to research in the area of digital security and connectivity.

Illustrative examples of partial R&D topics (not a comprehensive list):

- R&D focused on secure communication and cyber security
- R&D focused on the protection of the control systems of settlements
- R&D for secure access to information

R&D&I topics in application sectors

Strategic topic DS09VVI01 Digitalisation and systemic interconnection of infrastructure and the natural environment

This theme/sector/area is based on digitalisation and systemic interconnection of different types of infrastructures with the natural environment. The area deals with research and development of tools for modelling and simulating territorial units (decarbonisation, urban design, digital support for spatial planning, with emphasis on minimising impacts on the quality of life of inhabitants and creating resilient landscapes), "smart" environment, "smart" infrastructure, including the development of efficient digital infrastructure extension. Spatial units start with neighbours and extend to villages, city districts to entire cities and regions.

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- Digital technologies and artificial intelligence and their implementation into structures and products used in construction and human settlements, municipalities, cities and regions
- Digital resources for design in architecture and sustainable urban planning
- R&D focused on the structure of green infrastructure in relation to grey infrastructure in accordance with the requirements for preferred ecosystem services
- Autonomous warning and protection systems of buildings, public space and territorial units, including solutions for crisis management

Strategic topic DS09VVI02 Sustainability and decarbonisation

This is a theme/sector/area that deals with the sustainability of territorial units in the economic, environmental and social spheres. The area is dedicated to research and development of tools and measures to increase the sustainability of neighbourhoods, villages, city districts to entire cities and regions.

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- Materials for construction, advanced materials (including nanomaterials) and their use in construction
- Advanced technologies and manufacturing processes and their application in construction and human settlements, municipalities, cities and regions
- Improvement of the energy performance of buildings and reduction of the negative environmental impacts, including the development and use of "green wall" technologies, such as "green roofs".
- The use of materials from secondary raw materials in construction, implementation of circular economy, and design thinking in the creation of products and services
- Sustainable development of landscapes and human settlements, environmental protection in the context of construction and environmentally-friendly technologies
- R&D focused on global changes to the climate and adaptation to climate change
- Materials and waste management and reuse (recycling), (the cradle-to-cradle principle)

Strategic topic DS09VVI03 Resilience

This theme/sector/area that deals with the issue of resilience of territorial units, such as against natural disasters, climate change, cyber-attacks, power outages, social threats through cyberspace, etc. The area is dedicated to research and development of various tools and measures to increase the resilience and self-reliance of neighbourhoods, villages, city districts to entire cities and regions.

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- R&D focused on the principle of sustainability in architecture and urban planning
- Slope deformation, landslides and similar Earth surface phenomena
- Security research focused on resilient communities (safe public space, infrastructure security and environmental safety/security) Safe smart homes and settlements, municipalities, cities and regions, e.g. for emergencies
- R&D aimed at ensuring cyber security and control system protection in buildings, settlements, municipalities, cities and regions

R&D&I topics in the social sciences and humanities

The domain concerns units in which people live and it therefore offers a wide range of opportunities for research in the field of SSH. Smart settlements take advantage of digital technologies and communication infrastructure, introduce elements of smart public administration, and apply new trends in urban planning and spatial planning. All of this is significant to the quality of life of the population. It is important to know how e.g. decarbonisation and sustainability measures will be received by society, as they may also have negative economic and social impacts on different groups of people. On the other hand, there may be opportunities for smart building if this is expected by the population. Human settlements should have certain resilience to potential negative phenomena such as crime, natural disasters or cyber-attacks. This opens up space for security research, which can result e.g. in the design of effective procedures e.g. in dealing with the consequences of natural disasters (floods, tornadoes, natural phenomena associated with drought, etc.). The increasing frequency of cyber-attacks on public institutions, increasing digital literacy of the population and the use of digital channels of communication have created a need to intensify research in the field of cyber security.

DS09SHUV01 Research on the interrelationships between society, technology and innovation

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- The impacts of new technologies on social relationships and privacy
- Research on the impacts of the implementation of SMART solutions on the quality of life in a changing public space
- Development of SSH based on the requirements of new (digital) solutions from the public sector

DS09SHUV04 Security research

Illustrative examples of partial R&D&I topics (not a comprehensive list):

- Security and other research into resilient communities (safe public space, infrastructure and environmental security, resilience of individuals and social groups to influence through social networks)

Recommendations for the implementation of NRIS3 instruments

The analysis and the EDP process resulted in the following recommendations for developing instruments to support R&D&I:

- Given that in the sector there are a large number of domestic SMEs pursuing their own R&D activities, their R&D needs to be further strengthened and they need to be stimulated to carry out more demanding R&D, especially in cooperation with public-sector ROs
- Given that R&D results from all KETs are applied in the application sector, the projects should also include multidisciplinary R&D (e.g. carried out in collaboration with research centres that were built using resources from the EU Funds)
- Given that, in most cases, businesses in the construction industry will not have experience with R&D in all the required technology areas (KETs), it is necessary to support projects implemented in cooperation between businesses and ROs (financed from public funds) and the use of the results of these projects in construction and human settlements, and in solutions in municipalities, cities and regions;
- Stimulate the establishment of new companies that are based on the results of public R&D (especially in digital technologies and AI-enabled technologies, where there is a significant offshoring of knowledge abroad), whose products will have applications in construction, buildings, their equipment, during the development of space in cities and municipalities and during landscaping, etc.

- Since cooperation between businesses and ROs is quite widespread in this sector, it is necessary to involve other entities in the cooperation that do not yet have R&D, in particular public sector procurement

With particular reference to the New European Bauhaus, support within this domain will be an important contribution to the implementation of the Green Deal for Europe. It is necessary to take into an account other current challenges and trends related to this domain (ageing population, individualisation and decentralisation of solutions, etc.).

2. Societal challenges and RIS3 missions

The missions respond to megatrends and recent social challenges that no state can ignore. It is necessary to prepare for the limited availability of natural resources, the negative impact of climate change, global warming, a growing and ageing population on the planet, safety risks and the related demands on transport, health, education and other goods and socio-economic and environmental systems in their broader conception and interrelationships.

These new societal challenges cannot be addressed by isolated measures in the form of interventions in a specific area, but rather by a coordinated approach, including well thought out activities that use synergies and multi-source funding to achieve the goal. This is a mission-oriented approach, i.e. the establishment of a specific mission, to the fulfilment of which the coordinated activities and interventions of various entities contribute.

RIS3 missions will not aim to solve a problem comprehensively, but to contribute to its solution exclusively through research, development and innovation. Once a mission has been set, the idea is to engage as many entities as possible with the capacity and resources to support R&D&I in achieving its goal(s).

The approved National RIS3 Strategy 2021+ (NRIS3) envisages the application of **RIS3 missions**. These are NRIS3 priorities that will be oriented towards solving societal challenges and will correspond in their setting to the "mission-oriented innovation policy", which is currently the trend in research and innovation support policies both at the EU level and in many other developed countries. The upcoming RIS3 missions should mainly:

- Focus R&D&I in the Czech Republic on solutions to selected societal challenges with regard to the geopolitical situation in the world and aspects of sustainability
- Have links to key European strategic guidelines and documents
- Link themes across domains of specialisation, encourage collaboration across National Innovation Platforms/sectors, promote interdisciplinarity.
- Involve other interesting stakeholders in RIS3, activate existing participants in the EDP process including national funders and regional governments
- Define specific, measurable goals achievable through R&D&I.

As stated in Chapter 4.3.2 of the National RIS3 Strategy 2021–2027 main document, the missions take the form of thematic priorities of the National RIS3 Strategy, i.e. the same status as specialisation domains.

As far as the content of the missions is concerned, the content of the first two RIS3 missions has been elaborated in detail compared to Version 3 of Annex 1 of NRIS3:
M01 **Improving the material, energy and emissions efficiency of the economy**
M02 **Strengthening society's resilience to security threats**
where, in addition to the focus of the two missions and an initial description of the objectives for their fulfilment, the R&D&I themes relevant to each of the mission objectives are now described. In particular, the following inputs were applied during the EDP process for the RIS3 missions:

- a background analysis of the RIS3 mission "Improving the material, energy and emissions efficiency of the economy" prepared by the Technology Centre Prague within the STRATIN project and background analysis of the RIS3 mission "Strengthening society's resilience to security threats" prepared by the Ministry of Interior of the Czech Republic
- interim findings from the regular monthly meetings of the expert group of RIS3 R&D&I support providers
- workshops of experts from applied research, companies, social sciences and humanities, regions and state administration, facilitated by the Prague Technology Centre
- workshop of the Consultation Group of the Ministry of the Interior of the Czech Republic
- discussion and recommendations by the National Innovation Platforms
- comments and suggestions from the regions.

Background material for both missions, explaining the broader context, will be available on the RIS3 portal.

Existing governance structures relevant for the implementation of the entire National RIS3 Strategy (in particular the RIS3 Management Committee, the National RIS3 Team, the National Innovation Platforms, the Expert Group of Support Providers, regional RIS3 teams and ad-hoc expert groups) will be used to coordinate the content definition of the missions, as well as to define the methodology for continuous monitoring and subsequent evaluation.) The outputs of the ongoing project with the Joint Research Centre "Science, Technology and

Innovation Roadmaps for Sustainable Development Goals"[6] should provide a methodological basis for monitoring and evaluation.

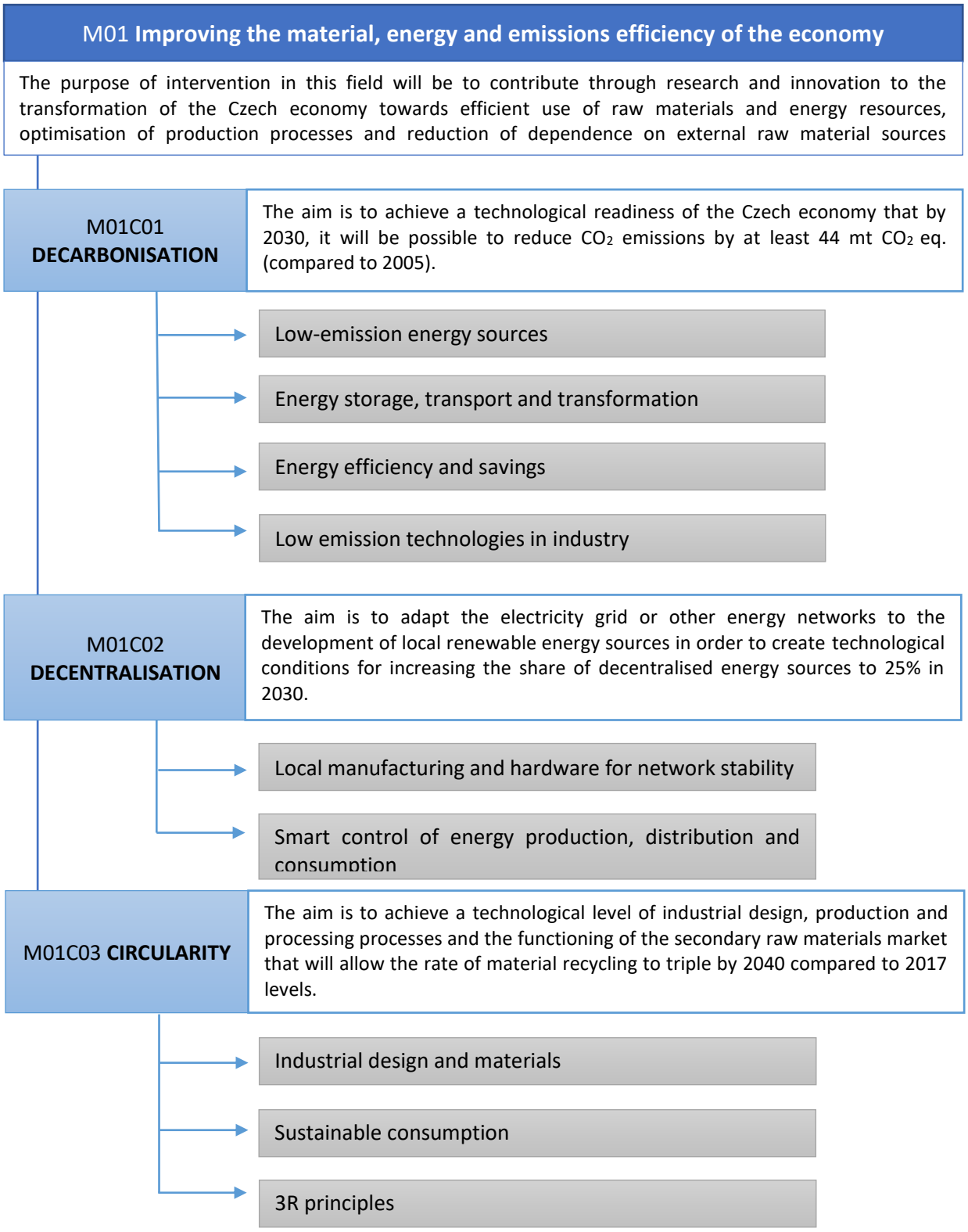
The approved Annex No. 1 to the National RIS3 Strategy is forwarded to the relevant Managing Authorities of the Operational Programmes and to the Managers of the Support Programmes. The RIS3 Managing Committee will receive regular reports from these Managing Authorities and Support Managers on how the thematic definition of the RIS3 missions has been incorporated into the implementation of the programmes, including providing assistance in the subsequent monitoring and evaluation of the missions.

In terms of financial support for missions, the RIS3 Expert Group of Providers is key. It includes providers of support for research, development and innovation (relevant Operational Programme Managers and Support Programme Managers) implementing relevant programmes / calls in the 2021–2027 period. Support for projects fulfilling the mission can be provided through targeted calls, or through a credit under the standard calls of the relevant programme, or through the method of project alignment with the mission, which has the same status as the specialisation domain.

[6]The Czech NRIS3 a pilot European project for linking the RIS3 approach with the Sustainable Development Goals approach (SDG - the Science, Technology and Innovation Roadmaps for Sustainable Development Goals). Cooperation with experts from the JRC continues mainly in preparing a methodology to monitor and evaluate missions.

2.1 The Mission **Improving the material, energy and emissions efficiency of the economy**

The mission "Improving the material, energy and emission efficiency of the economy" was selected in relation to current development trends in the field of energy and raw material resource management and taking into account the key needs of the Czech economy and society related to transformation. The mission is structured into the strategic objectives of Decarbonisation, Decentralisation and Circularity, for the fulfilment of which the themes for



R&D&I have been identified through the EDP.

Mission objective card: **Decarbonisation**

Mission objective	**The aim is to achieve a technological readiness of the Czech economy that by 2030, it will be possible to reduce CO_2 emissions by at least 44 mt CO_2 eq. (compared to 2005).**
Contents	The emphasis on reducing greenhouse gas emissions in the energy sector is related to the pressure on the development and use of l**ow-emission or low-carbon energy sources** (in particular renewable energy and nuclear sources) on the production side and to increase **energy efficiency** on the production and consumption side. The use of new energy sources and their combinations is also linked to the necessary emphasis on the development of technologies for **efficient energy storage, transport and transformation** and solutions to minimise losses. Technologies are also being developed to enable the continued use of fossil fuels without negative impacts on climate change (the use of CO_2 as a feedstock, e.g. in the CCS/CCU technology), with the production of Power-to-X synthetic fuels. The economic and technological intensity of reducing GHG emissions varies between sectors. This is related, among other things, to the trend towards electrification where many sectors, including industry, will seek to use more electricity. Related to the trend towards electrification is the trend towards the interconnection of individual energy sectors and greater integration of the end-use and energy supply sectors. The concept of "mobility as a service" is also very important. Then there are the most emission-intensive **industries** (steel, cement, chemicals), where a significant or major part of the emissions do not come from the combustion of fuels, but from the primary production process itself (e.g. the use of coke in the production of primary steel, the calcination process from clinker production for cement, fossil raw materials for the production of chemicals). In these cases, the objective of the Circularity mission (production of steel based on scrap in electric arc furnaces, reduction of the clinker ratio in cement production, mechanical or chemical recycling of plastics, and replacement of fossil raw materials with alternative ones based on renewable biomass and CCU technology, allowing CO_2 to be recycled into synthetic fuels) will play a crucial role. Decarbonisation must seek a compromise with the Energy and Material Security mission. Therefore, the research must include impact studies of the proposed measures with their preliminary optimisation.
Range of topics for R&D&I	**Low-emission energy sources** Research and innovation activities should focus on three main areas related to the production and use of low-emission energy sources: 1. The safe and socially acceptable development of nuclear energy, where emphasis should be placed on the development of small nuclear reactors (even in a longer term than 2030) and their integration into the energy mix and on reliability, minimising unplanned reactor outages, including analysis of the causes of outages. In this context, it is necessary to ensure the safety of the interaction of different low-emission energy sources (safety zones), including the identification of suitable sites for the installation of small nuclear reactors and related creation of conditions for urban planning. It is essential to make progress in research into the safe storage and recycling of nuclear fuel. In terms of the socially acceptable development of nuclear power and other potentially risky aspects of the new energy mix, emphasis needs to be placed on research into the attitudes and behaviour of society. In the long term (2050+), nuclear fusion research is still promising and emphasis should be placed on the involvement of Czech research teams in larger international projects. 2. Renewable energy sources, where the main challenges for research and innovation activities include the effective integration of these sources into the energy mix, which is possible with adequate strengthening of the

	transmission system and the construction of suitable backup sources of constant power. In addition to material research to make solar and wind power generation technologies more efficient, technological advances are also needed in the field of geothermal energy sources. A research and innovation potential also exists in the field of biomass (including usable bio-waste) biofuels and synthetic fuels using low-emission electricity for use not only in transport but in the energy mix in general. The research must include impact studies of the proposed measures with their preliminary optimisation. 3. Technologies for Climate Neutral Use of Fossil Energy Sources, where emphasis should be placed on technological progress in CCS/CCU technologies and their integration into technology chains for efficient use of coal-based energy sources. Other areas for research and innovation activities are geological sequestration and CO2 storage in building materials. Other important areas are Carbon farming or Agrovoltaics. **Energy storage, transport and transformation** Research and innovation activities should focus on a broader portfolio of energy storage methods such as mechanical, electromechanical, electrical, thermochemical, chemical or thermal. Power-to-X is a promising area for various research and innovation activities, involving many ways of converting surplus electricity (e.g. from intermittent renewables), transforming it and using it in other sectors (e.g. transport or chemical industry). In cogeneration processes, the challenge for research and innovation is mainly to increase the efficiency of waste heat recovery in integrated cogeneration systems. A related area for research and introduction of innovative solutions is industrial thermal energy storage in liquid salts. Hydrogen technologies focus research and innovation activities on the production of low-carbon hydrogen, the safe storage and transport of hydrogen and the integration of hydrogen into the energy mix in transport and industry. **Energy efficiency and savings** Research and innovation activities should focus on the three most important segments of the Czech economy: 1. The energy sector, where emphasis should be placed on research and introduction of innovations in the field of product and process design, improving the energy efficiency of existing production processes and technologies, introducing energy-saving technologies and tools for energy management of manufacturing companies, introducing circularity principles and increasing the share of RES in the energy mix in production or monitoring the carbon footprint. An optimal compromise must be sought between energy consumption and the replacement of human labour in hazardous or routine activities. The research must include impact studies of the proposed measures with their preliminary optimisation. 2. Transport and transport infrastructure focusing on technological and system solutions for mobility, the development of more environmentally friendly techniques and technologies in transport and vehicle production. In terms of system solutions, there is potential in the development of the Mobility as a Service (MaaS) concept, applicable to both passenger transport and logistics, but this will also require new technical solutions on the vehicle side. Carbon footprint monitoring is important. 3. Construction and building materials, with an emphasis on tracking the energy performance of buildings and the emissions footprint across the entire life cycle from design through materials, materials use, procurement

	and construction, to operation and end-of-life (i.e. Whole Life Carbon or WLC), including recycling of usable construction waste. At the same time, there is a need to strengthen the focus on the development of concepts and the introduction of innovative solutions in the field of energy networking in buildings (e.g. community energy sector). **Low-emission and low-carbon technologies in industry** R&D&I should focus, in particular, on alternative technologies in industrial processes where these technologies do not primarily target energy savings or energy efficiency.
Tools	OP JAC Ongoing negotiations with other R&D&I support providers
Monitoring and evaluation	The monitoring will be based on the indicators of individual R&D&I support instruments and together with the evaluation process will use the outputs of the cooperation with JRC.

Mission objective card: **Decentralisation**

Mission objective	**The aim is to adapt the electricity grid or other energy networks to the development of local renewable energy sources in order to create technological conditions for increasing the share of decentralised energy sources to 25% in 2030.**
Contents	Decentralisation and namely the development of intermittent renewables are associated with significantly higher flexibility requirements. The decentralisation trend is also associated with a change in energy flows from a relatively simple model of energy flow (i.e. electricity in particular) from centralised generation plants to final consumers to a significantly more complex model with a relatively large number of decentralised generation plants, largely directly connected to the final consumer. The condition is the strengthening of grids to transfer the necessary power and the construction of backup sources of constant power to stabilize the grid. In this respect, the key trend is digitalisation, enabling the management of these flows and increasing the reliability, quality and safety of electricity supply through smart grids, but also greater involvement of the end consumer through better information and enabling their operational response and interaction with the energy system (in particular smart metering). Another aspect of the digitalisation trend is the relatively dramatic increase in the amount of data transmitted and the number of digitised devices and their expansion into areas where they were not used in the past; in this respect, we are talking about the Internet of Things, which increases the demands on the availability of energy and its quality. The research must include impact studies of the proposed measures with their preliminary optimisation.
Range of topics for R&D&I	**Local manufacturing and hardware for network stability** The challenge for the future is the creation of local communities and the strengthening of the Prosumers Principle, which will enable the localisation of production and consumption and the sharing of resources. The topic of the community energy sector is related to the social aspects of the energy sector transformation and needs to be taken into account, among other things, in legislation. Therefore, research activities should focus on related topics, including the issue of back-up energy sources and the link to centralised energy sources. This may include, among other things, the production, use and consumption of energy and materials. With local communities, resource flows can be closed in smaller locations than they are now. Local communities can be used to pilot test local solutions, e.g. in the form of smart neighbourhoods or living labs. This will be an integral solution on a larger or smaller scale.

	R&D&I should not only cover technical topics The challenge is to find an active and appropriate involvement of local authorities and local action groups. When creating local communities, it is important not to forget about socially sensitive/inclusive alternatives for people who will not be able to cope with new models of engagement for various reasons. R&D&I themes should also include the development of appropriate (and new) funding models for emerging local communities and individual households. Emphasis should also be placed on sharing of resources within a site, the use of local renewables and the use of small and intermittent sources of heat and power where transport over longer distances is not efficient. The use of agrovoltaics and bioeconomy(also e.g. composting technologies, processing of vegetable waste before using it for biogas plants) is also a challenge. They can benefit from low transport costs in local production and promote local sharing and self-sufficiency. The research must include impact studies of the proposed measures with their preliminary optimisation. Residues from production and waste that cannot be used in other ways should be the preferred source of heat and energy generation. **Smart control of energy production, distribution and consumption (electrical and thermal)** Research and innovation activities should focus on preparing models for a centralised and decentralised energy system, its flexibility and readiness for bi-directional energy flows. Energy transport and the provision of smart grids will also be important. Research and innovation activities in smart metering, digitalisation and automation will be important for smart metering, its digitalisation and automation. Cyber-physical systems will also be included. By linking centralised generation with local generation, R&D&I topics will arise for appropriate (probably central) management of the decentralised system. The necessity for a new set of communication and relationships between manufacturers, distributors and customers will also be a challenge for R&D&I. The challenges of ensuring the cyber-security of these systems will necessarily have to be taken into account. It is important to emphasise the application of these research themes to support SmartCities, including the development of central production in territorial units, the sharing of waste management and energy and industrial production as part of smart cities
Tools	OP JAC Ongoing negotiations with other R&D&I support providers
Monitoring and evaluation	Monitoring will be based on the indicators of individual R&D&I support instruments and together with the evaluation process will use the outputs of the cooperation with JRC.

Mission objective card: **Circularity**

Mission objective	**The aim is to achieve a technological level of industrial design, production and processing processes and the functioning of the secondary raw materials market that will allow the rate of material recycling to triple by 2040 compared to 2017 levels.**
Contents	Economic and social development is determined by technological, economic and social changes in the world, including the impacts of climate change, the fourth industrial revolution, shortages of certain raw materials (especially critical ones), reducing water supplies, exponential population growth and increasing pollution.

	A broader transformation of the Czech economy and society towards climate neutrality, zero waste, raw material security and long-term competitiveness also requires significant involvement of circular economy principles in all areas of the Czech economy. It can bring significant material savings in value chains and production processes, significantly reduce greenhouse gas emissions from the production of primary materials (and by that directly contribute to the objectives of the Decarbonisation mission), create added value and new economic opportunities, contribute to the sustainable use of all raw material resources, with an emphasis on the efficient use and eventual recycling of critical raw materials, and strengthen raw material security. Similarly to the energy sector, the principles of the Decentralisation mission (and the requirements for data transfer and processing) will gradually be reflected in the circular economy and material management system, i.e. Decentralisation of material sources (in the form of waste streams, by-products and secondary raw materials as a substitute for centralised production of primary materials), requirements for digital passports and digital twins of products and buildings for recording and tracking materials during the use phase in material banks and for repair and refurbishment purposes are being introduced; there will be a need to link data on these material sources across economic sectors for the optimal functioning of circular models of production, construction, etc. Therefore, research and development activities should focus on fulfilling the principles of sustainable production and consumption and closing, slowing down or narrowing material flows within the scope of priorities set by the Circular Czech Republic 2040 strategic framework, but also by the Secondary Raw Materials Policy of the Czech Republic and the Strategic Framework for Sustainable Development of the Czech Republic.
Range of topics for R&D&I	**Industrial design and materials** Research and innovation activities should focus on two main areas related to industrial design and the use of materials: <u>Design of materials, joining and finishing technologies, and a full product design to enable environmentally friendly product design</u>, with the aim of researching and developing materials and technologies to address very demanding performance requirements in downstream applications, including improved recyclability. These are materials, technologies and designs that promote durability, reliability, reusability, modularity, upgradability and repairability of end products, lower unit material consumption (material efficiency). The material composition and construction of new products and their design should reduce the production of waste in manufacturing, promote higher recycled content of products, the possibility of remanufacturing and recycling, including reuse or even disassembly and application of entire products. <u>Increased use of alternative raw materials</u> aims at integrating more sustainable alternative raw material sources into the production of end products. This involves research into the possibilities of using secondary raw materials, biomass or various waste materials or alternative local raw materials and by-products of industrial production. Within this use, it is necessary to ensure the consistent use of the raw material in the downstream parts of the processing chain, referred to as bio-based value chain. Research into alternative raw materials for production will enable the replacement of current strategic, expensive, scarce, emission-intensive or non-recyclable materials. **Sustainable consumption** Research and innovation activities should focus on strengthening the use of services and products that improve the quality of life while reducing the

consumption of natural resources and emission-intensive primary materials, the use of toxic substances, and the production of waste and pollutants.

The efficiency of the manufacturing process seeks to maximise the use of all resources entering the system, including primary and secondary raw materials, water and energy, waste prevention, the use of by-products during production, etc. Higher efficiency of production processes can also be achieved by better use of resources and energy for production in different production sites or sectors through the development of industrial symbiosis. Digital tools, platforms and artificial intelligence technologies will play a key role in this area.

Circular business models use business strategies that significantly reduce the ecological footprint of production, limit the production of operational waste and make the most efficient use of precious resources. Research and innovation activities should focus on the possibility of retaining ownership of products where the producer leases the product to the customer and is also responsible for the product until the end of its life. This provides an economic incentive to design products that are durable, repairable and upgradeable, and also to maximize the utilization rate of products that are in circulation based on extended service models. Related to this strategy is the extension of product life, which can become a key competitive feature and enables the setting of selling prices. It is also possible to implement business models based on a product design that allows for easy disassembly and efficient recycling. Another key element is the correct setting and consistent implementation of effective criteria and incentives for public (and private) procurement that favour circular and green products, services and construction.

The life cycle analysis (LCA) of manufacturing machines and technologies takes into account the environment and carbon footprint. It involves the development of tools and techniques to understand more accurately how production machines and technologies burden the environment and to be able to better assess different machine designs and use scenarios. It is desirable to be able to introduce these LCA and GHG burden prediction tools into industry and into design and production chains.

3R principles – Reduce, Reuse, Recycle

Research and innovation activities should focus on promoting technologies to increase the efficiency of recycling and recovery processes.

The waste recycling technology emphasises the development of technologies for the mechanical, chemical and thermal decomposition of products (e.g. consumer and industrial goods) into basic raw materials that can be industrially processed and recovered again, or to neutralise harmful substances that may be part of the recycled products. Research should also focus on the possibilities of controlling the quality and usability of secondary raw materials and recyclable products (LCA aspects), on the usability of residual materials, and on technologies for processing plant waste before it passes to biogas plants

The means for efficient recycling allow development and innovation activities to focus on materials research and the development of technologies for digital passports and product data sheets with information on product composition and recyclability, and tools to predict the life cycle of products, expected service interventions, repairs and the expected time suitable for recycling.

When extending the lifetime of products and technologies, we strive for better serviceability, with prediction of service interventions. It is necessary to look for solutions to design machines and technologies with a longer

	lifetime, while addressing better serviceability in terms of time and economic burden and minimal disruption to production use.
Tools	OP JAC Ongoing negotiations with other R&D&I support providers
Monitoring and evaluation	Monitoring will be based on the indicators of individual R&D&I support instruments and together with the evaluation process will use the outputs of the cooperation with JRC.

2.2 The mission **Strengthening society's resilience to security threats**

Due to the current trend of globalisation, there is an evolving need to respond to current and emerging security threats that have different dynamics than before. The purpose of the mission "Strengthening society's resilience to security threats" is to find possible solutions to respond flexibly to developments in society and, in particular, to predict and achieve the ability to prevent emergencies or, after an emergency, to eliminate the consequences and restore the facts to their original state in a higher quality, through the results of R&D&I.

M02 Strengthening society's resilience to security threats

The mission of the interventions is to contribute through research, development and innovation to the acquisition and effective development of innovative knowledge, methods and technologies that enable the security system of the Czech Republic and its stakeholders to face current and future risks arising from the

M02C01 Stability, reliability and sustainability of social, economic and environmental systems

The aim is to contribute to the stability, reliability and sustainability of social, economic and environmental systems in terms of safety and security innovation

- Naturogenic threats
- Ensuring the functioning of the economy
- Anthropogenic threats

M02C02 Reducing risks and increasing resilience

The aim is to increase resilience through research and development and, at the same time, reduce the risk of emergencies and crisis situations that can have a negative impact on individuals and society, thereby increasing the level of resilience of society.

- Safe public space
- Security of infrastructures
- Environmental safety
- Security aspects of new technologies

Mission objective card: **Stability, reliability and sustainability of social, economic, and environmental systems**

Mission objective	**The aim is to contribute to the stability, reliability and sustainability of social, economic and environmental systems in terms of safety and security innovation**
Contents	Assuming that security is a fundamental priority of the state, it is essential to achieve stability, reliability and sustainability of all systems of the state, including democratic, socio-economic, health and social systems and to ensure their functionality. These systems should be able to respond flexibly to security threats (e.g. terrorism, organised crime, espionage, subversion), risks arising from emergencies such as the war in Ukraine, with the primary impact of the energy crisis, and should also achieve a certain level of resilience in order to achieve a sufficient level of resilience for the state and state institutions as well as the general public. Long-term trends and recent developments confirm the crucial importance of systems preparedness to respond to **threats of a naturogenic nature**. The experience with the COVID-19 pandemic has brought to the forefront the need to expand research to respond to health threats (epidemics, epiphytes, epizootics). Climate change and the associated increase in the incidence of various types of natural disasters is a key challenge where efforts to mitigate its impacts on social, economic and political systems need to be viewed both in terms of mitigating the impacts of disasters that have already occurred (droughts, floods, temperature extremes) and in terms of increasing the resilience of systems against their possible outbreak (ensuring a stable water supply, smart cities technology, threats from chemical disasters, etc.) The rapid deterioration of economic forecasts over the med-term in response to the energy crisis and the war conflict in Ukraine demonstrates the need for increased emphasis on **ensuring the functioning of the economic system** in its various aspects (energy, raw materials and industrial security). The destabilisation of the economy at the state and interstate level affects all sectors of human activity, and increasing the resilience of economic infrastructures is a priority that once again presents scope for research in a number of different fields. Effective assurance of the stability and reliability of systems is not possible if **anthropogenic threats** are not adequately taken into account. Disinformation and radicalisation of society can potentially directly undermine the democratic foundations of the state, and the issue of legal migration can contribute to radicalisation while at the same time presenting itself as a space for seeking research solutions to its impact.
Range of topics for R&D&I	Research capacity should focus on topics in the following three areas: • **<u>Increasing the resilience and preparedness of systems to naturogenic threats</u>** The focus in this area should be primarily on solutions contributing to the **mitigation of natural disasters** and the safety, reliability and sustainability of environmental systems, e.g. reduction and prevention of water, soil and air pollution, disruption of the structure and function of important ecosystems, biological invasion**.** For example, **extreme drought**, **inundations** or **floods** are typical threats and pose risks of accidents of naturogenic origin that can be expected to increase based on an analysis of the current situation. At the same time, climate change is increasing the need to find solutions to mitigate the impacts of more frequent **temperature extremes**. In addition to the above-mentioned thematic areas directing research capacities towards finding measures against specific disasters, it is also necessary to view the impacts of climate change in terms of systematically

preparing systems and increasing their resilience to long-term impacts. In this respect, it is desirable to make progress, for example, in the development of **smart cities** technologies, including addressing the risks of industrial accidents, ensuring a stable and safe **supply of drinking water**(water management) for urban and rural areas and agricultural operations, ensuring uncontaminated soil, food security and other related areas such as chemical use and environmental impacts. Natural threats relevant especially for space technology and autonomous transport (drones, autonomous vehicles) – include the danger of **space weather effects.** Last but not least, the study of the evolution of the Covid-19 pandemic should also define a broad scope for the topic of **threats to health** and further development **of the health system**. With respect to pandemics, there is a wide scope for research into measures to contain the spread of disease, the management of key systems under difficult conditions, or the societal impacts of an outbreak **epidemic or pandemic**. In addition, research activities should also focus on the possibility of an epidemic outbreak, which includes **epiphytotics** or **epizootic** should also be the focus of research activities. In addition to research focused purely on epidemiology, the thematic area of health threats must be viewed comprehensively, including the impact of epidemic emergencies on health and social service systems. Research in this area should also help to improve their effectiveness in the event of a sudden increase in pressure.

- **Ensuring the functioning of the economy**

Research activities in this area should comprehensively contribute to increasing the resilience of the economic system with an emphasis on socio-economic specificities on the one hand, and to improving the adaptability and flexibility of the system in case its stability should already be disrupted on the other hand. The military conflict in Ukraine and the related energy crisis have shown the need for new solutions to increase **energy security**. For example, research and development in the field of **smart grids** or technological solutions to stabilise the **energy supply system.** Last but not least, there is a clear need for solutions contributing to the **diversification of energy sources**. In the field of **raw material security**, research capacity should be directed primarily towards solutions that improve the **stability of the material reserve system**, contribute to decentralisation and **diversification of resources**, and **strengthen the resilience of supply chains**. Emphasis must also be placed on **food security**, i.e. the availability of sufficient quantities of good quality food.

Last but not least, increased attention must be paid to research topics in the field of industrial safety. Industrial espionage is a challenge for small, medium and large companies that is becoming increasingly important as technology evolves. At the same time, in the context of the ongoing transformation of industry at a global level, there is an increasing demand for solutions contributing to the mitigation of potential safety risks arising from the increasing **automation of operations**. The issue of preventive and reactive measures in relation to chemical accidents is also an important topic.

- **Increasing the resilience and preparedness of systems to anthropogenic threats**

This area offers a space for primarily, but not exclusively, social science research aimed at enhancing the stability and resilience of political, social, democratic and socio-economic systems. A focus on tools to analyse and **mitigate the impact of the spread of disinformation** can help to increase confidence in the democratic foundations of the state and the political system as a whole. A complementary thematic area of research is the **radicalisation of society** and its security aspects. In a broader sense, both of

	these areas cover the research topic of societal impacts of hybrid threats on the population. Last but not least, research capacity should focus on legal migration and its impact in areas such as **border security and monitoring**, social and economic implications, and possible measures for more effective implementation of migration policies. This is also linked to research efforts to make health and social systems more resilient in the event of a sudden increase in pressure caused by migration.
Tools	OP JAC Programmes of the Ministry of the Interior of the Czech Republic Ongoing negotiations with other R&D&I support providers
Monitoring and evaluation	Monitoring will be based on the indicators of individual R&D&I support instruments and together with the evaluation process will use the outputs of the cooperation with JRC.

Mission objective card: **Reducing risks and increasing resilience**

Mission objective	**The aim is to increase resilience through research and development and, at the same time, reduce the risk of emergencies and crisis situations that can have a negative impact on individuals and society, thereby increasing the level of resilience of society.**
Contents	The purpose of the Reducing risks and increasing resilience objective is to define individual thematic domains that will focus on issues directly related to security, but at the same time interfering with other responsibilities of R&D&I support providers. The first key area is the **safety of public space**s, involving both research into purely physical features that should make selected spaces more resilient, and educational activities and long-term planning opportunities that could contribute to more resilient communities in selected locations. The second priority area of research is the **security of infrastructures**, which again must be understood in a broader sense as a wide spectrum of types of social, economic and physical systems whose disruption can have major impacts on the security of the state. In particular, attention should be paid to transport and digital infrastructures, and the security aspect of space research is included in this broader concept of infrastructures. To some extent, following certain topics of the Naturogenic Threats category of Objective 1, the complementary category of **environmental security** also belongs under the objective of Reducing risks and increasing resilience. Increased resilience can be achieved in the area of meteorological research, in the area of resilience of people and goods to hazardous substances, and in the cultural and economic domain of illegal trade in endangered species. Last but not least, to increase resilience and reduce risks, it is essential to focus on the **security aspects of new technologies**, a topic that appears in some aspects in practically all the thematic areas listed above, but whose importance requires that it has its own position within the objective. Research topics offered here are mainly in the field of artificial intelligence, emerging technologies and selected aspects of cyber security.
Range of topics for R&D&I	• **Safe public space** Research activities in this area can focus on a number of aspects of public space security, which is viewed here in a broader sense. The resilience of public spaces can be increased primarily by **physical elements** (e.g. barriers, lighting, cameras) to ensure the protection of property and public goods, but can also include innovative measures and conceptual approaches to protect

	soft targets. These are complemented by the area of **public education and preparedness**, serving to increase societal resilience to a range of threats. At the sub-national level, importance should also be attached to proposals to **streamline security planning**, for example in the case of municipalities, regions or large companies. Equally important to the topic of safe public space is the area of Legal Regulation. • **Security of infrastructures** In this area, infrastructures should be conceived in a truly comprehensive way. On the one hand, research should focus on increasing the stability and **resilience of transport infrastructures** (road, rail, air) and **telecommunications infrastructure**, for example by researching **new material**s, but also by measures and proposals to improve **operational safety management** or other control elements. **Safety aspects of space research** are also a special category, where, in addition to new materials and controls (software, etc.), there are many other aspects requiring risk reduction. The area of **digital infrastructures** is closely related to the issue of cyber security; however, here it is conceived in a broader sense as a distinct area containing specific challenges that can be addressed through the research process. • **Environmental safety** The thematic areas in this category are complementary to the research topics related to naturogenic threats from Objective 1. Research capabilities here can be aimed at increasing the resilience of society and infrastructures through **research on the Earth's atmosphere and near space environment,** or **increasing the resilience of people and assets to hazardous substances** such as chemical disasters and chemical hazards. This includes, for example, the issue of **detecting** and reducing the risk of potential **industrial accidents** At the same time, the research should address the topic of **illegal trade in endangered species**, not in the criminal sense, but rather in conceptual-policy or regulatory terms. • **Security aspects of new technologies** To some extent, the topics in this area embrace virtually all of the other thematic areas contained in this mission. However, their relevance to security and other systems is significant enough to deserve substantial attention from research teams. A fundamental topic here is the **security aspects of artificial intelligence**, which in the long term will be involved in an increasing number of systems in the private and public sectors, so we can assume a high relevance of research results with this focus. A related issue is **emerging technologies**, where research capacities should be spent, for example, on research into cryptocurrencies, blockchain, big data analytics and others. Last but not least, attention should also be paid to **cybersecurity**, which offers, for example, ensuring the cybersecurity of financial institutions, private companies and other non-state actors and the related area of **educating vulnerable groups** (e.g. children, seniors) about cyber threats.
Tools	OP JAC Programmes of the Ministry of the Interior of the Czech Republic Ongoing negotiations with other R&D&I support providers
Monitoring and evaluation	Monitoring will be based on the indicators of individual R&D&I support instruments and together with the evaluation process will use the outputs of the cooperation with JRC.

3. The projection of RIS3 in support instruments

In its latest updated version, Annex 1 is mainly used by providers of R&D&I support for preparing calls and instruments to be implemented in accordance with the National RIS3 Strategy (NRIS3).

The variants of projection of RIS3 priorities into support instruments (National RIS3 Document, Chapter 5.3.)

Option 1: Consistency with the RIS3 specific objective

These *horizontal interventions* target cross-cutting or systemic measures that are aimed at improving the basic background necessary for the functional development of the country's strengths and its knowledge and innovation potential. A necessary condition is a link to at least one of the RIS3 specific objectives.

Chart of the objectives of the National RIS3 Strategy

Key areas of change

Research, Development and Innovation	Public research and development	People and smart skills	Digital agenda
Strategic objectives			
A. Increasing the innovation performance of companies	**B. Improving the quality of public research**	**C. Increasing the availability of skilled people for R&D&I**	**D. Increasing the use of new technologies and digitalisation**
Specific objectives			
A.1 Strengthening the innovation performance of existing companies and responding to industrial transformation, technological and societal changes	B.1 Enhancing the quality and societal relevance of public research	C.1 Improving the capacity of the education system to prepare people for research, development and innovation	D.1 Promote digitalisation and the use of new technologies in business
A.2 The establishment and growth of new companies and the exploitation of new opportunities	B.2 Improving the quality of the environment for public research	C.2 Developing skills for smart specialisation, industrial transformation and entrepreneurship	D.2 Promoting digitalisation and the use of new technologies in the public sphere
A.3 Improving the functioning of innovation ecosystems at the national and regional levels		C.3 Increasing the potential and motivation of staff in research organisations	

Option 2: Alignment with a specialisation domain

Option 3: Alignment with a topic in the area of key enabling and newly emerging technologies within a specialisation domain

Option 4: Targeted call for R&D&I topics within a specialisation domain

Verticalised or thematic calls/programmes and targeted calls require consistency with the specialisation domain and must be linked to the R&D&I themes listed under each domain. This means that in the case of such calls it is important that the project focuses on at least one of the R&D&I topics defined for each specialisation domain (see the schematic representation in the following figure).

To promote interdisciplinarity in projects, intervention parameters may combine binary and credit criteria in line with RIS3 priorities.

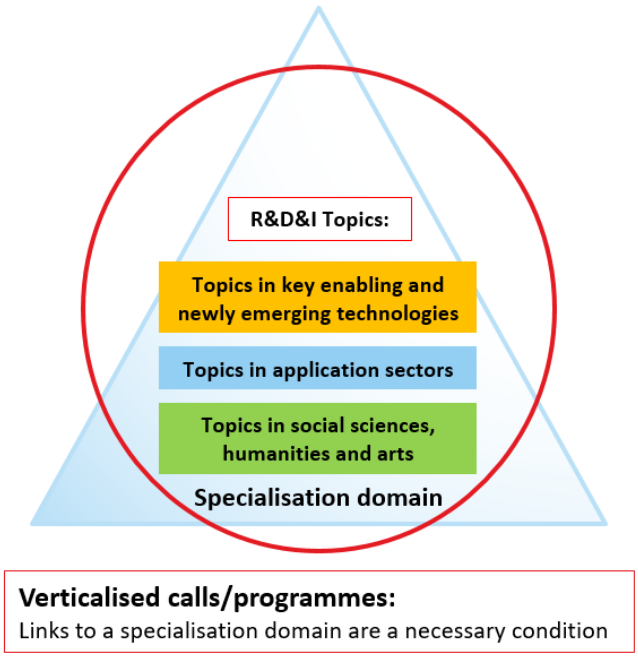


Figure 2 Alignment with a specialisation domain

Option 5: Targeted call for missions

A specific subset of targeted calls are calls for thematic missions aimed at addressing problems arising from a selected societal challenge through research, development and innovation.

Alternatively, topics that fall under the missions can be taken into an account through awarding bonuses in standard calls.

The R&D&I topics will be used in the monitoring system code lists for the EU Funds (MS2021+). In each call, support providers will thus be able to determine which attributes of projects applying for support will be mandatory or optional. Based on these attributes, it will then be possible to monitor the fulfilment of the RIS3 strategy.

3.1 RIS3 Code-Lists

In collaboration with the Ministry of Regional Development (MRD-NCA), the Ministry of Industry and Trade prepared a system for project data collection (data sets) in operational programmes with links to the RIS3 Strategy. Data will be obtained through a data connection with the MS2021 monitoring system.

Monitoring of the RIS3 strategy is set up in a way that, among other things, includes PROJECT SETS for operational support programmes, which allow for all individual projects with a link to the RIS3 Strategy to identify the **sources and scope of financial support** for the following seven RIS3 entities:

- *specific objectives of the RIS3 Strategy;*
- *RIS3 Strategy specialisation domains;*
- *R&D&I strategic topics;*
- *key enabling technologies (KETs);*
- *R&D&I topics in social sciences and humanities;*
- *regional domains of specialisation in support schemes designed to give support to disadvantaged and deprived regions in the Czech Republic;*
- *RIS3 Missions.*

To meet the above requirement on the monitoring of the RIS3 Strategy, all projects under calls linked to the RIS3 Strategy will be marked in the MS2021 system with the RIS3 attribute and assigned to the above entities according to their substantive focus as designated in seven **RIS3 code-lists** (see Figure 2).

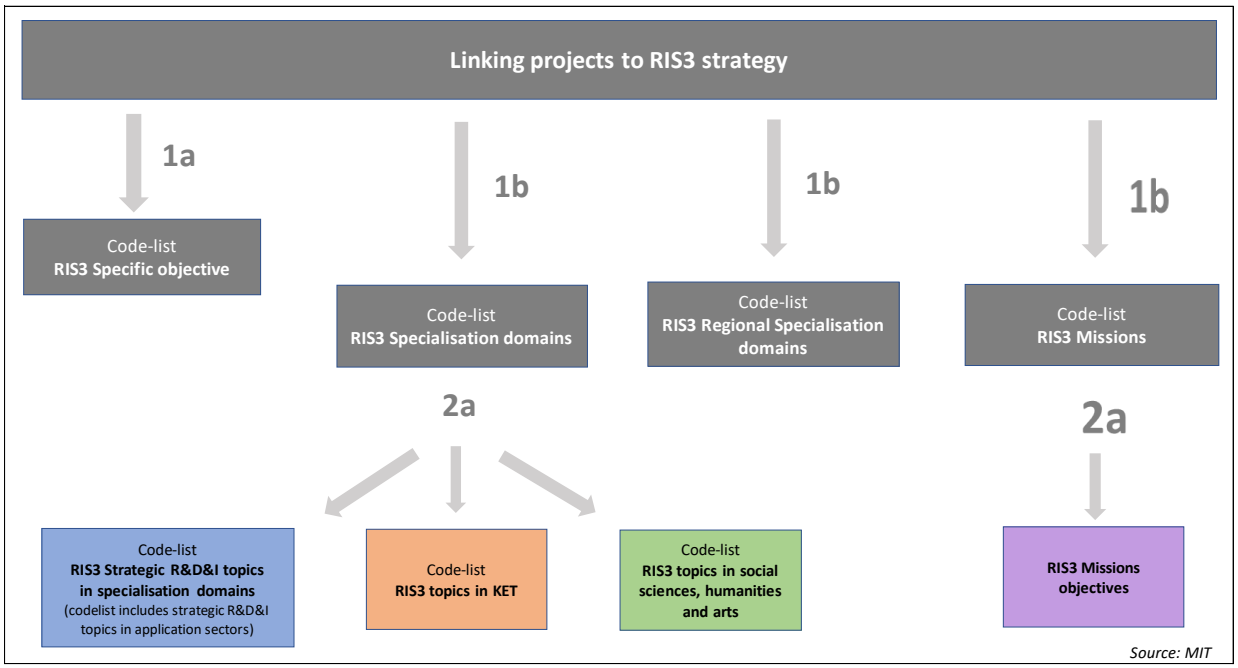


Figure 3 The structure of RIS3 code-lists

1a At the call level linked to the RIS3 Strategy, the respective managing authority for the operational programme must select at least one entry from the **RIS3 Specific Objective** code list. In each grant application, each project **must fulfil** at least one specific objective of the RIS3 Strategy according to the RIS3 code list. If a project fulfils a number of specific objectives of the RIS3 Strategy, applicants must determine in what ratio the project's expenses are to be distributed among the individual specific objectives (totalling 100%).

Note: Details on the individual specific objectives of the RIS3 Strategy are provided in the text of Annex 3 Monitoring Indicators and Financing (version 4).

1b For all projects under calls linked to the RIS3 Strategy's specialisation domains, the respective operational programme managing authority must select at least one entry from the **RIS3 Specialisation Domain** code list. If more than one specialisation domain is selected, applicants are obliged to choose at least one domain of specialisation. If a project supports a number of specialisation domains in the RIS3 Strategy, applicants must determine in what ratio the project's expenses are to be distributed among the individual domains (totalling 100%).

Note: Details on the individual RIS3 specialisation domains are provided in the relevant chapters.

Code lists linked to RIS3 specialisation domains

2a When preparing a call **linked to** an RIS3 specialisation **domain**, the project must always include at least one entry of the linked code lists below:

- **RIS3 Strategic R&D&I specialisation domain topic,**
- **RIS3 KET**,
- **RIS3 R&D&I topics in the area of SSH**.

In a call linked to an RIS3 specialisation domain, the respective managing authority may determine combinations in which the above code lists can be used in projects – however, at least one code list (one entry in the code list) must be used.

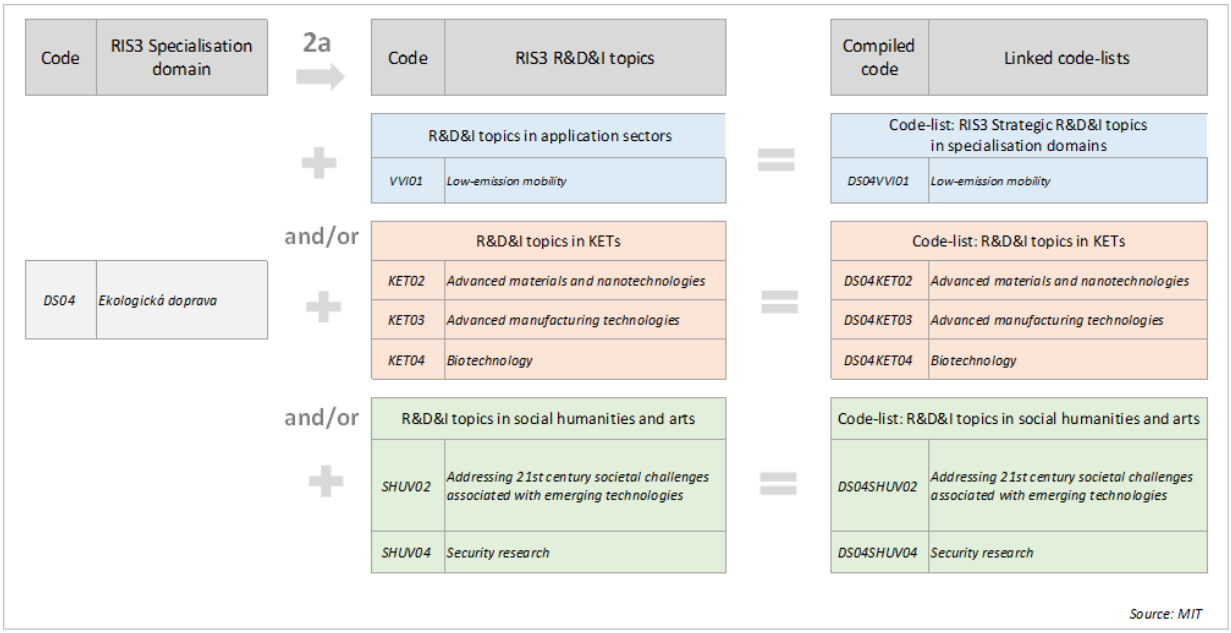


Figure 4 Example of code-linking in the specialisation domain of Environmentally friendly transport

Strategic R&D&I topics under RIS3 are topics that have the potential to support industries within the specialisation domains towards better prosperity and improve the competitiveness of the Czech Republic. Strategic topics include the sub-topics of R&D&I that either emerged from analyses or are newly proposed within the EDP. The division into strategic and sub-topics is intended to make the RIS3 Strategy clearer and to create more acceptable material for providers of R&D&I subsidy support, who can thus better target interventions for applied research in the Czech Republic.

The areas of **KET research and development**, together with their potential for application in individual specialisation domains, were defined based on conducted analyses and inputs from the EDP.

The initial starting point for proposing **research topics concerning social sciences and humanities (SSH)** were mainly the proposals drawn by the 'MIT expert group for identifying priorities in the area of social sciences and humanities and social challenges', which were supplemented by other topics based on discussions of the National Innovation Platform members and suggestions from the self-governing regions. However, for the purposes of submitting project applications and monitoring the support provided, the composition of these topics was very diverse, and users found it difficult to use. Therefore, the SSH research topics were consolidated to form four overarching R&D&I topics that can integrate all existing, previously identified SSH research topics. The basic distinguishing feature of the first two topics is their relationship to the time horizon of their implementation, or the degree of their novelty and risk: **firstly**, whether the research addresses the implications of current technologies and innovations and their relationship to society, whether it builds on already implemented topics in an innovative way, or **secondly**, whether the research addresses potential threats and possible impacts that might occur in the future, i.e. whether it raises and opens up entirely new research topics. The **third** aspect is research on the systemic conditions that make it possible to introduce innovations, or as the case may be, barriers on the part of the individual and the societal system. The **fourth** specific topic is security research.

Note: Details of the individual Strategic R&D&I themes, KETs R&D themes and SSH R&D themes are provided in the relevant chapters.

1b The selection of regional domains of RIS3 specialisation only applies to specific integrated territorial investment (ITI) calls announced under the Operational Programme 'Technology and Application for Competitiveness' (OP TAC) and the Operational Programme 'Jan Ámos Komenský' (OP JAK). It also applies to calls announced under the Operational Programme 'Just Transition' (OP JT) with a specific link to the RIS3 Strategies of the Karlovy Vary, Ústí nad Labem and Moravian-Silesian Regions. For all above calls, the respective managing authority for the operational programme must select at least one entry from the **RIS3** code list of **regional domains of specialisation**. If more than one specialisation domain is selected, applicants are obliged to choose at least one regional domain of RIS3 specialisation. If a project supports a number of regional domains, applicants must determine in what ratio the project's expenses are to be distributed among the individual domains (totalling 100%).

The place of project implementation must be in the same region as the respective regional domain of RIS3 specialisation.

Note: Details of the regional domains of specialisation are provided in Annex 2 of the Regional RIS3 Strategy Cards (version 4).

1b For all projects under calls linked to the **RIS3 Mission**, the respective managing authority for the operational programme must select at least one entry from the RIS3 Mission code list. If a project supports a number of RIS3 Missions, applicants must determine in what ratio the project's expenses are to be distributed among the individual missions (totalling 100%).

Code lists linked to RIS3 Missions

2a When preparing a project with a focus on **RIS3 Missions**, the project must always include at least one entry from the linked RIS3 mission objectives below:

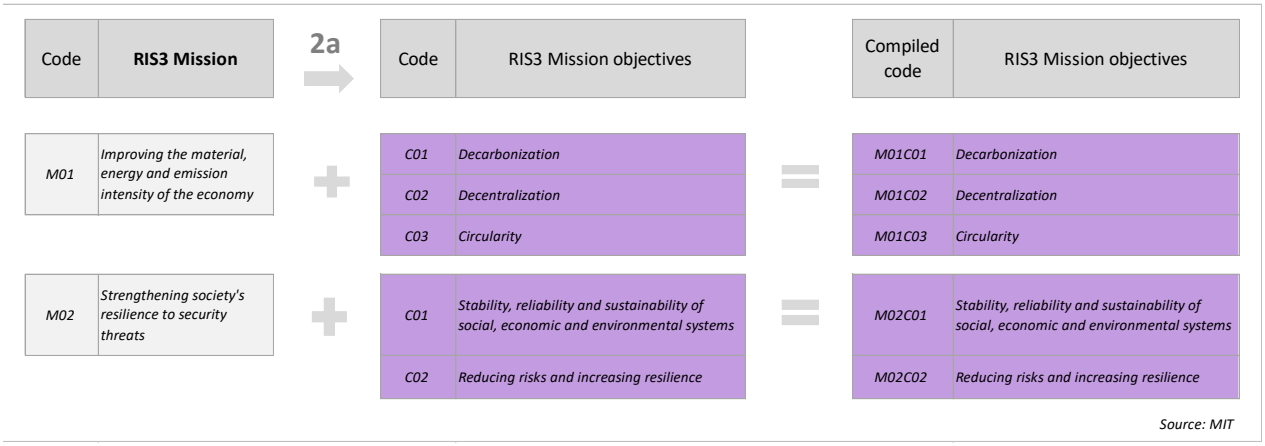


Figure 5 RIS3 Mission Code-List