REPUBLIC OF BULGARIA

MINISTRY OF TRANSPORT,

INFORMATION TECHNOLY AND COMMUNICATIONS

CONCEPT FOR THE DEVELOPMENT OF ARTIFICIAL INTELLIGENCE IN BULGARIA UNTIL 2030

Artificial intelligence for smart growth

and a prosperous democratic society

OCTOBER 2020

SUMMARY

The current draft Concept for the Development of Artificial Intelligence (AI) in Bulgaria until 2030 is in line with the documents of the European Commission, which consider artificial intelligence as one of the main drivers of digital transformation in Europe and a significant factor in ensuring the competitiveness of the European economy and high quality of life.

The specific aspects of the European vision of "reliable AI", in which technological progress is accompanied by a legal and ethical framework to ensure the security and rights of citizens, as well as measures to collect accessible high-quality data, disseminate information and equal access to the benefits of AI technologies. An overview of the three main types of sectors is made in relation to the creation and use of AI - sectors developing AI, consuming AI and enabling the development and implementation of AI.

Prerequisites and challenges for the development of AI in Bulgaria in the next decade are presented. The state of the Bulgarian ecosystem in the field of AI is considered, followed by SWOT analysis. The goal of the Concept for the development of AI in Bulgaria (**AI-BG**) and the related sub-goals are defined. The main areas of impact and specific measures have been identified: building a reliable infrastructure for AI development, including data infrastructure; development of research capacity for scientific excellence; creation of knowledge and skills for the development and use of AI; support for innovation to implement AI in practice; raising awareness and building trust in society; creating a regulatory framework for the development and use of reliable AI in accordance with international regulatory and ethical standards.

Possible priority sectors are listed with arguments about their importance. The main statements related to the implementation, monitoring and financing of the activities are outlined. It is proposed to establish an Interdepartmental Working Group, which will include representatives of key state institutions, district administrations, academia, business and professional associations, as well as related non-governmental organizations. Its task will be to analyze the overall state of the sector and to prepare an operational National Plan / Roadmap for the implementation of the Concept, which will determine the specific measures, deadlines, responsible institutions and organizations, expected results and indicators, sources of necessary financial resources and organization for performance reporting and periodic updating.

This concept is based on documents developed by a team of the Bulgarian Academy of Sciences (BAS) and external experts: A National Strategy Framework for the Development of Artificial Intelligence in Bulgaria (2019) and Strategy for the Development of Artificial Intelligence in Bulgaria until 2030 (preliminary vision) (2020).

CONTENT

LIST OF ABBREVIATIONS AND ABBREVIATIONS

AI	Artificial Intelligence
COM	Communication from the European Commission to the European Parliament, the Council, the Economic and Social Committee and the Committee of the Regions
DESI	Digital Economy and Society Index
GDPR	General Data Protection Regulation
BAIA	Bulgarian Artificial Intelligence Association
BAS	Bulgarian Academy of Science
BASSCOM	Bulgarian Association of Software Companies
SEGA	State e-Government Agency
SARI	State Agency for Research and Innovation
EC	European Commission
EU	European Union
BSMEPA	Bulgarian Small and Medium Enterprises Promotion Agency
AI	Artificial Intelligence
AI-BG	Concept for the development of artificial intelligence in Bulgaria 2030
ICT	Information and Communication Technologies
ISSS	Innovative Strategy for Smart Specialization
MI	Ministry of Interior
ME	Ministry of Energy
MH	Ministry of Health
MAFF	Ministry of Agriculture, Food and Forestry
MoE	Ministry of Economy
MoD	Ministry of Defence
MoES	Ministry of Education and Science
MOEW	Ministry of Environment and Water
MoJ	Ministry of Justice
SME	Small and Medium Enterprises
MTITC	Ministry of Transport, Information Technology and Communications
MLSP	Ministry of Labor and Social Policy
MoF	Ministry of Finance
EQD	Educational Qualification Degree
OP SESG	Operational Program Science and Education for Smart Growth 2014-2020

1. INTRODUCTION

The definition of smart systems in the European Commission's (EC) report “Science, Research and Innovation Performance of the EU 2020: A Fair, Green and Digital Europe” [3][1] states: "**Artificial Intelligence (AI)** systems are software (and possibly also hardware) systems designed by humans that, given a complex goal, act in the physical or digital dimension by perceiving their environment through data acquisition, interpreting the collected structured or unstructured data, reasoning on the knowledge, or processing the information derived from this data and deciding the best action(s) to take to achieve the given goal. AI systems can either use symbolic rules or learn a numeric model, and can also adapt their behaviour by analysing how the environment is affected by their previous actions.” The term AI refers to both the thriving scientific discipline of "artificial intelligence", which emerged in 1956, and the technological phenomenon of modern intelligent systems, which analyze their environment and - with some independence - take action to accomplish their tasks. For the practical purposes of this concept, AI is a "set of technologies that combine data, algorithms and computing power" [4], which has the potential to transform key sectors of industry, services and society as a whole.

The growing capacity of computing infrastructure and the emergence of very large volumes of data are a major reason for recognizing that Europe's sustainable economic growth and prosperity will increasingly rely on the deployment of smart systems and the economic benefits of data processing. However, the use of AI technologies poses a number of potential risks, such as non-transparency of the decision-making process, violation of privacy, criminal use or simply rejection and rejection by citizens due to the requirements for higher qualifications or fear of change in the labor market. In the context of global competition for a leading role in the development and implementation of AI, the EC is committed [5] to helping to achieve scientific breakthroughs, to maintaining the technological leadership of the European Union (EU) and to ensuring that new technologies will be at the service of all Europeans in order to improve their lives while respecting their rights. The Commission also calls on the Member States to contribute to building a European "ecosystem" for the development and use of AI in full respect of citizens' values and rights.

At European level, AI is a component of the **Digital Europe** Programme [6], which aims to bring about a digital transformation in the EU in the period 2021-2027, with maximum benefits for businesses, public administrations and society. The policies of the Digital Europe Programme focus on five main areas: *High-performance computing (HPC); Artificial Intelligence (AI); Cybersecurity and Trust; Advanced Digital Skills; Interoperability and Digital transformation*. AI is a basic digital technology that must become widely available and used by business, the public sector and all European citizens.

AI will also significantly support the development of automation and data exchange in production technologies, which will achieve a digital transformation in industry (the so-called

[1] *Note*: The designations [1], [2], [3], ... in the text are references to the number of documents in Part 8, where a bibliography of the sources used is given.

Industry 4.0 [7]). Autonomous cyberphysical systems and the functioning of the Internet of Things in real time will be the basis for the emergence of virtual productions and smart factories. The EC is already addressing issues related to safety and responsibilities in the implementation of robotics and autonomous systems with AI [8].

The European approach to the development and use of AI is characterized by a **unique vision -** technological progress to be accompanied by a legal and ethical framework to ensure the security and rights of citizens, as well as measures to collect accessible data of high quality, wide dissemination of information, and equal access to the benefits of AI technology.

Europe aims to become a world leader in **"trustworthy AI"**, in which AI applications follow certain ethical standards and do not cause intentional or accidental harm even when they are handled by people with minimal technical knowledge. This would increase public confidence in European AI, developed in a unique **"trust ecosystem"**, and motivate industry to offer products and services where reliability is a competitive advantage. Ethical norms will be an incentive for new research, scientific breakthroughs and innovation in AI. In this way, the EU will set global standards for AI. The High-Level Expert Group on Artificial Intelligence (AI HLEG)[2] in 2018 identified ethical principles and related values that should be respected in the development, implementation and use of AI systems: the principle of respecting human autonomy, the principle of prevention of harm, the principle of fairness and the principle of explainability [9]. In 2019, the EC published seven key requirements [10] that AI applications must meet to be considered reliable:

human agency and oversight – AI systems should not impair human autonomy and cause other adverse effects;

technical robustness and safety – the physical and mental safety of AI systems to be verified at all stages by all parties concerned;

privacy and data governance – the data is free from inaccuracies or errors and does not reflect social prejudices;

explainability and transparency – to record and document both the decisions taken by the AI systems and the whole process that led to these decisions;

diversity, non-discrimination and fairness – to ensure universal design for equal access for people with disabilities;

societal and environmental well-being – to monitor the social impact of AI, as well as the sustainability and environmental responsibility of AI systems;

accountability – to ensure responsibility and accountability for AI systems and their outcomes, to minimize potential negative impacts.

Regarding the technical stability and security of AI systems, a number of recommendations and specific requirements have been set for new types of risks and vulnerabilities: possible covert attacks through data manipulation and decision-making mechanisms, as well as abuses of the “black box” effect due to the use of machine learning and big data. The essential difference between AI systems and "traditional" information and

[2] https://ec.europa.eu/digital-single-market/en/high-level-expert-group-artificial-intelligence

management systems is that in AI it is not always possible to explain why a model has led to a specific result or solution, and what combination of input factors has contributed to this. In these cases, the algorithms are likened to a "black box" and the principle of "explainability" is proposed, which is directly related to the "transparency" requirement and is essential for building and maintaining citizens' trust in AI applications. Processes must be transparent, the capabilities and purpose of AI systems must be openly communicated, and decisions must be explained, to the extent possible, to those directly or indirectly affected by them. Other explanatory measures are also proposed (traceability, auditability and transparent communication about the capabilities of the system). The approach in the "self-assessment list" of AI systems published by the EC according to the seven key requirements is also based on risk assessment depending on the degree of criticality in using AI systems and the solutions they offer, the dependence on their correctness and possible harmful consequences. The latest version from July 2020 of the Assessment List for *Trustworthy Artificial Intelligence (ALTAI)* [11], developed by the High-Level Expert Group on AI, also offers an online self-assessment platform to raise awareness and knowledge of implementing organizations and companies (especially small and medium-sized businesses) on the risks and methods of prevention.

Regarding the need to develop and implement AI-specific standards, the EC has published a Rolling Plan for ICT Standardization [12], which includes an AI section with five specific measures to coordinate actions between Member State and EU institutions on policies, requirements and investments, as well as coordination with international standardization organizations and world practices. A special section is devoted to the specific aspects of AI cybersecurity, identification of gaps and necessary standards regarding security, safety and protection of personal information in AI systems, the possibilities of using AI for cyber protection, as well as the specifics of protection against malicious use of AI. From the beginning of 2020, special groups have been set up in European standardization organizations - for example, the *ETSI Securing Artificial Intelligence group* (European Telecommunications Standards Institute). An expert group on Artificial Intelligence Cybersecurity has been set up at the European Union Agency for Cyber security (ENISA).

Data is an important raw material for AI and a key prerequisite (along with computing infrastructure) for the development of new algorithms and applications. The EU has strict rules on the use of personal data (GDPR) [13], which make it difficult to access information for citizens, for example in healthcare. In order to facilitate the collection of large volumes of anonymised personal, non-personal and public data and to make them accessible to all interested parties [14] [15], the EC plans to create **European Data Spaces** [16] as an initiative shared with Member States. This is an extremely challenging task due to the need to standardize formats and ensure interoperability, especially given that some of the data is in free text in different languages.

In order to facilitate the widespread dissemination of AI and equal access to new technologies for citizens and small and medium enterprises, the EC will establish **World-class AI Reference Testing and Experimentation Facilities** in several areas: hardware, software, components, systems, data, computing infrastructures and cloud computing [17]. These facilities will provide a highly specialized network of shared resources at European level and

will support the implementation of AI in healthcare, smart agriculture, robotics, manufacturing, smart cities and more.

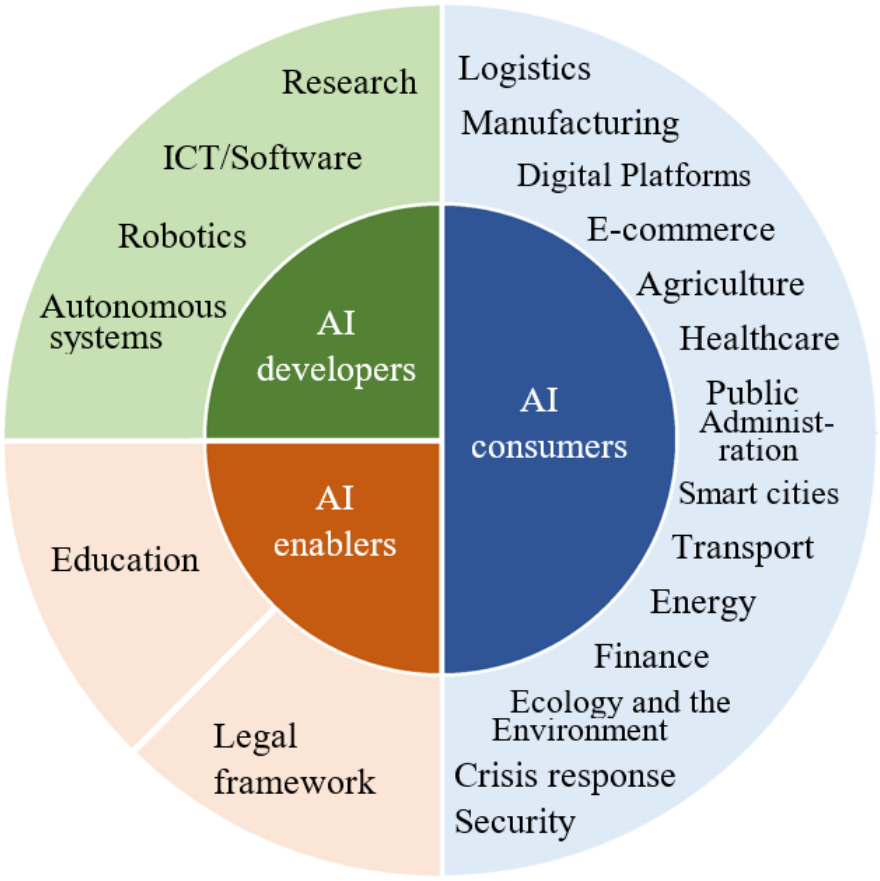
Along with developing an ethical and legal standard for AI, the EU will build a **"high-performance ecosystem"** throughout the value chain, starting with scientific research and innovation. The activities of related Scientific Research Centers of Excellence will be supported and coordinated and it will be ensured that at least one Digital Innovation Hub specialized in the field of AI is set up in each Member State. However, Europe's ambitious agenda must be realized over the next decade in competition with superior US and Chinese investment plans [18] and in an aggressive battle for markets with the products of technology giants such as Google, Amazon, Microsoft and others which currently dominate the development of most leading AI technologies [19]. Achieving a scale requires a pan-European approach to AI that will prevent the fragmentation of the European Research Area and the single market. Member States are invited to draw up national AI strategies or programs, or to integrate this dimension into other related strategies and programs, outlining the envisaged investments and implementation measures [20].

The current draft Concept for the Development of AI in Bulgaria (**AI-BG**) for the period 2020-2030 follows the guidelines outlined by the High-Level Expert Group on AI in the document "Policy and investment recommendations for trustworthy AI" [21]. The main areas of impact are building AI infrastructure, developing scientific research capacity and adequate digital skills, supporting innovation, developing a legal framework, increasing public confidence, and focusing specifically on selected priority areas for individual countries. Examples of priority areas are often cited as health, agriculture, public administration and transport. The EC documents do not discuss the use of AI for military purposes - for example, the development of autonomous weapons, which does not preclude the development of such scientific research and applications at the national level.

The areas of impact, priorities and activities proposed in the **Concept** take into account the Bulgarian strategic and normative documents created so far, which address the digital transformation of the economic and public sectors, upgrading them with specific measures for the development of AI in our country.

2. AI AS A DRIVER OF DIGITAL TRANSFORMATION FOR ECONOMIC GROWTH AND QUALITY OF LIFE

The rapid entry of AI is radically changing a number of sectors of the economy and society as a whole. Although the ideas and some fundamental techniques of AI originated long ago, today, as a result of the accumulated computing capacity, communication potential and big data, the world is facing transformations that are much more far-reaching than the technological revolution of the last century. Changes do not happen at the same pace in different sectors due to different degrees of readiness of AI technologies for implementation, insufficient readiness of the sector to accept them, especially if solid financial investments are required, unclear regulatory framework, lack of staff, lack of consensus in the professional community, consumers or society as a whole and others. The countries with high-tech economies and a high level of computer skills of citizens are most dynamically implementing intelligent systems. However, daily news shows that AI as a key tool for development is also entering Bulgaria, often as an imported product with limited use and, albeit more slowly, becoming a catalyst for digital transformation.



Sectors and their connection with the creation and use of AI

Regarding the creation and use of AI in different industries, three groups of sectors stand out:

- Artificial Intelligence developing sectors;
- Artificial Intelligence consuming sectors;
- enabling the development and implementation of Artifiicla Intelligence;

2.1. Artificial Intelligence developing sectors –research

Excellence in fundamental and applied research in AI, ICT, robotics, autonomous systems and other related fields, which create and test reliable AI technologies, is one of the main factors for Europe's intellectual and commercial leadership. Currently, European scientists publish most articles with scientific and applied results in the field of AI (over 27% of the global scientific production in Scopus for 2018 [22]), but they work mainly in relatively small and fragmented scientific units, which calls for the unification of the European research community through enhanced international cooperation and targeted funding, talent retention mechanisms in Europe and the implementation of sustainable technology transfer schemes to industry through public-private partnerships.

Research fields in which the largest increase in the number of published articles is observed are: machine learning, including deep learning; natural language and speech processing; machine vision; AI in cyberphysical systems and robotics (US $ 7.7 billion was invested in self-driving vehicle research in the world in 2019 [22]); cognitive systems. Other research areas of strategic importance are: development of AI-algorithms for chips embedded in Internet of Things devices; creating a hybrid AI with capacity for inference and learning as the core of systems capable of explaining; development of algorithms for learning facts from small data sets, etc. The capacity of AI systems to draw inferences over big data is expected to increase significantly in the coming decades [23]. The improvement of AI presupposes the development of the basics of ICT and will lead to the emergence of a new generation of technologies. AI is already beginning to be used for software development, which allows automatic synthesis of program code.

The European High-Level Expert Group recommends the establishment of a Strategic Roadmap for AI research in the EU, outlining the specialized and interdisciplinary scientific problems and major research challenges. The map should be regularly updated and guide research in the EU to achieve reliable AI, helping to harmonize Member States' research programs [21].

2.2. Artifical Intelligence consuming sectors

Practically every sector using digitization is a potential consumer of a type of AI, because the implemented computer systems can incorporate intelligent services or devices for automation of routine repetitive activities. This also applies to large and medium-sized industrial organizations, which typically generate big data. SMEs are also potential users of AI,

which helps analyze customer data and offers ways to personalize services and products. A survey on the perception of AI in companies [24], conducted in December 2019 with representatives of 25 industries shows that 85% of respondents with the largest share of the software industry, followed by finance and banking, are interested in AI. AI is mainly used for analysis or is integrated into the production process. The biggest obstacle to the implementation of AI is the lack of support from the organization.

Here are examples of the various ways in which AI is transforming industry, services and society today and the expected changes in the near future.

E-Commerce: This seems to be the sector with the most widespread use of AI at the moment. Global e-commerce platforms track customer choices, accumulate profile data for each individual customer, and offer a personalized selection of preferred products. Geo-targeted promotions with language localization and automatic price optimization allow worldwide sales. Automatic dialog assistants with the ability to recognize natural language speech with good accuracy, also called chatbots, provide interaction and communication with customers without the participation of human staff, answer basic questions and help to make round-the-clock sales. Large e-commerce platforms such as Amazon make extensive use of strategies to personalize and model customer expectations, increasing their revenue at an impressive rate.

Modern platforms (on the Internet): Technology giants such as Google, Microsoft and Lenovo use AI to facilitate communication with their many customers. Some of their products are difficult for the average non-specialist user to understand, and therefore specialized virtual assistants are created using speech recognition and natural language comprehension in certain narrower areas. Smart voice assistants analyze user replicas in real time and generate appropriate responses. Machine translation on the Internet is a revolution in the field of communications and its quality is constantly improving. World leaders in social networks such as Facebook use AI components to recognize images (faces, objects) and filter fake news. Technology giants gain a competitive advantage by acquiring smaller companies, innovators in certain niches of AI, and thus consolidate their dominant position.

Finance and Banking: Lending and investment management also use AI systems to assess customer solvency. Virtual assistants specializing in banking and financial services can use AI to mimic human logical reasoning skills and provide personalized advice. As online transactions become more popular every year, the financial and banking industries are facing more and more complex cases of identity theft and fraud losses. AI will help build next-generation financial cybersecurity through systems that use deep real-time self-learning and analysis that detect patterns of behavior and detect suspicious deviations and potential fraud.

Energy: AI will provide new solutions to improve energy efficiency through the collection and processing of large volumes of data and machine learning, as well as through robotic energy grid inspection systems. The analysis of data on energy consumption by individual consumers will allow optimization to be carried out in order to achieve more efficient consumption and reduce energy consumption and price paid. Monitoring the operation of power grid facilities through sensors and drones in real time will allow for assessment of their condition, reporting of local meteorological changes and the impact of other environmental factors, as well as data collection as a basis for optimization and planning. energy production, and others.

Production: AI helps manufacturers reduce costs while maintaining high quality products and services. This is achieved by optimizing operations: improving efficiency by planning maintenance, reducing downtime or supply chain optimization. Today, AI is built into automated machines that perform uniform repetitive activities. In the coming years, however, a transition from "assistive intelligence" to "autonomous intelligent factories" based on Internet-connected devices is expected. Data collected from connected devices in production lines will be integrated with data from design, engineering and quality control teams, creating an intelligent work environment for training "smart machines" that simulate intelligent behavior with little or no human intervention. Manufacturing companies will maintain and increase their competitiveness if their production is managed by AI systems.

Logistics: The exchange of goods and cargo is a global activity that can be optimized through AI and machine learning. Coordinating the exchange of billions of individual products and goods on the world transport network is a task that already goes beyond human management capabilities. AI applications in logistics match supply and demand, and also help to coordinate and plan production, warehousing, transport networks and vehicles and supplies. Thus, with the use of AI, distribution can reach optimal levels of efficiency, while reducing the cost of logistics activities in general.

Healthcare: AI can provide a radical improvement in the analysis of complex medical images such as X-rays, computer tomography examinations, and various screenings and tests. Data from clinical trials in patient records and external sources of knowledge, such as medical ontologies, genetic databases, conceptual resources including open related data, etc., will allow the detection of unknown patterns and correlations in the onset and course of disease, early diagnosis , finding a better treatment for chronic diseases and building a personalized treatment plan for each patient. Applications of AI in biotechnology help to shorten the process of creating new drugs. Last but not least, the success of the automatic analysis of free text allows to quickly find relevant facts in the scientific literature. Almost everywhere, software platforms are being set up to automatically provide medical advice to patients in real time, including immediate advice when symptoms occur (which is an example of an ethical and legal issue related to the protection of personal data and liability).

Agriculture: In this area, AI provides approaches to managing expert information and knowledge about nature, natural processes and modern agricultural technologies to find smart solutions for efficient land use as a source of health, food and income. In animal husbandry, AI provides tools to automate animal monitoring and robotize technological operations, including intelligent waste management. AI will be key in addressing important issues related to crop protection and forestry, veterinary pharmacy and medicine, agroecology and toxicology, plant and animal genetics and selection. Elements of AI are used in data management for climatic, meteorological and soil conditions, for in-depth analysis of statistical information on agricultural production, for processing images from drones and real-time means of communication, in the construction of digital duplicates, to support automation of processes and reduction of human labor. AI will significantly contribute to the development of modern, efficient, knowledge-based agriculture, which will increase the quality of food and protect natural resources.

Public administration: Most national AI strategies in the EU include modernizing public administration as a priority [25]. In the context of emerging digitalization and the accumulation of increasing data on citizens and public life, management practices are expected to be based on modern approaches to data processing and thus increase the capacity to offer better administrative services. Various AI technologies have already been implemented in European public organizations: image recognition, which allows automatic identification of faces and objects in photos or video; interactive communication and reference systems with voice connection, which are able to perform automatic analysis and generation of text and speech; profiling, which facilitates the grouping of citizens with similar needs and the creation of personalized public services; automation of repetitive administrative tasks in order to alleviate the workload of civil servants. The EC has published a report on the use of AI in public organizations in the Member States [26] and plans to develop a methodological framework for assessing the benefits of AI implementation, as well as a roadmap for the implementation of AI technologies at different levels of government.

Transport: AI is also changing the transport sector [27]. In road transport, revolutionary changes are associated with the emergence of autonomous vehicles. Fully automated vehicles (including parcel delivery) are already being tested in a limited number of situations and driving areas. AI technology monitors traffic at real-time traffic lights and sends traffic warnings and information to drivers about the fastest alternative route. In air transport, AI will improve the training of airplane autopilots, the management of increasingly active air traffic and airspace planning, airport passenger flow management systems, and security clearance systems. Projects are being funded for prototypes of smart trains, which, unlike the metro, run in an open environment and can encounter unpredictable obstacles. In shipping and waterborne transport, except for autonomous vessel prototypes, AI is used in accident management systems, ensuring safety and minimizing environmental risks in shipping. The optimization of transport routes and the efficiency of transport nodes is another area for application of AI.

Smart cities: AI is the foundation of smart city decision-making technologies. Objects in the city are connected to sensors that communicate with each other on the Internet of Things, this generates a considerable amount of data and through them AI understands and optimizes the physical world to make the city a better place to live. One of the first features is the analysis of traffic data monitored by connected internet cameras in order to help cities reduce congestion and air pollution. Over time, AI learns and decisions become better. The emergence of 5G networks will allow real-time monitoring and optimization of the efficiency of energy systems, utilities, water supply networks, waste collection, real estate management and urban planning, as well as coordination between libraries, schools, hospitals and other public services with purpose of sharing resources. Some of the listed functionalities have already been implemented in large cities around the world (a significant part of them are in the EU).

Ecology and the environment: Significant advances in image recognition will help to automatically collect and analyze data related to observations of biodiversity, depletion of natural resources, pollution and changes in the environment. Better, data-based models of the observed processes will be created, which will allow studying the trends and predicting important factors such as water availability, pollution, ecosystem conservation, etc. In the next decade, more sophisticated AI systems will appear for integrated processing of unstructured

data - text, images, video, audio, which will be able to inform about emerging environmental crises and offer optimal solutions for environmental sustainability, protection of the most ecologically efficient lands, etc.

Security and crisis response: AI systems are increasingly used in the field of national security and defense, response to natural and man-made disasters, search and rescue operations and more. Particularly rapid implementation of AI methods and tools is observed for the protection of digital environments and systems, achieving cybersecurity, cyber resilience, and cyber defense. AI systems are used for early signaling of deviations in the behavior of the observed complex environments for management of critical activities (critical infrastructure) and critical communication and information resources. AI (mainly based on machine learning / self-learning) is particularly effective in analyzing and eliminating "false positives" and optimizing the operation of security management centers and rapid response teams. Modern cyber and hybrid attacks and campaigns are also increasingly using AI methods, making them particularly adaptable and dangerous with rapid escalation and mass effect. The only way to counter this is to use 'smarter' AI systems to identify and neutralize them. AI is an effective assistant in assessing the situation at regional and national level, reporting diverse and incomplete information, predictive simulations, damage assessment, as well as early warning of cyber and hybrid attacks, terrorist attacks and other malicious actions. Simulation models with AI help to assess impacts and forecasts in natural disasters and accidents, and decision-making systems offer sound options for decisions and reactions. The optimization of the means and resources used in rescue, search and emergency operations is also based on AI systems. AI enters security and defense systems widely with the ability to process and interpret multi-channel and large-scale information, interact and share knowledge with similar systems of partner and allied countries (mainly through the EU, NATO, and cross-border), and it is expected that more fully and with a certain calculated degree of confidence the systems will offer in real time possible scenarios, alternatives for reaction, as well as to continuously self-learn.

Technologies, systems and products that use AI will also enter social life, which will include applications of AI in solving various problems:

- verification and validation of information - facilitating the provision, verification and recommendation of useful, valuable and reliable information for all. The aim is to filter or counteract content that could mislead and distort perceptions, including the identification of false and polarizing information disseminated through relatively new Internet and social media channels;
- management of the public and social sector - support of initiatives related to the effective management of the subjects of the public and social sector;
- equality and inclusion - addressing challenges related to equality, inclusion and self-determination, such as reducing or eliminating bias based on race, sexual orientation, religion, citizenship and disability;
- security and justice - prevention of harm (both from crime and other physical hazards), security issues, police work and criminal justice as a unique category similar to public sector governance [18].

The EC White Paper on Artificial Intelligence states that " it is essential for public administration, hospitals, utility and transport services, financial supervisors and other areas of public interest rapidly begin to deploy products and services that *rely on AI in their activities.*" [4]. In this way, the EC calls for rapid implementation in the public sphere of projects for which the technology is already well developed and allows large-scale implementation.

2.3. Sectors enabling the development and implementation of AI

There are two main sectors enablers, those that create conditions for the development of AI - education and training at all levels of the education system, including vocational retraining through lifelong learning, and the existence of an adequate legislative framework. Higher education creates specialized specialists in the field, while in secondary education basic computer literacy and basic knowledge of ICT are built, in particular the use of AI systems. The role of research and education, as well as lifelong learning, is fundamental to the development of AI and its implementation in practice in all other sectors. Legislative activity is a mandatory step in the process of building a reliable and focused on human AI and its acceptance by society.

Education and lifelong learning

A key role for the development and implementation of AI is the availability of human potential: specialists who are familiar with the latest discoveries and trends in the field, to master methods and tools for scientific research, implementation in practice and teaching, or to be able explain the benefits of adopting intelligent systems for widespread use.

To create a critical mass of specialists with higher education, the most developed European countries are planning solid investments in university structures and doctoral programs in AI. A number of national AI strategies propose the creation of educational platforms for free distance learning courses in this discipline. Finland has already created public course slides on basic AI concepts[3], which it will provide in all official languages in the EU, and plans to upgrade and develop a series of courses. Last but not least, integration with research and business plays a key role in achieving high quality AI education. To this end, almost all national European strategies propose the creation of this type of cooperation.

The introduction of AI in school education programs will have a profound effect on the skills required by 2030. The acquisition of these skills should lead to faster and easier adaptation of students to the work environment after graduation, while on the other hand it prepares them for the professions of the future. The programs for high-tech vocational high schools should be prepared and constantly adapted with the help of the higher schools and the research organizations, as well as in close connection with the leading Bulgarian companies in the field of AI. The integration along the axis "school-university-business" is key both for the quality and current curricula in the field of AI, and for filling the critical deficits of teachers and

[3] https://www.elementsofai.com/

lecturers in the rare, most difficult and most sought-after specialties - mathematics, informatics, electronics, programming, communications, robotics, embedded systems, etc.

The development of students' hardskills (mathematics, data analysis and processing, basic skills programming and use of software environments, skills for working in a distributed environment, working with data), STEM skills[4], digital skills and transversal skills play a key role in learning knowledge and skills for professional realization using artificial intelligence. This will lead to overcoming the expected structural shortage of professionals with vocational education in the medium and long term.

Lifelong learning is essential for people facing the societal challenges of the 21st century. The use of AI in the creation of educational content for qualification and re-qualification of working and unemployed can significantly accelerate the process of training qualified specialists. At European level, the Electronic Platform for Adult Learning in Europe (EPALE)[5] is a multilingual, interactive and innovative platform that is a key starting point for adult education and training in Europe, to help all those professionally involved in this field. EPALE is not intended for adult learners. It is aimed at professionals who organize, fund or provide adult education and training.

Legislative activity

Reliable AI presupposes the development of a legal framework to ensure that the fundamental rights of citizens are preserved, including ensuring product safety and determining legal liability.

In EU countries, the development and implementation of AI should be carried out in compliance with established rules and regulations arising from international law and European Union human rights law. At the same time, the principles on which these rules are based (non-discrimination, accountability, respect for human dignity, privacy) should be integrated into AI systems at the earliest possible stage of the development process. Among the key normative acts at international/EU level in this regard are:

- Convention for the Protection of Human Rights and Fundamental Freedoms, 1950;
- International Covenant on Political and Civil Rights, 1966;
- International Covenant on Economic, Social and Cultural Rights, 1966;
- Convention №108 for the Protection of Individuals with regard to Automatic Processing of Personal Data, 1981;
- Charter of Fundamental Rights of the European Union, 2009;
- Regulation (EU) 2016/679 of the European Parliament and of the Council on the protection of natural persons with regard to the processing of personal data and on the

[4] Science, Technology, Engineering, (Arts,) Mathematics

[5] https://epale.ec.europa.eu/bg/

free movement of such data, and repealing Directive 95/46 / EC (General Data Protection Regulation)), 2016 [28].

National rules in the field of fundamental rights and the protection of personal data relate to the transposition of relevant European legal provisions. Key documents in this regard are Directive 2000/43/EC implementing the principle of equal treatment between persons irrespective of racial or ethnic origin[29], Directive 2000/78/EC for equal treatment in employment and occupation [30], Directive 2011/83/EC on consumer rights [31], and Directive (EU) 2019/882 on the accessibility requirements for products and services [32].

The issue of legal liability in the event of an incident involving AI should be considered in comparison with the progress of the relevant technologies. In the future, the improvement and dissemination of stand-alone AI applications is expected to make it difficult to distinguish between producer responsibility and consumer responsibility [33]. Overcoming this challenge requires the establishment of a due diligence system that clearly defines the role, powers and responsibilities of the relevant stakeholders, to ensure continuous and effective monitoring.

Much of the existing EU legislation in the field of product safety and liability, including industry-specific rules, supplemented by national laws, concerns a number of emerging AI applications and may apply to them. Key documents include Directive 2001/95/EC on general product safety [34], Regulation (EC) 765/2008 setting out the requirements for accreditation and market surveillance relating to the marketing of products [35], Regulation (EC) EU) 2019/1020 on market surveillance and compliance of products [36] and Directive 85/374/EEC [37]. Member States are committed to transposing European rules at the national level, as well as to providing mechanisms for their effective compliance.

In the White Paper on Artificial Intelligence, the European Commission provides a framework for reliable AI based on excellence and trust, following a risk-based approach. In partnership with the private and public sectors, the aim is to mobilize resources throughout the ecosystem and create the right incentives to accelerate the development of artificial intelligence. The results of the public consultation on the White Paper show that Member States, including Bulgaria, prefer to avoid over-regulation so as not to hamper innovation. The European legal framework for AI is expected to be ready in the first quarter of 2021, and some legislative requirements will be proposed for high-risk AI applications.

When transposing the European legal framework on AI in Bulgaria, the general principles and rules for limiting the administrative regulation and administrative control over economic activity, regulated in the Law for limiting the administrative regulation and administrative control over economic activity, will be applied. Legislative activity should aim not to hinder, but to facilitate and encourage the implementation of economic and scientific research activities in the field of AI, stimulating the natural course of technology development in Bulgaria and limiting to socially justified limits the administrative regulation and administrative control carried out on it by the state bodies and the bodies of the local self-government. Insofar as one of the purposes of the administrative regulation is to limit the potential harms to the society, first of all real risks related to the use of AI should be identified and assessed empirically, as

this should serve as a basis for the introduction of normative requirements, the observance of which is provided by exercising administrative control.

3. PREREQUISITES AND CHALLENGES FOR THE DEVELOPMENT OF AI IN BULGARIA FOR THE PERIOD 2020-2030

3.1. Political framework

The horizontal nature of AI policy implies the involvement of a number of institutions, as well as the investment of public funds and the mobilization of private investment for its development and widespread use. Various aspects of this policy are included in national and sectoral strategic and programming documents.

The coordinator of the activities related to the implementation of digital technologies in the economy and society is the Ministry of Transport, Information Technology and Communications (MTITC). The Digital Bulgaria 2025 Programme with a Roadmap is in operation, which paves the way for the modernization and widespread introduction of smart IT solutions in all spheres of the economy and social life [38]. On July 21, 2020, the Council of Ministers adopted the National Strategic Document "Digital Transformation of Bulgaria for the period 2020-2030". The document sets out the principles of digital change in the main spheres of economic and social life [39]. One of the main priorities is to improve the existing infrastructure by ensuring the wide deployment and use of very large capacity networks. High-speed optical routes, as well as fifth-generation networks, will be among the most important building blocks of the digital economy and society. Improving connectivity will allow the development of innovative business models in many sectors such as scientific research, industry, digital and distance health, security, logistics, autonomous and connected vehicles, digital governance and digital education, and the development of "smart" cities. Support for digitization will be accompanied by measures to increase digital skills and stimulate the demand for Internet-based services by citizens and businesses.

In January 2020, the "Vision, Goals and Priorities for the National Development Program: Bulgaria 2030" was approved [40]. The document defines three strategic goals - accelerated economic development, demographic upswing and reduction of inequalities. To achieve the strategic goals, 13 national priorities have been defined, for the implementation of which targeted policies and interventions are envisaged, grouped in five interconnected and integrated development axes - Innovative and Intelligent Bulgaria; Green and Sustainable Bulgaria; Connected and Integrated Bulgaria; Responsive and Just Bulgaria; Spiritual and Vital Bulgaria. The document emphasizes that digital connectivity is the core of the digital transformation and an important factor not only for the competitiveness of enterprises, but also for supporting social inclusion and the development and use of e-government services. The implementation of Bulgaria 2030 envisages massive interventions at all levels of the education system, as well as the system of qualification and retraining to overcome the low level of digital competencies and human resources skills in the country, which hinders the widespread use of information and communication technologies. services based on them for achieving digital growth. The measures have a special focus on young people, the unemployed, the economically inactive and the representatives of disadvantaged groups, and the main tool in building the necessary digital

skills of the population will be the development of partnerships with the private sector. The focus of Bulgaria 2030 is also the development of the smart economy and e-health through targeted support for the development and introduction of innovative high-tech products, processes and business models, providing affordable and quality services.

The field of education and science is related to reform at all levels. The Ministry of Education and Science (MoES) is actively changing curricula and policies for funding ICT-related scientific research. Digital skills training is already starting in primary school, and computer science is a stronger focus in secondary education. The opportunities for teaching informatics in higher education, including through distance learning, are expanding. Bulgaria has adopted a National Strategy for Lifelong Learning for the period 2014-2020 and a National Information System for Adult Learning[6] has been established. Although slowly, research funding is improving. The Updated National Scientific Research Strategy 2017-2030 [41] identifies as a key element the linking of funding of both researchorganizations and individual scientists with the results of their activities. Good practice has been established to develop and update the National Roadmap for Scientific Infrastructure [42] and to finance major projects on important scientific and applied topics through National Scientific Research Programs[7].

In 2014, the Ministry of Economy (MoE) developed an Innovative Strategy for Smart Specialization of the Republic of Bulgaria (ISSS) [43], which defines priority areas for the programming period 2014-2020. ISIS aims to ensure a qualitative leap in Bulgaria's innovative performance at the EU level and to contribute to addressing societal challenges in the field of demography (reducing brain drain, attracting successful Bulgarians, stimulating youth entrepreneurship), sustainable development, intellectual capital and the health of the nation by setting a strategic goal by 2020 for Bulgaria to move into the group of "moderate innovators" (which according to a report from 2019 [44] is already a close but still unrealized goal). Two of the four main thematic areas in the focus of ISSS are ICT and mechatronics and clean technologies. Currently, MoE has prepared a "Concept for digital transformation of Bulgarian industry (Industry 4.0)" [7], which should become the basis for developing a Strategy for Bulgaria's participation in the Fourth Industrial Revolution (Industry 4.0) and a Roadmap for the period 2020-2027.

With Decision № 54 /18.09.2019 of the Council of Ministers, an Updated Strategy for Development of e-Government in the Republic of Bulgaria 2019-2023 was adopted, together with an Updated Roadmap with measures for its implementation and a Concept for register reform [45]. The update ensures the implementation of the European principles of e-government, introduced at the national level, and builds on what has been achieved by planning specific goals and activities. The Agency maintains the Bulgarian Open Data Portal[8] and has developed a concept for high-value datasets, as well as current regulatory changes in the re-use of public sector information.

[6] http://lll.mon.bg/

[7] MoES: National Scientific Research Programs, https://www.mon.bg/bg/100525

[8] https://data.egov.bg/

In 2019, the Ministry of Agriculture, Food and Forestry (MAFF) published a “Strategy for Digitization of Agriculture and Rural Areas of the Republic of Bulgaria” [46], which identifies areas of impact and measures for accelerated digitization. The "Analysis of the state of agriculture and the food industry" published in January 2020 [47] states that a system for sharing knowledge and innovations in the country's agriculture has been established, which includes diverse and well-developed scientific, university, private and professional organizations - as a potential infrastructure for data sharing.

The National Cyber security Strategy "Cyber-sustainable Bulgaria 2020" adopted by the Council of Ministers in 2016 [48] outlines the goals and phases for the period 2016-2020 to provide a modern framework and a stable environment for the development of the national cyber system. security and achieving an open, safe and secure cyberspace for the development of society and industry. It is emphasized that new technologies and growth trends provide new opportunities for the development of industry and services, but also lead to new, still insufficiently predictable threats and challenges. In addition to the development of high-speed communications (5G), cloud services and high-volume data analysis, billions of "smart devices" (the so-called "Internet of Things"), robotic AI systems, have been identified as key areas of challenge. and advanced multimedia forms of communication on social networks. A number of autonomous and intelligent systems (from the car and the plane to the smart refrigerator and vacuum cleaner, smart clothes, cyber substitutes for human organs, etc.) are practically constantly in the network and exposed to a new type of attacks and vulnerabilities, as for most of them there are no established requirements for their security. Applied research and implementation of these new technologies are also needed to monitor and increase the security of the used ICT and management systems. For example, the National Security Strategy, updated in 2018, aims to increase the security and safety of the transport sector through the introduction of intelligent transport systems.

As the largest research and industrial center, Sofia is developing its own strategy for smart specialization [49], creating a “Program for financing innovative and/or start-ups” to facilitate the access of start-ups and/or innovative enterprises to financial resources in connection with the realization and development of their business projects. The emphasis is on the main thematic priorities of ISIS of Sofia: living in an intelligent urban environment and mobility; cyberphysical systems; future cloud technologies; future network solutions; healthcare and healthy lifestyle; protection of personal data, security and trust; intelligent energy systems and intelligent spaces.

3.2. State of the Bulgarian ecosystem in the field of AI

Bulgaria's potential in the field of AI will benefit significantly from the accelerated development of the Bulgarian ecosystem, which is formed around scientific communities, innovative entrepreneurs, investors, large corporations and government organizations. This type of ecosystem is based on collaboration between scientists who conduct both basic and practical research, developers and users of intelligent systems. It encourages the development of an intensive business environment that supports technology start-ups and attracts large international corporations and companies that invest and work with scientists and start-ups.

This in turn leads to the creation of a large number of new, high-tech jobs and creates a natural link between science and business.

Bulgaria has relatively good connectivity in the context of Southeast Europe (according to the DESI index for 2019 [50]), ranking first in the EU in the number of municipalities covered by the WiFi4EU initiative to build free access to wireless internet in public places throughout Europe. Bulgaria is entering the digital age as a modest but catching-up innovator with the potential to become a moderate innovator in the coming years [44]. Although according to the DESI index for 2019 Bulgaria ranks 28th in the EU, the increase in its overall results is visible, and its ranking is lower on the one hand due to the limited results on some of the reported indicators, and on the other hand - due to the better performance of other Member States in some of the dimensions of DESI. Taking into account the complex picture of progress, in May 2020, the report "Science, Research and Innovation Performance of the EU 2020: A Fair, Green and Digital Europe" [3] gives a relatively good assessment of the Bulgarian government's readiness to develop AI, ranking Bulgaria ahead of five other EU Member States[9]. The same place is assigned to the country by the report of the McKinsey Global Institute [18] from 2019[10].

The academic infrastructure that can be used to solve important tasks in the field of AI will improve dramatically in the coming years due to the funding of nine major projects under the Operational Program "Science and Education for Smart Growth" (OP SESG) 2014-2020, ICT-related activities including AI, robotics and mechatronics[11] - three Centers of Excellence, five Centers of Excellence and one for complementary support of the GATE project, funded by Horizon 2020, Widespread-Teaming, Phase 2. Almost all Bulgarian research organizations and universities, in which research on AI is carried out and relevant curricula and doctoral programs are maintained, participate in these projects. Launched in 2017-2018, the projects are at the stage of building a scientific infrastructure, to be followed by planned research activities. In 2024, scientists from all over the country will have a new generation of scientific infrastructure. A significant increase in the expert capacity and development of scientific and applied research in contemporary topics of ICT and AI is also expected.

There is a shortage of staff in the field of ICT (and in particular AI) everywhere, but in Bulgaria the capacity of scientific organizations to retain talented young scientists is very low. Due to the attractiveness of the IT sector or work abroad, a significant part of young IT professionals are turning to a career in industry, neglecting the scientific field. In recent years, the number of published scientific articles by Bulgarian authors in the field of AI has decreased significantly: 387 scientific publications for the period 2015-2018, Bulgaria being followed by six countries with smaller populations[12]. A search in Scopus shows the most common topics of Bulgarian scientific publications: machine self-learning including neural networks, computer vision (image processing), data mining, natural language processing, robotics, knowledge

[9] Figure 7-35, page 492 of [3]: https://ec.europa.eu/info/sites/info/files/srip/2020/rec-19-003_srip_chap-7.pdf

[10] Figure 20, page 40 of [18]

[11] http://sf.mon.bg/?go=projects&name=&priority_axes=Приоритетна+ос+1

[12] Figure 7-12, page 467 of [3]: https://ec.europa.eu/info/sites/info/files/srip/2020/rec-19-003_srip_chap-7.pdf

presentation, etc. The articles referred to in Scopus come from a small number of scientific organizations.

There are also a number of weaknesses of the Bulgarian scientific system as a whole. The Updated National Scientific Research Strategy 2017-2030 [41] analyzes negative trends such as the general aging of scientists, declining internationally visible scientific output, lack of staff, fragmentation of scientific research, unbalanced regional distribution of scientific research organizations and universities and others. It should be noted that the MoES is aware of the need to modernize the scientific sector and in the last two years the country has been following the Operational Plan for implementation of the first stage of the Updated National Scientific Research Strategy, which includes a Roadmap for implementing European scientific research priorities space in our country [41].

Bulgaria has a traditionally strong sector in informatics and automation, the foundations of which as a scientific field were laid in 1962, and after 1980 even serial production of industrial robots was achieved. Despite the difficulties and losses during the transition years, today's dynamic IT sector is built on these foundations with revenues that form about 3.4% of the country's GDP [51]. A number of Bulgarian high-tech companies are very successful in the field of AI and fulfill contracts for large clients from Western Europe and the USA [52]. Such is the company Ontotext (Sirma), one of the world leaders in the field of semantic technologies, whose product GraphDB for managing knowledge graphs ranks among the most popular in the global market[13]. In the field of mechatronics in our country more and more production bases and centers for scientific research and development of leading corporations in the automotive industry, microelectronics and IT products are in a process of opening.

The growing popularity of AI technologies is creating a wave of start-ups in the country. According to a report by SeeNews "AI ecosystem in Bulgaria" [52], developed in cooperation with the international innovation company Vangavis in 2019, a total of 47 companies develop or use AI in Bulgaria. Of these, 32 are start-ups and escalators, and 15 are developed Bulgarian or international companies. The sector employs over 3,000 people; AI-related jobs account for 3% of the total labor market in Bulgaria. According to the report, the startup ecosystem of companies developing or applying artificial intelligence in Bulgaria is still at an early stage of its development, but has seen a significant boost in recent years. One third of all companies surveyed for the report were established in the period 2016-2018.

Implementation of AI technologies in enterprises

According to the report “Science, Research and Innovation Performance of the EU 2020: A Fair, Green and Digital Europe” [3], the level of perception of AI in Bulgarian industry is relatively good for the region (medium-low)[14], but also shows the limited number of offered bachelor's and master's programs in the country[14], so there is still much to be desired in connection with staff training.

[13] https://db-engines.com/en/ranking/graph+dbms

[14] Figure 7-33 page 489 of [3]: https://ec.europa.eu/info/sites/info/files/srip/2020/rec-19-003_srip_chap-7.pdf

In 2020, the first study on the deployment of AI technologies across the EU was published, carried out by Ipsos for the European Commission [53]. It has been found that 42% of businesses in the EU currently use at least one AI technology, a quarter of them use at least two types, and 18% have plans to implement AI technology in the next two years. Three key internal barriers to the perception of AI are the difficulty of hiring new staff with the right skills (57%), the cost of deployment (52%) and the cost of adapting operational processes to new technologies (49%). The results of the survey, which covers a total of 9640 enterprises in the 30 countries surveyed, are structured on the basis of measured key performance indicators (KPIs): awareness, implementation, supply, and external and internal barriers to AI acceptance.

A total of 380 Bulgarian companies of all sizes participated in the survey. The results for Bulgaria are as follows:

- In general, the awareness of AI among companies is constantly high in different sectors of enterprises.
- 54% of the survey participants use at least one AI technology, 31% use at least two technologies, and 11% plan to use AI over the next two years. Only 36% do not use AI and do not plan to implement it at all. According to this indicator, Bulgaria is among the top three countries in the EU.
- The most common procurement strategy is by purchasing software or ready-to-use AI application systems, or by hiring external vendors to develop AI technology.
- Among the internal barriers to the introduction of AI, Bulgarian companies point out as the main one finding specialists with the necessary qualifications in AI (68%). The most needed skills are in the field of big data management (41%), programming (41%), machine learning and modeling (35%), robotics (32%) and cloud computing (27%). The costs of adoption, adaptation of operational processes and insufficient or incompatible IT infrastructure are also considered as a barrier to the adoption of AI by many enterprises.
- Among the external barriers to the perception of AI, the biggest are the lack of public and external funding (43%) and the need for new laws and regulations (37%).

Digital skills

One of the main challenges for Bulgaria's progress in the development and implementation of AI technologies is the low level of digital skills at the individual and company level.

Despite the subjective view of Bulgarians that we are a well-developed ICT society, the report of the European Commission on the DESI index for 2019 [50] shows that Bulgaria reports significantly below the average result in the dimension of human capital. The share of people with at least basic skills in the field of digital technologies amounts to about 29% of the Bulgarian population (57% on average for the EU), and only 11% of people have skills above basic (with an average for the EU of 31%). The lack of AI-related skills (including AI technical skills, AI skills and management skills for using AI in business) has been identified as the biggest barrier to AI adoption in Europe [18]. A change in the education system is needed throughout the cycle of formal education, vocational training and higher education, while

placing greater emphasis on lifelong learning to enable people to acquire and improve adequate skills relative to the changing environment. Close cooperation between the public and private sectors, especially educational institutions, employers and non-governmental organizations, as well as international cooperation and the adoption of examples of good practice are essential.

The relatively low level of computer skills is also reflected in the industry. Bulgarian small and medium-sized enterprises (SMEs) are the main driver of economic growth in the country, but in the sector of high-tech and medium-tech industries they are only 0.8% (2% in the EU) and in the sector of knowledge-intensive services - only 16% (28% in the EU). This is a sign of the presence of a low-skilled workforce, which is not able to create added value in high-tech industries and services. An additional challenge is the lack of training programs to facilitate the transition of SMEs to more technological levels of work [54].

Innovation policies at national and regional level

Bulgaria traditionally has a low place in the Innovation Scoreboard, which reflects the state of the EU member states in terms of innovation development and research and development. According to data for 2019, the country is ranked 27th out of 28 Member States with an efficiency level below 50% of the EU average. In order to overcome the weaknesses and the division of innovation activities in the public and private sector, in September 2020 the State Agency for Research and Innovation was established as a specialized body to the Council of Ministers to manage and implement the state policy in the field of research, innovation and technology. This Agency will develop a new set of policies that will encourage the development of applied research and innovation, as well as the strengthening of public-private partnerships.

Another known problem of the current state of the scientific research system and the business environment in Bulgaria is the unbalanced regional distribution of scientific organizations, universities and successful industrial centers. The vision of the Updated National Scientific Research Strategy 2017-2030 [41] is “gradual development of scientific research in the regions as well, as the first step will be to support applied scientific research through the establishment of regional scientific research centers. In the future - during the third stage of implementation of the strategy, planning and implementation of scientific research and innovation complexes in less developed regions of the country is envisaged. At the same time, a report by independent experts for the evaluation of the Bulgarian scientific research and innovation system from 2015 [55] draws the following conclusion: “Although Bulgaria seeks to invest in modern research infrastructure ... it is debatable whether there is a possibility for better use of existing facilities and more strategic investments in future ones, in line with the smart specialization strategy. In addition, the problem of the lack of a critical mass of skilled human capital to support R&D and business innovation in regional and local ecosystems needs to be addressed. This deficit is exacerbated by the fact that public universities tend to follow traditional curricula that do not meet modern business needs and are also limited by the lack of appropriate pathways for researchers wishing to work in the public and business sectors. So the availability of staff stands out as a necessary condition for reaching a modern technological level in the regions.

A challenge for the development of the national innovation infrastructure is the establishment of Sofia Tech Park as a strategic testing laboratory for innovation, which will allow its effective use as a true innovation ecosystem. The successful development of Sofia Tech Park could show good practices for creating specific regional and local innovation ecosystems.

3.3. SWOT analysis of the Bulgarian ecosystem in the field of AI

Strengths	Weaknesses
Existence of Centers of Excellence in ICT and Centers of Competence in ICT and Mechatronics with international prestige and long traditions in AI and robotics research.	Critical reduction in the number of scientists, insufficient funding of academic organizations to preserve the potential and conduct research on AI at the global level.
Existence of internationally recognized scientific production in AI and robotics.	Maintaining a constant amount of internationally recognized scientific output and significantly lagging behind other countries, where it is growing steadily.
Good level of international cooperation on AI and maintaining partnerships with leading research centers in the EU and the world.	Insufficient funding to use the full capacity of international cooperation, weak internationalization of scientific research groups.
Existence of enterprising scientists, ready for new scientific developments.	Low success of ICT projects of Bulgarian teams in EU scientific research and innovation programs, low return on funds from these programs.
Accelerated improvement of research and innovation infrastructure.	Uneven distribution of scientists, scientific organizations and IT companies by region.
Significant growth of the high-tech IT sector due to existing traditions and competitive labor prices.	Weak links of scientific organizations with business and insufficiently effective mechanisms for knowledge transfer.
Existence of investments in the field of mechatronics, robotics and microelectronics from world automobile corporations and other leading manufacturers.	Ineffective policy for coordinating activities affecting science and innovation.
Significant progress of the startup ecosystem by companies developing or implementing AI in Bulgaria.	Low number of world-significant innovations and original products produced in Bulgaria.
Improve connectivity and support digitalisation across the country.	Relatively low level of computer skills of the population as a whole.
Strengthening the education in informatics in secondary education and increasing active participation of the IT business in the education in information technologies in schools.	Relatively low level of digitalization of small and medium enterprises.
Good level of readiness for implementation of AI in enterprises.	

Opportunities	Threats
A chance for a complete change in the revolutionary transition to intelligent digital solutions, including in public administration, industry, healthcare, etc.	Lack of determination or inability to reach a consensus on radical change in order to build a high-tech society.
Existence of solid European support for the development of AI and robotics through the provision of strategic and program documents, targeted funding, pan-European cooperation, basic legal framework and ethical norms, transfer of good practices.	Planning reforms "by stages" and investing available resources in fragmented and incoherent goals with limited scalability of results.
Existence of a consistent state policy oriented towards overcoming the negative phenomena through structural changes in the management, increase of the national funding for science and innovations, introduction of new forms of project financing, attestations, payment according to the results, etc.	Slow and inefficient commercialization of the scientific and applied results in AI, capture on the market by foreign products.
Existence of a vision for conceptual change of the educational system, lifelong learning and retraining in the period 2021-2027.	Insufficient capacity to create in the period 2021-2027 a critical mass of trained staff for scientific research organizations, business and innovation activities in regional and local ecosystems.
Visible trend for the return of young specialists with high-tech professions in Bulgaria.	Insufficiently effective retraining mechanisms to assist dropouts in the introduction of AI.
	Further lagging behind in the competition to attract qualified staff from third countries.
	Delay the accumulation of accessible big data on which to build products and services for the public sector.

4. VISION AND GOALS OF THE CONCEPT FOR THE DEVELOPMENT OF AI IN BULGARIA (AI-BG)

The Concept for the Development of AI in Bulgaria 2020-2030 (**AI-BG**) is a framework strategic document, determining the vision and general goals of the policy for the development and introduction of AI in all economic and social sectors and public administration, including their territorial dimensions.

Vision

In 2030, Bulgaria is a country with a high-tech, efficient and sustainable ecosystem for scientific research, technology transfer, development of its own original products and services and implementation of world-class solutions in the field of AI, big data, and robotics. The excellent achievements in scientific research, intensive international cooperation, highly educated human resources, a successful IT industry and the existence of a legal framework for the development of human-oriented AI while respecting fundamental human rights form an intensive business environment supporting the implementation of innovation in every economic and social sector and improving the quality of life of all citizens.

Goals

The main goal of the Concept for the development of AI in Bulgaria 2020-2030 (**AI-BG**) is to focus efforts on the development and implementation of AI systems by creating research, expert, business and management capacity, supporting the coordination of measures and activities set as a priority in relevant National Strategic Documents, including "Vision, goals and priorities for the National Development Programme: Bulgaria 2030" [40]. **AI-BG** is expected to play an important role in the implementation of the development policies set in Bulgaria 2030 in the following areas:

- science and scientific infrastructure;
- education and skills;
- intelligent industry;
- electronic public administration;
- sustainable agriculture;
- e-health.

In order to ensure the maximum benefit from the invested public and private financing, **AI-BG** includes the implementation of the following strategic goals:

4.1. Providing modern communications and scientific infrastructure development and introduction of AI and digital new generation

By 2030, the government is geared up to provide gigabit connectivity for all major socio-economic drivers such as schools, transport hubs and major public service providers, as well as digitally intensive enterprises. Efforts will be focused on building an efficient cloud

infrastructure and data storage, and exchange centers in the context of the European Cloud Initiative.

The availability of a modern and sustainable research infrastructure at a global level, open and accessible to all scientists and businesses in Bulgaria and abroad, as well as the facilitation of access to scientific data and results through the European Open Science Cloud (EOSC) will contribute to the retention of highly qualified staff in the country, attracting young scientists and stimulating international research cooperation. Efforts will be focused on the development and utilization of the capacity of the main research complexes in the country with potential for connection in European networks such as the National Center for High-Performance and Distributed Computing (NCHDC), the European Supercomputer Complex in Sofia Tech Park and other sites within the roadmap of the research infrastructure.

4.2. Developing an advanced system for education and lifelong learning

Education and training at all levels have a leading role in overcoming the challenges posed by the development and implementation of AI. Building and using safe and stable AI requires a deep understanding of its nature and impact from school. Efforts will be focused on both mass basic training in the field of AI and vocational secondary and higher education, including the necessary technological disciplines and training content related to management and business skills. It is also essential to increase the professional qualification of teachers. Adapting human resources to the changing labor market will be achieved by providing opportunities for lifelong learning.

AI will contribute to the modernization of education and training systems themselves. It is planned to create and maintain a cloud environment for the provision of intelligent educational services, as well as the implementation and development of modern flexible content platforms in support of preschool, school and higher education, and lifelong learning that use modern ICT equipment and software and provide distance learning, knowledge control and learning content management.

4.3. Strengthening and developing the capacity for research and technology transfer in the field of AI and related technologies

AI is an interdisciplinary, broad-spectrum and rapidly evolving scientific field, which is developed through intensive research in integrated research teams with established international collaborations with leading partners. This requires transforming the country's research system towards increasing and expanding the capacity of researchers, attracting young talent, building networks of national research units and sustainable integration into elite pan-European research initiatives. The aim is to create new and more advanced algorithms and methods in AI, development of new technologies and original prototypes of products and services. Other expected results are the development of international and intersectoral cooperation and increasing the capacity of the system for permanent retention of young scientists in the field of AI. Academic entrepreneurship and the commercialization of innovation to the private sector will also be encouraged by strengthening the links between science and business and creating

joint research and applied projects, establishing start-ups to academic organizations and various forms of technology transfer to industry and especially SMEs.

4.4. Unlocking the potential of data as a raw material for AI development

Access to open public data and unrestricted cross-sectoral trafficking of non-personal data will allow the creation of high value-added products and services for the benefit of citizens, businesses, the public sector and academia. Information obtained from public and business non-personal data should enable better decisions to be made and competition to be promoted accordingly. Investments should cover actions with a significant impact on data spaces, covering data sharing architectures (including data exchange standards, best practices, tools) and management mechanisms, as well as enriching and achieving interoperability of available public data and information systems. The established national data spaces will be integrated into the European data space to support the development of new AI technologies and their testing and implementation. These activities will be harmonized with the European policy of making the EU a world leader in data-driven economics [16].

4.5. Introducing AI-based innovation in key sectors

The results of achieving this goal will include facilitated access to financial instruments and plans, consulting services, infrastructure for testing innovative products and services in real conditions, including at least one center for testing and experimenting with AI applications in enterprises and government institutions, as well as effective participation in European research and innovation programmes. Priority will be given to innovations based on AI for technological renewal of Bulgarian industry, implementation of new business models and development of Industry 4.0, the development of intelligent agriculture, building management, control and safety systems for various modes of transport, sustainable management, "smart energy networks", modernization of the healthcare system, environmental monitoring and protection, smart cities, modernization of administrative services, etc. Through the widespread application of AI, the economy will increase its competitiveness and sustainability, as well as generate new revenues from a variety of business models and services that create jobs. Public sectors will be able to provide new diverse and quality services to citizens. Investments in AI are also investments in achieving the ambitious goals of the European Green Deal, such as building a clean and circular economy, intelligent mobility, energy integration, precision agriculture and others.

4.6. Building trust in AI and a regulatory framework for the development and implementation of reliable AI technologies, in line with established legal and ethical principles within the EU

Activities to achieve this goal include various forms of effective public dialogue as a key factor that helps build trust and formulate sustainable policies for active interaction between AI developers and users and prepare for the introduction of the future European regulatory framework for AI. . It must create a unique "trust ecosystem" by ensuring compliance with EU rules, including those for the protection of fundamental human rights and consumer rights, especially in relation to high-risk AI systems. The framework should allay citizens' concerns

about using AI applications and provide businesses and NGOs with the necessary legal certainty when implementing AI-based innovations. Future regulations will build on current European legislation. The new legal framework is expected to remain proportionate and not lead to over-regulation. To this end, new rules will be introduced mainly for high-risk systems using AI, such as biometric and facial recognition solutions, technologies for self-driving cars, recruitment platforms (which, depending on the data used in their training may lead to discrimination on the basis of gender, ethnicity or other principle), etc.

The **AI-BG** concept is based on the principles for the development and implementation of AI technologies adopted at the EU level, taking into account the need for a broad-spectrum approach that encourages the introduction of next generation digital technologies in Bulgaria and allows a timely and reliable assessment of possible risks. **AI-BG** also includes measures to improve international cooperation through the participation of Bulgarian organizations in initiatives and programmes of the EU and other countries to facilitate the transfer of high technologies and their entry into practice. As part of the planning of the "Digital Bulgaria" programme, **AI-BG** develops and supplements with specific activities for AI the following national strategic documents:

- National Programme Digital Bulgaria 2025 andRoadmap, December 5, 2019 [38],
- National strategic document "Digital Transformation of Bulgaria for the period 2020-2030" [39].

5. AREAS OF IMPACT AND SPECIFIC MEASURES OF THE AI-BG CONCEPT

5.1. Building a reliable infrastructure for AI development

Europe needs infrastructures capable of providing high-performance computing, secure data collection, storage and processing, 5G connectivity and next-generation software to support the development and deployment of AI technologies. This requires investment in building and maintaining computing infrastructure, communications and service software, as well as the accumulation of large data sets. Bulgaria is already creating a modern computing infrastructure in ICT through projects funded by OP SESG and the decision to build a petascale supercomputer in Sofia Tech Park. Further development of both the 5G network and the provision of data under the Digital Europe 2021-2027 programme are planned. Digital innovation hubs (digital innovation centers) are another important component of the overall national research and innovation ecosystem, which will allow the development and widespread dissemination of intelligent systems and digital business transformation through the introduction of AI technologies. The innovation hubs will provide a wide range of services to business, public administration and citizens, testing and experiment laboratories to implement the idea of "pre-investment testing", as well as secure shared spaces for public and private data and will be particularly useful for SMEs and start-ups that will have the opportunity to test applications and services based on the latest technologies, including AI and robotics.

Specific measures that will contribute to the construction of appropriate infrastructure for the development of AI are:

- Organizing and integrating the infrastructure, newly built through the Centers funded by OP SESG until 2023, in safe and secure clusters for scalable high-performance computing and mechatronic experiments, freely available to Bulgarian researchers working in the field of AI and mechatronics.
- Organizing groups of experts in priority areas for the accumulation of large data sets (eg health and agriculture) to help define formats, structures and annotation schemes, standardization approaches and interoperability of significant subsets of data according to the FAIR[15] principles, to be added as a public resource to the national Open Data Portal [16].
- Providing access to methods and tools that make datasets comparable and useful at the international level, using a common data format and combining different datasets in the public space.

[15] FAIR — Findable, Accessible, Interoperable and Reusable, i.e. the data is easy to find, accessible, interoperable and reusable, see https://ec.europa.eu/info/sites/info/files/turning_fair_into_reality_1.pdf

[16] https://data.egov.bg/

- Encouraging the sharing of non-personal data[17] through the development of scenarios and software environments for ethical, secure and lawful exchange.
- Creating rules for anonymization and pseudonymization of personal data for the purposes of data exchange in healthcare, as well as developing a scheme for donation of data for specific purposes with clear rules for transparency, management and protection of personal space.
- Creating incentives for organizations to share data in the national Open Data Portal, as well as in private data spaces and platforms, and in the Bulgarian Open Science Portal[18] maintained by NACID.
- Providing freely accessible arrays of high-quality data for machine self-learning in the construction of prototype AI applications, planning activities for clearing, calibration, annotation and marking of data, construction of knowledge graphs, ensuring compatibility with open related data repositories and others.
- Providing high-tech AI platforms that are integrated with European ones and ensure interoperability (with each other and with European platforms), as well as providing open access (open programming interfaces) enabling the creation of AI-based innovative solutions and services.
- Constructing digital information hubs in the field of AI and robotics, co-financed by the European programme "Digital Europe".

5.2. Development of research capacity for scientific excellence

The EC's White Paper on Artificial Intelligence states that it is imperative for Europe "to create more synergies and links between the various European AI research centers and to synchronize their efforts to improve their performance, to retain and attract the best researchers and to develop cutting-edge technologies"[4]. For Bulgaria it is necessary to overcome the fragmentation between the few units doing research in AI and to create conditions for building human potential in a connected national academic environment, as the latter will have a positive impact on the number of trained young scientists and the quality of higher education.

The following activities will help to develop research capacity in the field of AI:

- Creating a Bulgarian Research Programme for comprehensible, people-oriented AI and robotics, as a union of scientific organizations and universities that have original developments in the field, including Centers among the nine established under OP SESG[19]. The consortium will implement an ambitious research plan on scientific topics with strong Bulgarian capacity (neural networks, machine learning, hybrid AI, natural language processing, processing of knowledge and data appearing in the information space as huge public arrays - knowledge graphs and linked open data, etc.), as well as the

[17] For example, anonymised datasets used to analyze large data sets, precision farming data that can help monitor and optimize pesticide and water use, or data on the maintenance needs of industrial machinery, cf. [14].

[18] https://bpos.bg/

[19] http://sf.mon.bg/?go=projects&name=&priority_axes=Приоритетна+ос+1

generation of explanations for decisions made by AI. Applied research in the field of modern intelligent robotics should be aimed at creating research prototypes in specific niches, using AI and Internet of Things technologies, given the expected widespread introduction of 5G communication. Through the projects financed under OP SESG, an infrastructural environment for communication and performance of complex calculations in real time is created in the country, which allows to plan modern scientific and applied researches in advanced technological directions. The programme will provide a research environment for the training of doctoral students and career development of postdoctoral students, as well as for the training of specialized personnel in intelligent components in mechatronics and robotics. A single portal will be maintained in which the research results can be freely disseminated, together with the accompanying data and programme code, with comments in Bulgarian and orientation towards researchers from Bulgaria.

- Involving Bulgarian teams in pan-European networks in artificial intelligence, robotics and digitalization, such as the initiatives of CLAIRE[20], AI4EU[21], euRobotics[22] and CLARIN[23] & DARIAH[24], as well as in European testing and experimentation centers related to healthcare, robotics and agriculture.
- Establishing and developing an active cooperation in the field of AI of Bulgarian scientists with researchers from the EU and other leading countries.
- Involving Bulgarian academic institutions in international organizations such as the RDA[25], which bring together researchers from around the world and work to build policies and infrastructures to support the generation, collection, storage, transfer and sharing of research data in all areas of the world knowledge.
- Promoting spaces for collaboration between researchers and AI professionals. Encouraging the creation of a network of universities, vocational schools and companies to build vital laboratory infrastructures in which universities, vocational schools and companies develop joint AI training (regionally and nationally, as well as internationally).
- Creating prerequisites for strengthening the interest in training in the educational and scientific degree "Doctor" and a significant increase in the number of full-time doctoral students in the field of AI, including by introducing changes in the current legal framework to encourage the announcement of full-time doctorates with guaranteed targeted project funding under appropriate financial conditions.
- Providing more opportunities for growth and development of habilitated scientists in the field of AI. Creating prerequisites and new forms for attracting talented young scientists and postdoctoral students, as well as established scientists from abroad.

[20] Confederation of Laboratories for Artificial Intelligence Research in Europe, https://claire-ai.org/

[21] https://www.ai4eu.eu/

[22] https://www.eu-robotics.net/eurobotics/index.html

[23] Common Language Resources and Technology Infrastructure, https://www.clarin.eu/

[24] Digital Research Infrastructure for the Arts and Humanities, https://www.dariah.eu/

[25] Research Data Alliance, https://www.rd-alliance.org/

- Introducing measures for additional stimulation of research in the priority areas for the country, carried out by the scientific organizations and universities with the highest assessment for research activity in these areas according to the ranking of the Ministry of Education and Science.
- Creating conditions for a significant increase in the number of publications in leading scientific journals, ranked in the top positions of world-famous databases.
- Expanding and enriching the activity of the Bulgarian Artificial Intelligence Association (BAIA)[26].

5.3. Establishing a knowledge base and skill set for the development and use of AI

Europe needs to overcome the skilled staff shortages [56] by adapting education systems and raising the skills of the workforce. This is even more important for Bulgaria with the registered low level of digital skills of a large part of the Bulgarian population. The role of STEM disciplines (natural sciences, technologies, engineering and especially mathematics), as well as the building of the so-called "soft" skills, significantly increases the development of quality human potential, capable of developing and applying AI, along with digital skills. (organizational qualities, teamwork skills, etc.). To this end, the Ministry of Education and Science develops policies and tools to promote innovative teaching practices and methods (interdisciplinary teaching, project training, IT business partnerships with schools).

A major part of the measures to be taken in this direction is laid down in the document "Artificial Intelligence in Education and Science" (2020) prepared by the Ministry of Education and Science [57]. The following specific measures will contribute to the development of the knowledge base and skill set needed to work in the field of AI, as well as to work in an environment using AI applications.

Secondary education:

- Acquiring digital skills specific to the creation and application of AI - both analytical (such as data structuring, algorithm design, deductive and inductive reasoning, solving complex problems, etc.) and applied (such as knowledge and use of languages for programming and modern environments for building applications with AI).
- Increasing students' competencies in the field of ethical issues related to the use of information technology and their rights in the digital world in which they live [58].
- Applying AI tools in education to increase the quality, attractiveness and efficiency of the educational process, while strictly observing the protection of fundamental rights and proper consideration of the vulnerable situation of children.

[26] http://www.aimsaconference.org/BAIA/

Higher education:

- Training of a larger number of bachelors in computer science, information systems, software engineering, computer engineering, etc., to have higher levels of mathematical knowledge and technical skills, in particular a good understanding of areas such as discrete structures, mathematical logic, theory of probabilities and mathematical statistics, design and analysis of algorithms, computer architectures, approaches and tools for data collection, storage, analysis and visualization, etc.
- Expanding and intensifying the training of specialists with higher education in the field of AI. Establishing AI-oriented profiles in the curricula of appropriate bachelor's specialties in the professional fields "Informatics and Computer Science", "Communication and Computer Engineering", etc. Developing the existing and creating new master's programmes in AI or other directions in AI. Creating conditions and motivation for a sharp increase in the number of trained doctoral students in the field of AI. A necessary step in this regard is the introduction of changes in the current legal framework to enable the functioning of models of master's and doctoral programmes, as close as possible to those established in Western Europe and the United States, including by removing existing educational restrictions in priority professional areas such as Informatics and Computer Science, Communication and Computer Engineering, etc.
- Creating and maintaining special talentprogrammes designed to encourage and support the development of the most distinguished students.
- Supporting interdisciplinarity - rethinking regulatory constraints and creating mechanisms to promote interdisciplinary (hybrid) academic training programmes for bachelor's and master's degrees and interdisciplinary doctoral programmes.
- Building skill sets related to data analysis and AI in all academic disciplines and professions to increase the potential of areas in which AI applications can be developed and used.
- Updating the university educational programmes for training teachers and staff for educational management by developing the competencies of teachers to work with information, digital technologies and AI regarding the changing nature of teaching, as well as the use of AI-supported systems for school system management.
- Special attention to the study of the impact of AI on society, as well as to the standards for building reliable AI. This suggests, on the one hand, the inclusion in the university educational programmes in informatics and technical specialties of academic disciplines focused on the legal, ethical and social aspects of AI, and on the other hand, the inclusion of disciplines for researching the impact of AI in the schools of social sciences, legal sciences and humanities.
- Implementing AI in university management. Given the breakthrough in the use of data to transform planning processes, to develop and integrate AI technologies and tools that are important for improving education management information systems (EMIS) to optimize data collection and processing to achieve a fairer, more inclusive, open and personalized education [59].

Vocational training and continuing education:

- Offering short-term training and internships aimed at acquiring and improving digital skills, programming skills, data analysis, ability to understand and apply AI in practice to increase the number of experts in digital fields.
- Designing and implementing of programmes for expansion or change of qualification of existing IT specialists within the framework of lifelong learning programmes implemented by the higher schools.
- Creating specialized schemes for (re)qualification in the conditions of cooperation between business, trade unions, universities and public authorities - for professional profiles that are threatened by automation.
- Creating more opportunities for the validation of informal and private learning in order to ensure more flexible mobility [60].
- Developing a platform "Education and AI" for open sources of AI courses, AI tools, examples of AI in educational policies, regulatory frameworks and best practices for AI in education[27].

5.4. Support for innovation to implement AI in practice

It is important for businesses, including small and medium-sized enterprises, to have information about the potential of AI and to use it. To this end, the European Commission is committed not only to building Digital Innovation Hubs under the Digital Europe programme, but also to setting up the AI on demand platform[28], which is yet to be developed. In Bulgaria, the Centers of Competence, funded by OP SESG, also aim to support applied research and the integration of science with business.

The following activities will help to develop innovation capacity and implement AI in real business:

- Involving Bulgaria in international initiatives for innovations related to the use of AI, including in company-oriented competitions on Horizon Europe. Deepening cooperation with the European Institute of Innovation and Technology.
- Facilitating and stimulating the participation of Bulgarian teams in European competitions for innovative developments, where national co-financing is required (by accelerating the process of considering proposals and signing project contracts, more efficient procedures, increasing administrative capacity, determining adequate payment rates for Bulgarian participants).
- Establishing Sofia Tech Park as a successful strategic testing laboratory for innovation at the national level and transfer of good practices to regional innovation centers.

[27] Recommendations for such platforms are available, for example, in the German AI Strategy (teach-and-learn AI), in Vilani's report on France "For a Meaningful AI", and in the Beijing Consensus on AI and Education of UNESCO (AI for Education)

[28] https://ec.europa.eu/digital-single-market/en/news/artificial-intelligence-79-partners-21-countries-develop-ai-demand-platform-eu20-million-eu

- Analysing the needs and developing financial mechanisms and other measures to support automation and accelerated implementation of AI solutions in industry and services, especially in SMEs.
- Organizing Living Labs and virtual information centers through which companies, especially SMEs, can learn about examples of successful use of AI products and services (eg for intelligent data processing, customer profiling analytics, AI for industrial applications).
- Encouraging the transfer of knowledge from science to business by building incubators and supporting the development of start-ups in universities, research organizations and competence centers.
- Developing further the existing legal framework in relation to data protection, cooperation between the public and private sector and creation of public-private data sets.
- Enabling the development of research capacity in the industry by funding innovative laboratories at the company level, in order to test new AI technologies and business models in practice.
- Stimulating the development of innovation capacity in public research organizations and universities by introducing indicators such as "innovation index" in ICT and AI, through which to calculate targeted increases in subsidies.
- Disseminating at national level the European best practices for the integration of AI in Industry 4.0, as well as EU observations on the impact of AI on employment and specialist demand.

5.5. Raising awareness and building trust in society

There is a need to raise both citizens' awareness of the benefits of AI and the practical competence of the population on cyber risk prevention, the misuse of AI for mass impact, manipulation and misinformation [61] [62]. Along with the many expected benefits, the implementation of AI systems and products can both deepen existing ones and create new risks and vulnerabilities. Their effective prevention requires the creation of a socially responsible ecosystem that ensures that the development and use of AI is carried out in accordance with established normative and ethical principles. Effective public dialogue is a key factor that helps build trust and formulate sustainable policies for active interaction between AI developers and users. Building trust should be part of the dialogue with citizens within the Digital Bulgaria programme, as digitalisation will be one of the focuses of public attention in the next decade.

The following measures will help to intensify the dialogue with society and build trust:

- Planning initiatives and awareness-raising campaigns at local, regional and national level to provide information in an appropriate way depending on the respective use of AI. Campaigns should be tailored to the needs and interests of the specific target groups they aim at, e.g. specific business sectors, schools, universities, public service institutions, vulnerable social groups, etc.
- To reduce tensions due to changes in the labor market and prevent the exacerbation of social and economic inequalities due to the introduction of AI technologies, organizing

campaigns to disseminate information on retraining opportunities and the acquisition of higher digital skills in the affected groups of workers.

- Inviting business to support an effective, focused and consistent discussion with the scientific community and public authorities as a prerequisite for the development of public-private partnership on the development and implementation of AI in Bulgaria, by creating a platform for public-private debate on AI and getting involved in organizing discussions.
- Establishing the direction of activities and a respective structural unit of the future national Center for Excellence in AI, aimed at ensuring publicity of the achievements of the Center and the expected benefits for the society from their practical implementation.
- Creating a site with short videos in Bulgarian language about AI applications implemented in Bulgaria. Inviting publicly funded research projects to upload materials . Inviting Bulgarian scientists from abroad to record their lectures for display on the site. Creating a series of videos with examples of the data function in AI applications, to raise public awareness of the importance of data as a raw material for products and services with high added value.
- Actively implementing various EC initiatives such as the European Night of Scientists, etc. to raise the awareness of the general public and build a positive attitude and trust in the results of theoretical and practical developments in the field of AI.
- Purposefully collecting and disclosing in the media examples of innovative practices related to the successful application of intelligent robots and other types of AI systems in emergency situations, epidemic conditions, hazardous working conditions, etc.
- Organizing specialized editions of the traditional information days of academic organizations such as Open Days, Career Development Days, etc., and inviting representatives of companies with achievements in the creation of AI software to participate.
- Organizing competitions and hackathons on AI for students or pupils, using forms with already established traditions - for example, Olympiads for students and pupils; competitions organized by the Ministry of Education and Science and leading universities; Student Institute of BAS; events of the Union of Bulgarian Mathematicians, the Society of Automation and Informatics, the Union of Scientists in Bulgaria, etc.

5.6. Establishing a regulatory framework for the development and implementation of reliable AI in accordance with international regulatory and ethical standards

EU Member States are committed to implementing, directly or after transposition into national law, the requirements of EU law, including in the field of product safety and legal liability, and to providing mechanisms for its effective compliance. The principles of respect for fundamental rights, non-discrimination and the protection of personal data should be seen as an integral part of the requirements that ensure the safety of AI technologies.

It is important to pay attention to the possible social impact of the widespread implementation of AI technologies, taking into account the various factors that influence the risks of harm due to technical failure, negligence, unethical use of algorithms and data and abuse. To provide the necessary conditions for ensuring the development of reliable AI technologies in Bulgaria, an assessment of the applicability and effectiveness of the existing regulations on guaranteeing the fundamental rights of citizens and the safety of new products, including AI technologies, as well as the methodology for licensing these products and putting them into operation. It is necessary to analyze the overall set of existing security and legal liability measures, together with the mechanisms for their implementation. This includes:

- the challenges that AI creates for the effective implementation and enforcement of relevant national legislation;
- restrictions on the scope of existing national legislation;
- changing the functionality of AI systems;
- the distribution of legal responsibilities between the various economic operators in the supply chain;
- changes in the safety concept [4].

As of October 2020, the pan-European legal framework on the development and use of AI is under development. It is recommended that the analysis at national level be carried out after the establishment of a regulatory framework at EU level, which will allow for the relevant ongoing regulatory changes to be taken into account. Achieving an optimal balance between the need for regulation and the need to ensure regulatory freedom for business should be set as a fundamental principle in the preparation of the national analysis. This will serve as a prerequisite for the creation of a regulatory regime that supports the business environment while ensuring the rights of citizens and the well-being of society. The national assessment will contribute to the development of a set of broad-spectrum measures to ensure the development of reliable AI, including:

- Creating a national framework for risk assessment related to the development of AI technologies. The purpose of the framework is to provide an opportunity for a comprehensive overview of the legal and ethical aspects of AI technologies. The framework will be based on the precautionary principle [63] and will include a pan-European methodology for assessing high-risk AI technologies.
- Establishing a specialized mechanism for monitoring and assessment of the impacts of AI technologies. The mechanism will be of an advisory nature and will operate in accordance with the principles of the national framework. Its main goal is to provide an opportunity for targeted and consistent discussion and effective interaction between all stakeholders: government, business, experts and the scientific community. This in turn will help to form and formalize public-private partnerships that serve as platforms for constructive debates on the development and implementation of AI.
- Creating a set of tools to stimulate the adoption of the principles of safety and legal responsibility among the participants in the development, implementation and use of AI technologies. As the life cycle of an AI system involves many participants and shared

legal responsibility, it is crucial that each participant understands its responsibilities regarding the prevention of the risks associated with AI technologies. To this end, the set of tools should include a combination of procedures and flexible approaches that encourage informed judgment in the decision-making process. Such approaches are the creation of ethical (sector- or organizational-oriented) commissions for conducting research or implementing specific solutions based on AI; the development of sectoral codes of conduct with accompanying tools for implementation in practice; and the development of ethical guidelines for specific business lines and business models based on AI.

- Creating opportunities to increase public engagement on the role of AI in social life. Effective public dialogue is a key factor in building trust and formulating sustainable policies. It will contribute both to raising public awareness and to promoting active citizen participation in decision-making processes on trends in the development and use of AI. In this context, it is important that the relevant regulatory authorities (Consumer Protection Commission, Personal Data Protection Commission, Protection against Discrimination Commission, Communications Regulation Commission, etc.) have the power to explain to citizens the use of AI and how this affects the observance of their fundamental rights.

6. PROPOSAL FOR DEVELOPMENT OF AN ACTION PLAN AND SELECTION OF PRIORITY SECTORS

Given Bulgaria's limited resources, it is important to set national priorities for the thematic areas of AI implementation. Chapter 7, which outlines a framework for implementation, coordination and funding, proposes to organize a Working Group, including representatives of all stakeholders, to map the status of sectors important for the development and implementation of AI (regulations, industry 4.0 , assessment of the national and regional innovation capacity in ICT, etc.) and to develop an Action Plan in the short, medium and long term until 2030.

A fundamental proposal is for Bulgaria to focus on technological specialization in the field of data economy, as the country would find it difficult to achieve strong industrial specialization due to the lack of a critical mass of leading industrial companies in the AI sector. Today, the trend is for data to come to the forefront in AI and for the focus in machine self-learning to shift from algorithms to data [64]. Such is the European policy to make the EU a world leader in data-driven economics [16]. An example of a useful service that would be very valuable for AI applications is the integration of private (company) data with publicly available ontologies and very large databases to prepare a data resource for further analysis.

It is possible to list branches and thematic areas in which it is important to conduct scientific and applied research and to create both innovative prototypes and real, implemented in practice applications.

Software industry. The information technology industry (in which software development plays a central role) is a sustainable development and of ever-increasing importance for Bulgaria - both in purely economic aspects as a growing contribution to the country's gross domestic product, with the highest staff pay in the industry, as well as in social and other aspects - retention or return from abroad of highly intelligent and qualified personnel, crucial for the inclusion of broad goups of the population in high-tech tools in everyday life, etc. At the global level, Bulgaria is increasingly establishing itself as a destination for the development of research and development activities, as well as intensive innovative technologies in software. The software-AI relationship should be developed in two aspects:

- application of AI methods in software development: in this aspect the prospects are very good, considering that on the one hand, Bulgarian researchers have documented and recognized achievements at the world level[29], and on the other - in general the qualification of Bulgarian software developers is high and they are open to the adoption

[29] For example, M. Vechev and V. Raichev, founders of the software company DeepCode, a spin-off of the Zurich Polytechnic, purchased in 2020 by the unicorn company Snyk. The main product of DeepCode performs semantic analysis of real-time programme code based on AI and has over 100,000 users.

and application of new methodologies and tools for AI-based software development (including so-called Software 2.0);

- software development with built-in AI such as: tools / systems / environments for intelligent software development and management systems; building systems and means for cyber protection with AI; AI systems for analysis and prevention of hybrid attacks (including misinformation, manipulation, fake news, etc.); AI systems for critical infrastructure protection; systems for processing and communication in natural language with inclusion of the Bulgarian language; real-time image recognition and analysis systems / software for large volumes; means for training and protection against AI manipulations (including data protection and reliability); autonomous intelligent systems (robots, etc.) and cyberphysical systems.

The software, which is developed this way, in addition to being the subject of intensive exports (which is also typical for the software currently produced in Bulgaria), will significantly help the implementation of AI in the consumer sectors.

Creating AI applications for educational purposes. This area is important due to the rapid entry of e-learning in our country. It is no longer just about e-learning materials and online communication environments to accompany the main activities in the classroom[30], but about entirely distance teaching and assessment. AI tools can be used to improve a number of aspects of distance learning and to benefit from the information gathered, as long as they are carefully designed and trained on representative data. AI applications will allow:

- creation of learning materials with virtual reality, voice connection and attractive game elements;
- personalization of teaching with the help of intelligent training systems and adaptive navigation in the metadata of learning resources;
- diagnosing the attention, reactions, emotions and dynamics of the work of individual learners as feedback in personalized learning;
- supporting student assessment;
- supporting the generation of assessment tests by automatically synthesizing questions, answers and distractors according to a given textbook;
- analysis of the collected data on the success and opinions of students, parents and teachers to assess the quality of the learning process;
- creating software to support the planning of teachers' work;
- the integration of language technologies into systems for supporting the learning of foreign languages. In practice, any formalized set of grammar rules can be considered as a resource for automatic testing of knowledge of the relevant aspects of the language, which is built into specially designed tests for verification. It would be useful for Bulgarians abroad to provide a public online interface for learning Bulgarian grammar.

[30] The so-called “blended learning”

AI applications in public services. The report "Overview of the use and effect of AI in public services in the European Union" [26], published in July 2020, analyzes 230 deployments of AI services in the EU public sector for the period May 2019 - February 2020. The most common services as a percentage of the applications considered are:

- Chatbots, intelligent digital assistants, virtual assistants, advisory systems - 22.6%;
- Predictive analytics, simulations, data visualization - 16%;
- Computer vision (automatic image processing) and identity recognition - 12.6%;
- Expert systems, rule-based systems, algorithmic decision making - 12.6%;
- Natural language processing, text mining, speech recognition and analysis - 8%.

Other applications are: (deep) machine learning, process and vehicle automation, AI-based knowledge management, security analytics, audio processing. Bulgaria is among the countries with relatively lower growth in the implementation of AI applications (3), the Netherlands is leading with 19 systems, but nine countries are at the level of Bulgaria or with a lower number of considered applications.

The use of AI technologies in public services in our country can be expanded and deepened, because the country has qualified specialists and experience in all of the above AI technologies.

Intelligent agriculture. Bulgaria already has the necessary conditions for the development and implementation of relatively large-scale applications of AI in plant and animal husbandry - high degree of connectivity, cloud structures for data exchange and storage, accessible public data, qualified developers and specialists for the maintenance of complex cyberphysical systems. Embedding AI technologies will allow the creation of complex infrastructures that integrate the virtual and physical world and provide support for agricultural activities, such as remote process control; effective use and monitoring of the quality of water resources and soil; monitoring and controlling the growth of agricultural crops to increase yield and improve the taste of agricultural products; analysis of sensory data and publicly available satellite images and application of digital methods for diagnostics, forecasting and management of the production of quality products without negative effects on the climate and the environment. The introduction of modern technologies, such as the use of automation and robots in various plant and animal husbandry processes, will be an important practical evidence of the benefits of automating unattractive activities. Different AI technologies are integrated into intelligent agriculture systems: machine learning including deep learning; semantic modeling and ontological engineering; intelligent autonomous agents and multi-agent systems; accompanying technologies such as the Internet of Things and cloud structures; construction and maintenance of 3D models; analysis, integration and aggregation of big data for forecasting and operational decision making. Several prototype developments in this area after an in-depth assessment could serve as a reference infrastructure to be adapted and further developed for different regions of Bulgaria at the service of agricultural producers. This will support the formation and implementation of a consolidated agricultural policy, taking advantage of the application of AI in agriculture, and will facilitate the entry of digitalization and Industry 4.0 in

agriculture. In addition, it will be possible to plan measures for the development of professional staff in intelligent agriculture.

Another important direction in the development of intelligent agriculture, important in itself, is the collection, filtering, calibration, integration and organization of voluminous data sets and concepts in the field. Descriptive information needs to be presented as a text from which to derive (semi-) structured features in order to facilitate automatic integration with other data resources and analysis with AI tools. Important tasks related to data preparation are:

- To create an ontology with labels (names of concepts) in Bulgarian, which systematizes conceptual knowledge and data from natural sciences, biology and chemistry for crops, pests, pest control measures and the complex relationships between them. This information resource will make it possible to develop an intelligent system that can be easily used by a large number of users in the agricultural sector. This will lead to greater efficiency in the use of chemical and biological plant protection products and environmental protection. In the future, the system can be multiplied for plant protection of the forest (a essential natural resource of Bulgaria) and veterinary pharmacy.
- To organize and formalize the knowledge about strategy for Bulgaria crops and varieties - their biological, chemical and physical characteristics; spatial data on climate and soils; features of production: from seeds and planting material, through modern agricultural technologies, to quality, efficiency and market realization.

It is necessary to prepare the national information resource in a standardized format that will allow easy establishment of interoperability with internationally available information resources (eg open related data in the field of agriculture and life sciences), to feed the Bulgarian cloud of public data and to develop new intelligent analytical methods and approaches.

Applications of AI in healthcare and medicine. Under the Digital Europe program, the EC plans to develop AI applications in healthcare for the following six exemplary areas: supporting the decision-making process in clinical practice (how to treat a specific patient); treatment data exchange management - for example cross-border data exchange; improving logistics in hospitals; robotic surgery; detection of tumors in medical images and care for elderly patients and citizens with disabilities. The role of data (including genomic data) is to support decision-making in clinical practice and medical research, to provide opportunities for computer modeling and simulation, and to enable disease prevention and early detection. Among all the listed goals, Bulgaria is still at the stage of data collection - texts of patient records and medical images - and the organization of their use. There are also separate developments for the automation of patient care processes. More complex applications are usually purchased with the appropriate devices, such as the "Da Vinci" robotic surgical system.

During the last two or three decades in Bulgarian healthcare a number of health information systems have been developed and implemented with different goals and purposes, which provide information management in individual departments or support the accountability of GPs, pre-hospital care specialists and medical institutions at the National Health Insurance Fund. The lack of a comprehensive framework for e-health in the country and a unified concept for the architecture and integration of individual components prevents the introduction of

national, European and international health information standards, national and cross-border data exchange, to ensure the necessary high level of security of health data and leads to the lack of objective criteria for assessing the quality of health services and the effectiveness of the significant financial resources invested in the system. The general opinion is systemic dissatisfaction of the citizens and the medical staff with the existing health care system and lack of trust in its quality and efficiency. Thus, medical informatics, which is a highly valued profession in Western Europe, is becoming a misunderstood and therefore unattractive field of specialization for young Bulgarian computer scientists. There is a lack of competent specialists in this highly interdisciplinary field due to the insufficient representation of medical and health informatics in theprogrammes of medical universities.

The strategic documents for the development of Bulgaria in the next decade plan the creation of a National Health Information System, including a national system for electronic health records of citizens, electronic referrals and electronic prescriptions. This will be a prerequisite for the integration of health information systems and on this basis to overcome the existing fragmentation between them by achieving semantic interoperability of systems and technologies in health care and ensuring national and cross-border exchange of health data. The integration of elements of e-health systems in the e-government portal will allow citizens easy access to data related to the health system. It is proposed to create and maintain a National Access Point, providing national and cross-border secure exchange of electronic health records (with medical and health data from treatments, therapies, research, including medical images) and electronic prescriptions.

With the planned development of e-health in Bulgaria, it will be possible to apply the tools of AI for the analysis of patterns and predictive analytics for disease detection and risk factors over the gathered large collections of pseudonymous data for Bulgarian patients. If a risk of an observed or future disease is identified, it will be possible to send messages to at-risk patients and their doctors for prophylaxis within an integrated health information system. In this way, new models in health care and prevention of various diseases will be studied, based on the analysis of big data with the means of AI. Based on the data collected, it will be possible to set up decision support systems, including by improving the reading of medical images, in clinical practice and healthcare management. The detailed automatic analysis of anonymized records of Bulgarian patients will also help to create expertise that will be used in building a space for Bulgarian data in the field of healthcare as part of the European Data Space.

Another task is related to the semi-automatic creation of arrays of formalized knowledge with labels in Bulgarian, by using AI for partial machine translation of resources in English. In medicine, there is a solid resource of manually defined declarative conceptual knowledge, with names of concepts and connections in English - this is the Unified Medical Language System (UMLS[31]), which is freely available for research. One of its purposes is to support the creation of systems that automatically "understand" biomedical texts. There are also a large number of

[31] Unified Medical Language System see https://www.nlm.nih.gov/research/umls/index.html, built since 1986 by the US National Library of Medicine.

public ontologies[32] in the field of medicine, which are progressively recorded in a standardized format such as so-called "related data" or knowledge columns. All of these resources are created with the names of concepts and links in English. As it is unrealistic to plan the creation of a Bulgarian conceptual resource to help identify and analyze data from records in Bulgarian, AI tools need to be adapted to extract the necessary knowledge from resources in English. The extension of the terminology used in the Bulgarian medical nomenclatures will also help to annotate and mark interoperable data in the European medical data space.

Applications of AI in ecology and the environment. Integration of AI technologies into environmental monitoring systems will facilitate the analysis of information and increase the quality of observations. Data is a key component in these systems, as a resource that allows monitoring and assessment of the state of the environment and changes related to climate change. Collecting large data sets requires ubiquitous access to information, infrastructures with the capacity to store data and analyze real-time volumetric images, as well as organizing and delivering observations from robots, sensors, drones and satellite images with different resolutions. Ongoing monitoring by intelligent systems will help to address issues such as the protection of water bodies from pollution and drainage (early identification of hazardous pollutants or the risk of drainage of important water bodies), early identification of flood hazards (more rapid response to disasters), protection of forests from fires, parasites and illegal logging (faster response to events that threaten the country's forests), etc.

As discussed in Chapter 2, virtually every sector using digitization is a potential consumer of a type of AI, because the implemented computer systems can incorporate intelligent components or devices to automate routine repetitive activities. The choice of national priorities should be made in a relatively short period of time (e.g. 3-5 years) to allow for a flexible response to dynamic changes in the rapidly evolving field of AI. In addition, it should be noted that some of the AI applications enter the Bulgarian market as tested and certified products of leading foreign companies, which is why in many cases (e.g. some areas of robotic surgery) it is not effective to plan the development of national developments.

[32] https://ncbo.bioontology.org/

7. IMPLEMENTATION, MONITORING AND FINANCIAL PROVISION

7.1. Implementation

In connection with the effective implementation, monitoring and financial provision of the activities envisaged in the Concept, it is appropriate for the Council of Ministers to establish an Interdepartmental Working Group, which will include representatives of key state institutions, district administrations, academia, business and professional associations and related NGOs. This working group should analyze the state of the sector, map the expert units, achievements and implemented innovations, and prepare an operational National Plan / Roadmap for the implementation of the Concept, which defines the specific measures, deadlines, responsible institutions and organizations, expected results and indicators and sources of the necessary financial resources, as well as organization for reporting on their implementation and their periodic updating.

Given the horizontal nature of the topic, the implementation of the National Plan / Roadmap will be shared with the leading state institutions - the Ministry of Transport, Information Technology and Communications (MTITC), the Ministry of Education and Science (MoES), the State Agency for Research and Innovation (SARI), Ministry of Economy (MoE), State e-Government Agency (SEGA), Ministry of Labor and Social Policy (MLSP), Ministry of Health (MH), Bulgarian Small and Medium Enterprises Promotion Agency (BSMEPA), Ministry of Agriculture, Food and Forestry (MAFF), Ministry of Environment and Water (MOEW), Ministry of Energy (ME), Ministry of Justice (MoJ), Ministry of Finance (MoF), Ministry of Interior (MI), and the Ministry of Defence (MoD). Other ministries and agencies should be involved in the inclusion of other specific areas of application in the Roadmap. The regional authorities should prepare their own plans with measures for the implementation of **AI-BG** and establish their own regional units to support the dissemination of information on the results and opportunities for implementation. In addition to participants from state institutions, the Working Group should include representatives of universities and research organizations, business and industry organizations and clusters, Sofia Tech Park, as well as national non-profit associations related to science and technology (Federation of scientific technical unions in Bulgaria, the Union of Scientists in Bulgaria, the Union of Automation and Informatics, the Union of Electronics, Electrical Engineering and Telecommunications), and non-governmental organizations such as the American Chamber of Commerce, the Law and Internet Foundation and others.

7.2. Monitoring

In organizational terms, it is most appropriate for the monitoring of the implementation of AI-related activities in the relevant sectoral and regional policies to be carried out by a Coordinating Body / Council appointed by the Council of Ministers. The Council should involve representatives of all stakeholders and establish a model and mechanism for coordination at the strategic, political, operational and technical levels, ensuring that the

priorities and objectives of **AI-BG** are updated and linked to the development and implementation of national sectoral strategies. It is desirable to use the experience of EU partners to manage strategic interdisciplinaryprogrammes and to involve international experts in the Council. Much of the information needed for the work of the Council will be provided by the contractors under the usual measures of the monitoring structure to ensure the accuracy and correctness of this information, using an electronic platform for information sharing. The evaluation of the implementation will be carried out periodically and will be presented in reports, which will be submitted for approval by the Council of Ministers.

The purpose of the monitoring of the implementation of **AI-BG** is the possibility for continuous and accurate reflection of the current results of its implementation and, as a direct consequence of this - to take, if necessary, appropriate corrective actions. At the end of the planned period for implementation of the Concept, a full, objective and comprehensive evaluation of the final results will be performed.

The main parameters subject to monitoring are:

- compliance with the budget;
- compliance with deadlines;
- the achievement of the planned results and their quality.

While objective tracking of the first two parameters does not cause fundamental difficulties, this is not the case for the third parameter. The implementation of any planned measures or solutions must be accompanied by a measurement of their effectiveness, as well as by **criteria** that should determine the level of success of any such measure or decision.

To avoid subjectivity as much as possible, all measurements should, as a general rule, be quantitative and exceptions should be made where it is in principle impossible to define them. They must be carried out before the start of each activity to fix its initial state, during its implementation and after its completion. However, this means that the relevant **measures** must be defined, verified and validated in advance. To the parameters formulated in this way should be added some additional ones related to:

- the effective use of the provided resources - personnel, technologies, materials, information, etc.;
- compliance with various requirements - regulatory, ethical, motivational, etc.

Some of the criteria for the evaluation of the activities provided in **AI-BG** are already introduced or standard, such as indicators for the success of research and those related to the evaluation of the efficiency of resource use.

At the same time, there are criteria and indicators that need to be specified, such as assessing the impact of the emerging data economy, timely reporting of changes in the labor market, measuring public awareness and attitudes towards the perception of AI and others. New indicators are currently being developed within the composite Index for the Entry of Digital Economy and Society Index (DESI), which measures the development of EU Member States in terms of digitalisation in various fields, 5G coverage and use, artificial intelligence, ICT for

sustainable development, cybersecurity, data-based economy, e-health, high-performance computing and advanced digital skills.

In case of unsatisfactory results at some stage of the evaluation, corrective actions should include changes in:

- the organization of implementation;
- planned resources of different types;
- the deadlines in individual steps, and in the extreme case - the deadline;
- the content and characteristics of parts of the Concept.

In order for the monitoring to perform its tasks in a well-regulated environment, while avoiding conflicts between the participating countries as much as possible, it is necessary to take the following **measures**:

- defining the **goals**, **scope**, **tasks** and **expected results** of the monitoring;
- regulation of the powers of the supervisory body;
- preparation of a monitoring **plan**.

7.3. Financing

Sustainable funding is the only way to strengthen Bulgaria's scientific and innovation capacity in the field of AI and to ensure rapid accession to ambitious European initiatives for the development of AI research and for the creation and implementation of modern AI applications in key economic and social sectors. The High Level Expert Group on AI recommends: "Targeted, meaningful and long-term funding for basic and applied AI research is needed to maintain the competitiveness of European companies and meet societal challenges. In particular, funding should be provided for research that can help create critical mass projects on targeted topics, rather than focusing on individual projects without global coherence. This can help bring together research teams to work towards common goals. At present, there is no tool at European level to maintain this type of high-quality basic research, which could play a deterrent role for scientists to stay in Europe and attract the best from abroad"[21]. Although this recommendation is made at European level, it is fully valid for Bulgaria as well. Another ambitious decision of the EC is to significantly increase the funding of AI by combining public and private investments to reach at least 20 billion Euro per year for the next decade [65].

In connection with the goal of creating knowledge and skills for the development and use of AI, enshrined in the concept of **AI-BG**, it is necessary to increase investment in the education of AI specialists to reduce the shortage of staff with appropriate professional qualifications for work in this field, while updating the Bulgarian educational model so that it meets the needs of business. Efforts in this direction should be made by both the public and private sectors.

The financial provision of the implementation of the Concept is based on the presumption of optimized use of public and private finances, decentralization, strategic planning and programming, as well as seeking the added value of the implemented measures in support of the digital transformation of the economy and society and sustainable and environmentally friendly development. The efficient allocation of the existing financial resources, as well as

their efficient spending will be sought. Funding sources and financial instruments need to be complemented in a balanced way to build the necessary scientific infrastructure, create appropriate data sets, direct talented young researchers to AI research, build laboratory prototypes and implement real applications through public-private partnerships.

The main sources of funding for the activities implementing the Concept are the state budget, the Structural Funds of the European Union through the relevantprogrammes andprogrammes of the European Union "Horizon 2020" and "Digital Europe", as well as the National Plan for Reconstruction and Sustainability and other internationalprogrammes. Opportunities for public-private partnerships and attracting business investment will also be sought.

National and regional sources

Public funding of basic research in **AI-BG** and support for higher education should be provided through the Ministry of Education and Science and itsprogrammes, as well as through projects of the Research Fund. Applied research and innovation is the prerogative of the new State Agency for Research and Innovation (SARI). As AI is part of ICT, which is a priority of ISSS, some separate activities for applied research can be implemented through projects with the National Innovation Fund as tools for financing innovative solutions based on AI. The development of prototypes for experimental implementation in public organizations can also be financed by regional funds, for example, through partnerships in the cluster "Sofia City of Knowledge".

Programmes 2021-2027, funded by European funds

Theprogrammes are sources of funding for cohesion policy in the EU by reducing the disparities that still exist between European regions and countries. Policy Objective 1 for 2021-2027 is "A smarter Europe by promoting an innovative and smarter economic transition".

The **AI-BG** concept covers different areas of impact, which implies funding through different sources and with different instruments.

For Bulgaria for the period 2021-2027, an “Education Program” and a “Research, Innovation and Digitalization Programme for Smart Transformation” have been approved, which are a possible source of funding for some of the proposed specific measures, such as infrastructure construction. Theprogrammes will also support the Centers of Excellence and Centers of Competence established in the current period 2014-2020.

Another possible source of funding is the Enterprise Innovation and Competitiveness Program, whose specific objective (i) in Policy 1: "Strengthening research and innovation capacity and the introduction of modern technologies" will encourage cooperation between research institutions and industry to strengthen translational research, technology transfer and commercialization of results; and through a specific objective (ii) benefiting from digitalisation

/ enhancing digital connectivity, the deployment of AI applications in the public and private sectors[33] will be supported.

For the period 2021-2027, the Technical Assistance Program, the Strategic Plan for Agriculture and Rural Development, the Regional Development Programme and the Human Resources Development Programme have also been approved. Probably in them there will be an opportunity for at least partial financing of separate activities offered in **AI-BG**.

European (co)financing

Opportunities for funding some AI activities were provided at the European level in 2019 in the Horizon 2020 program, for example, through the competitions for the creation of the AI-on-demand platform (AI4EU) and "Building a a dynamic European network of AI[34] centers of excellence".

In 2021, the new seven-year Framework Programme for Research and Innovation Horizon Europe begins, which provides a significant budget for research on AI and other digital technologies. In addition, the Digital Europe programme has been launched, which provides a budget for the implementation of AI applications in various sectors.

The EU has a variety of opportunities to stimulate private sector investment and create more attractive conditions for start-ups to stay and grow in Europe, for example, through Horizon 2020 competitions, the European Fund for Strategic Investments (EFSI) and European Investment Fund (EIF).

The AI High Level Expert Group proposes that the European data infrastructure be funded through the Structural and Investment Funds to help create ecosystems to coordinate the exchange and access of data. Recognition of cooperation between the public and private sectors is crucial for increasing Europe's competitiveness, and it is recommended that public funding be redirected to sustainably develop a secure, safe and high-quality data infrastructure.

[33] http://opik.bg/uploads/2019/12/nov-programen-period-2021-2027-g-4.pdf

[34] Competition H2020-ICT-48-2020: Towards a vibrant European network of AI excellence centres.

8. DOCUMENTS REFERRED TO IN THE AI-BG CONCEPT

[1] Framework for National Strategy for the Development of Artificial Intelligence in Bulgaria, submitted by the Working Group of BAS on July 1, 2019, http://www.bas.bg/wp-content/uploads/2020/07/Towards-AI-Strategy-BAS-Vision-1July2019.pdf

[2] Artificial Intelligence for Smart Growth - Strategy for the Development of Artificial Intelligence in Bulgaria until 2030 (preliminary vision), prepared by the Working Group of BAS, June 2020. http://www.bas.bg/wp-content/uploads/2020/07/Proposal-National-Strategy-AI-2030-24June2020.pdf

[3] Science, Research and Innovation Performance of the EU 2020 (SRIP 2020). A Fair, Green and Digital Europe, European Commission, Directorate-General for Research and Innovation, Manuscript completed in May 2020, First edition, https://ec.europa.eu/info/sites/info/files/srip/2020/ec_rtd_srip2020-report.pdf

[4] COM(2020) 65 final: White Paper on Artificial Intelligence - Europe in search of excellence and an atmosphere of trust, 19.02.2020, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0065 link to the text in Bulgarian: https://op.europa.eu/en/publication-detail/-/publication/aace9398-594d-11ea-8b8101aa75ed71a1/language-bg

[5] COM(2018) 237 final: Artificial Intelligence for Europe, April 25, 2018, https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:52018DC0237

[6] EC – Factsheet: Digital Europe Programme: a proposed €9.2 Billion of funding for 2021-2027, 26.06.2019, https://ec.europa.eu/digital-single-market/en/news/digital-europe-programme-proposed-eu92-billionfunding-2021-2027

[7] Ministry of Economy: Concept for digital transformation of the Bulgarian industry (Industry 4.0), approved by the Council of Ministers on 30.08.2017, https://www.mi.government.bg/files/useruploads/files/ip/kontseptsia_industria_4.0.pdf

[8] COM(2020) 64 final: Report on the effects of artificial intelligence, the Internet of Things and robotics on safety and responsibility, 19.02.2020, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0064

[9] EC – High-Level Expert Group on Artificial Intelligence: Ethics guidelines for trustworthy AI, 08.04.2019, https://ec.europa.eu/digital-single-market/en/news/ethics-guidelines-trustworthy-ai

[10] COM(2019) 168 final: Building trust in human-oriented artificial intelligence, April 8, 2019, https://eur-lex.europa.eu/legal-content/BG/TXT/PDF/?uri=CELEX:52019DC0168&from=en

[11] European AI Alliance: The Assessment List for Trustworthy AI, https://futurium.ec.europa.eu/en/european-ai-alliance/pages/altai-assessment-list-trustworthy-artificial-intelligence

[12] EU 2020 Rolling Plan for ICT Standardisaiton, 05.05.2020, https://ec.europa.eu/docsroom/documents/41062

[13] General Data Protection Regulation (GDPR), https://gdpr-info.eu/

[14] Regulation (EU) 2018/1807 of the European Parliament and of the Council - on a framework for the free movement of non-personal data in the European Union, 14.11.2018 https://eur-lex.europa.eu/legal-content/BG/TXT/?uri=CELEX:32018R1807

[15] COM(2019) 250 final: Guidelines on the Regulation on a framework for the free movement of non-personal data in the European Union, 29.05.2019, https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:52019DC0250

[16] COM(2020) 66 final: European data strategy, 19.02.2020, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0066

[17] EC – Event Report: Workshops on reference testing and experimentation facilities for Artificial Intelligence in the Digital Europe Programme, 11.02.2020, https://ec.europa.eu/digital-single-market/en/news/workshops-reference-testing-and-experimentationfacilities-artificial-intelligence-digital

[18] McKinsey Global Institute: Tackling Europe's Gap in Digital and AI, Discussion Paper, February 2019, https://www.mckinsey.com/featured-insights/artificial-intelligence/tackling-europes-gap-in-digital-and-ai

[19] Gartner: Hype Cycle for Artificial Intelligence – 2019, 25.07.2019, https://www.gartner.com/en/documents/3953603/hype-cycle-for-artificial-intelligence-2019

[20] EC: Adopted conclusions on the Coordinated Plan on the development and use of Artificial Intelligence Made in Europe, 18.02.2019, https://data.consilium.europa.eu/doc/document/ST-6177-2019-INIT/bg/pdf

[21] EC – High-Level Expert Group on Artificial Intelligence: Policy and investment recommendations for trustworthy Artificial Intelligence, 26.06.2019, https://ec.europa.eu/digital-single-market/en/news/policy-and-investment-recommendationstrustworthy-artificial-intelligence

[22] Perrault R. et al.: The AI Index 2019 Annual Report, AI Index Steering Committee, Human-Centered AI Institute, Stanford University, December 2019, https://hai.stanford.edu/sites/default/files/ai_index_2019_report.pdf

[23] NATO Science & Technology Organization: Science & Technology Trends 2020-2040, March 2020, https://www.sto.nato.int/publications/Management%20Reports/2020_TTR_Public_release_final.pdf

[24] Magoulas, R., S. Swoyer: AI Adoption in the Enterprise 2020, O'Reilly Radar Report, https://www.oreilly.com/radar/ai-adoption-in-the-enterprise-2020/

[25] EC – AI Watch: AI for the public sector, https://ec.europa.eu/knowledge4policy/ai-watch/topic/ai-public-sector_en

[26] EC – AI Watch – Artificial Intelligence in public services, 3 July 2020, https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/ai-watch-artificial-intelligence-public-services

[27] European Parliamentary Research Service: Artificial intelligence in transport – Current and future developments, opportunities and challenges, March 2019, https://www.europarl.europa.eu/RegData/etudes/BRIE/2019/635609/EPRS_BRI(2019)635609_EN.pdf

[28] Regulation (EU) 2016/679 of the European Parliament and of the Council - on the protection of individuals with regard to the processing of personal data and on the free movement of such data, 27.04.2016, https://eur-lex.europa.eu/legal-content/BG/TXT/?uri=CELEX%3A32016R0679

[29] Council Directive 2000/43 / EEC - on the application of the principle of equal treatment between persons irrespective of racial or ethnic origin, 29.06.2000, https://eur-lex.europa.eu/legal-content/BG/ALL/?uri=CELEX%3A32000L0043

[30] Council Directive 2000/78 / EEC - establishing a basic framework for equal treatment in employment and occupation, 27.11.2000, https://eur-lex.europa.eu/legal-content/BG/TXT/?uri=CELEX%3A32000L0078

[31] Directive 2011/83 / EEC of the European Parliament and of the Council - on consumer rights, 25.10.2011, https://eur-lex.europa.eu/legal-content/BG/TXT/?uri=CELEX%3A32011L0083

[32] Directive (EU) 2019/882 of the European Parliament and of the Council - on requirements for accessibility of products and services, 17.04.2019, https://eur-lex.europa.eu/legal-content/BG/TXT/?uri=CELEX:32019L0882

[33] UNESCO, World Commission on the Ethics of Scientific Knowledge and Technology (COMEST): Report of COMEST on Robotics Ethics, 14 September 2017, https://unesdoc.unesco.org/ark:/48223/pf0000253952

[34] Directive 2001/95 / EEC of the European Parliament and of the Council on general product safety, 03.12.2001, https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32001L0095

[35] Regulation (EEC) No 765/2008 of the European Parliament and of the Council - laying down the requirements for accreditation and market surveillance relating to the marketing of products, 09.07.2008, https://eur-lex.europa.eu/legal-content/BG/TXT/?uri=CELEX:32008R0765

[36] Regulation (EU) 2019/1020 of the European Parliament and of the Council - on market surveillance and product conformity, 20.06.2019, https://eur-lex.europa.eu/legal-content/bg/ALL/?uri=CELEX:32019R1020

[37] Council Directive 85/374 / EEC - on the approximation of the laws, regulations and administrative provisions of the Member States concerning liability for damage caused by a defect in goods, 25.07.1985, https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex%3A31985L0374

[38] MTITC: National Programme Digital Bulgaria 2025 and Road Map, 05.12.2019, https://www.mtitc.government.bg/bg/category/85/nacionalna-programa-cifrova-bulgariya-2025-i-putnakarta-kum-neya-sa-prieti-s-rms-no-730-ot-5-dekemvri-2019-godina

[39] MTITC: Draft national strategic document "Digital Transformation of Bulgaria for the period 2020-2030, https://www.mtitc.government.bg/bg/category/167/proekt-na-nacionalen-strategicheski-dokumentcifrova-transformaciya-na-bulgariya-za-perioda-2020-2030-g

[40] MoF: Vision, goals and priorities of the National Development Programme Bulgaria 2030, https://www.minfin.bg/bg/1394

[41] Council of Ministers: Updated National Strategy for Development of Scientific Research 2017-2030 and Operational Plan for Implementation of the First Stage of the National Strategy for Development of Scientific Research in the Republic of Bulgaria 2017-2030, 19.05.2017, http://www.strategy.bg/StrategicDocuments/View.aspx?lang=bg-BG&Id=1231

[42] MoES: National Roadmap for Scientific Infrastructure 2017-2023, https://www.mon.bg/upload/4012/Roadmap_2017_BG.pdf

[43] MoE: ISSS - Innovation Strategy for Smart Specialization of the Republic of Bulgaria 2014-2020, updated 12/18/2018, https://www.mi.government.bg/bg/themes/inovacionna-strategiya-za-inteligentna-specializaciya-narepublika-balgariya-2014-2020-g-1806-287.html

[44] EC – European innovation scoreboard 2019, https://ec.europa.eu/growth/industry/policy/innovation/scoreboards_en

[45] SEGA: Updated Strategy for Development of e-Government in the Republic of Bulgaria 2019-2023 and Updated Roadmap for Implementation of the Strategy for the Period 2019-2023, August 2019, https://e-gov.bg/wps/portal/agency/strategies-policies/e-management/strategic-documents

[46] MAFF: Strategy for Digitization of Agriculture and Rural Areas of the Republic of Bulgaria, 2019, https://www.mzh.government.bg/media/filer_public/2019/05/10/strategia_za_cifrovizacia_na_zemedeli eto.pdf

[47] Institute of Agricultural Economics at the Agricultural Academy: Analysis of the state of agriculture and the food industry, January 2020, https://www.mzh.government.bg/media/filer_public/2020/01/21/analiz_na_sstoianieto_na_selskoto_stopanstvo_i_khranitelno-vkusovata_promishlenost_izgotven_ot_institut_po_agrarna_ikonomika.pdf

[48] Council of Ministers: National Cyber Security Strategy "Cyber Sustainable Bulgaria 2020", 18.07.2016, http://www.strategy.bg/StrategicDocuments/View.aspx?lang=bg-BG&Id=1120

[49] Innovation strategy for intelligent specialization of Sofia, 28.01.2016, https://www.sofia.bg/documents/20182/448750/ISIS_Sofia.pdf/f51fcd5a-2973-4679-89fe62b3dccb6662

[50] EC – DESI: The Digital Economy and Society Index, https://ec.europa.eu/digital-single-market/en/desi

[51] BASSCOM Barometer 2019, Annual Report on the State of the Software Sector in Bulgaria, December 2019, https://www.basscom.org/RapidASPEditor/MyUploadDocs/BASSCOM_Barometer_2019_BG.pdf

[52] Vangavis: Artificial intelligence ecosystem in Bulgaria, 2019, available at https://reports.seenews.com/

[53] EC: European enterprise survey on the use of technologies based on artificial intelligence, 28 July 2020, https://ec.europa.eu/digital-single-market/en/news/european-enterprise-survey-use-technologies-based-artificial-intelligence

[54] MoE: National Strategy for Promotion of Small and Medium Enterprises 2014-2020, 23.01.2014, https://www.sme.government.bg/uploads/2013/08/sme_strategy-2014-2020.pdf

[55] EC – Horizon 2020 Policy Support Facility: Independent expert evaluation of the Bulgarian research and innovation system, 2015,
https://www.mon.bg/upload/10722/Full_report_Peer_Review_of_the_BG_RI_system_under_the_PSF_bgl.pdf
summary in Bulgarian:
https://rio.jrc.ec.europa.eu/sites/default/files/report/PR%20Bulgaria_Executive%20summary%20Bulgarian.pdf

[56] Lopez Cobo et al.: Academic offer and demand for advanced profiles in the EU, EUR 29629 EN, Publications Office of the European Union, Luxembourg, 2019,
https://ec.europa.eu/jrc/en/publication/academic-offer-and-demand-advanced-profiles-eu

[57] MoES: Artificial Intelligence in Education and Science, July 2020,
https://www.mon.bg/upload/23352/MON+AI+Doc.pdf

[58] UNICEF: Artificial Intelligence and Childrens Rights, 2019,
https://www.unicef.org/innovation/media/10726/file/Executive%20Summary:%20Memorandum%20on%20Artificial%20Intelligence%20and%20Child%20Rights.pdf

[59] UNESCO: Beijing Consensus on Artificial Intelligence and Education: Outcome document of the International Conference on Artificial Intelligence and Education, Planning Education in the AI Era: Lead the Leap, Beijing, 2019, 70 p. (multilingual),
https://unesdoc.unesco.org/ark:/48223/pf0000368303

[60] COM(2016) 381 final: New European Skills Agenda: Working together to strengthen human capital, employability and competitiveness, 10.06.2016,
https://eur-lex.europa.eu/legal-content/BG/ALL/?uri=CELEX:52016DC0381

[61] National Academies of Sciences, Engineering, and Medicine, Artificial Intelligence: An International Dialogue: Proceedings of a Workshop – in Brief, National Academies Press, 2019,
https://www.nap.edu/catalog/25551/artificial-intelligence-an-international-dialogue-proceedings-of-aworkshop-in

[62] National Academies of Sciences, Engineering, and Medicine, Implications of Artificial Intelligence for Cybersecurity: Proceedings of a Workshop, National Academies Press, 2019,
https://www.nap.edu/catalog/25488/implications-of-artificial-intelligence-for-cybersecurity-proceedingsof-a-workshop

[63] UNESCO: World Commission on the Ethics of Scientific Knowledge and Technology (COMEST), The Precautionary Principle, 2005,
https://unesdoc.unesco.org/ark:/48223/pf0000139578

[64] Gartner Hype Cycle for Artificial Intelligence – 2020, 27 July 2020,
https://www.gartner.com/en/documents/3988006/hype-cycle-for-artificial-intelligence-2020

[65] COM(2018) 795 final: Coordinated Plan on Artificial Intelligence, 7.12.2018,
https://ec.europa.eu/digital-single-market/en/news/coordinated-plan-artificial-intelligence