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Development of the Digital Infrastructure of the State System of Scientific and Technical Information in 2021-2025 as a New Stage in Building a Knowledge Economy in the Republic of Belarus¹

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Abstract. The article examines the conditions created in the Republic of Belarus during the construction of the digital economy and the development of the information society. These conditions are recognized as the basis for new topical transformations of the State System of Scientific and Technical Information of the

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Republic of Belarus (SSSTI) as a key generator of knowledge of the National Innovation System. Scientific and technical information (STI) and the digital transformation of key areas of its collection, processing, and storage are becoming the main development goals of the SSSTI for 2021-2025.

Keywords: digital development, digitalization, information and communication technologies, STI, SSSTI, knowledge economy, digital infrastructure, NIS, digital content, digital platform, intelligent technologies, telecommunications infrastructure.

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Развитие цифровой инфраструктуры государственной системы научно-технической информации в 2021-2025 гг. как новый этап построения экономики знаний в Республике Беларусь

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Аннотация. В статье рассматриваются условия, созданные в Республике Беларусь в ходе построения цифровой экономики и развития информационного общества. Данные условия признаются базой для новых актуальных преобразований Государственной системы научно-технической информации Республики Беларусь (ГСНТИ) как ключевого генератора знаний Национальной инновационной системы. Научно-техническая информация (НТИ) и цифровизация ключевых областей ее сбора, обработки и хранения, а также формирование общего цифрового пространства НТИ становятся основными целями развития ГСНТИ на 2021-2025 гг.

Ключевые слова: цифровое развитие, цифровизация, информационно-коммуникационные технологии, НТИ, ГСНТИ, экономика знаний, цифровая инфраструктура, НИС, цифровой контент, цифровая платформа, интеллектуальные технологии, телекоммуникационная инфраструктура.

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Digital transformation of the Republic of Belarus

Commonly recognized conditions for creating favorable environment for effective economic development in current circumstances have become the processes of digital transformation, which have given rise to a new wave of innovations. Digital development today is a labor-consuming, incremental process of re-engineering business processes and introducing them into the digital space, i.e. automation of the vast majority of management systems and digitalization of physical information arrays.

Over the past 30 years, digital transformation has experienced several stages of development: formation (development of new markets for electronic services, e-business and e-commerce in 1990-2005); maturity defined as the building in online channels and digital penetration into traditional sectors of the economy (2005-2010); digital fever, currently: fundamental restructuring of business processes and transformation of business models [1, 2].

The digital development of Belarus was grounded upon a number of conceptual strategic documents which set out the goals, objectives and mechanisms of digital transformation. According to these documents, the digital development of the republic may be divided into several stages (Figure 1).

The first stages of digital transformation, which began when the Republic of Belarus became a sovereign state, were aimed at overcoming the crisis of state transformation, as well as setting up the national information space. Since 2000, the processes of automation and digitalization of various domains of national activity have been initiated. The National Program of Accelerated Development of Information and Communication Technology Services within 2011-2015 provided for the groundwork

for digital transformation of most sectors of economy, and the Program of Digital Economy and Information Society Development within 2016-2020 allowed to consolidate the achievements of previous years and to address digitalization with more comprehensively [2].

Now we are observing the results of the five years' work done under various governmental and industry-specific programs. The key advantage for the country has become the information and communication infrastructure developed over these years and the automation of all types of processes, both of public and private sector, whereby our country has entered a group of economies with a very high level of e-government development (Fig. 2).

A distinctive feature of the Republic of Belarus in almost all ratings which include technological aspects of state development was the advanced information and communication infrastructure. Obviously this is a key advantage of the country and a fertile ground for further digital transformation. In addition to the advanced infrastructure, a decent level of the regulatory environment of the information society has also been marked (see Fig. 1).

Despite the achieved results, digital development of the country is confronted by a number of problems and obstacles for its final establishment due to remarkable features of the formation and development of the state. These include:

- An obsolete document-centric management system and widespread use of paper media, a tiered vertical, and digitalization of outdated processes;
- The lack in some cases of interaction between information systems of institutions, and the lack of common principles of formation of systems and their integration;

Phase 1: First national initiatives in informatization	1991–1994
<ul style="list-style-type: none"> • The Republic of Belarus was the first CIS country to envisage an informatization program. • The formation of the national segment of the Internet was started. 	
Phase 2: Formation of the conceptual framework for digital development of the Republic of Belarus	1995–1999
<ul style="list-style-type: none"> • The Law of the Republic of Belarus ‘On Informatization’. • The concept of infosphere formation in the Commonwealth of Independent States (1996). • Resolution of the Council of Ministers of the Republic of Belarus ‘On Improving the Mechanism of State Administration of Informatization Processes in the Republic of Belarus’ (1997). • Ruling of the Council of Ministers of the Republic of Belarus ‘On the development of a unified scientific and information computer network in the Republic of Belarus’ (1998). • The concept of national policy in the domain of informatization (1999). 	
Phase 3: Elaboration of practical solutions for the digital development of the state	2000–2010
<ul style="list-style-type: none"> • National programs ‘BelElektronika’ (2001-2005), ‘Information Protection’ (2001-2005), ‘Information Technologies’(2001-2005). • National program of Informatization of the Republic of Belarus within 2003–2005 and as a long-term initiative, ‘Electronic Belarus’ until 2010. 	
Phase 4: Building an information society and the transition to digital transformation of industries	2011–2015
<ul style="list-style-type: none"> • The strategy for the development of information society in the Republic of Belarus for the period until 2015. • The Law of the Republic of Belarus ‘On Information, Informatization and Information Protection’. • Decree of President of the Republic of Belarus No. 515 as of November 8, 2011, ‘On Issues of Information Society Development in the Republic of Belarus’. • The Law of the Republic of Belarus ‘On Electronic Documents and Electronic Digital Signature’. • The national program of accelerated development of services in the sphere of information and communication technologies for 2011-2015. 	
Phase 5: Building an e-government	2016–2020
<ul style="list-style-type: none"> • The strategy for informatization development in the Republic of Belarus for 2016-2022. • Concept of information security of the Republic of Belarus. • Strategy ‘Science and Technology: 2018-2040’. • National strategy for sustainable socio-economic development of the Republic of Belarus until 2030. • National program of digital economy and information society development for 2016-2020. • National program of innovative development of the Republic of Belarus for 2016-2020, State scientific and technical programs: ‘Information protection’, ‘Intellectual information technologies’, ‘Robotic complexes and aerospace technologies’, etc. • Decree No. 8 ‘On development of digital economy’. • Presidential Decree No. 478 ‘On development of digital banking technologies’. • Decree No. 243 ‘On electronic document interchange in preparation and adoption of legal acts’. 	

Fig. 1. Phases of development of information society in the Republic of Belarus

- Continuous use of outdated technologies of formation of information systems;
- Dissimilar principles of data management, lack of unified data standards, poor implementation of Open data and Open access principles;
- Undulating and isolated nature of digital transformation due to varying degree of digital transformation in industries, departments and individual organizations;
- Low contribution of research and development efforts into the nation-

al economy, insufficient funding of works, low science intensity of GDP, as well as implementation issues of innovation potential.

Therefore, the further digital development of the state has a strong telecommunications basis, necessary for the introduction of cutting-edge technologies in state processes, but also it faces a number of constraints due to the specificity of working with data and some socio-economic characteristics typical to the country.

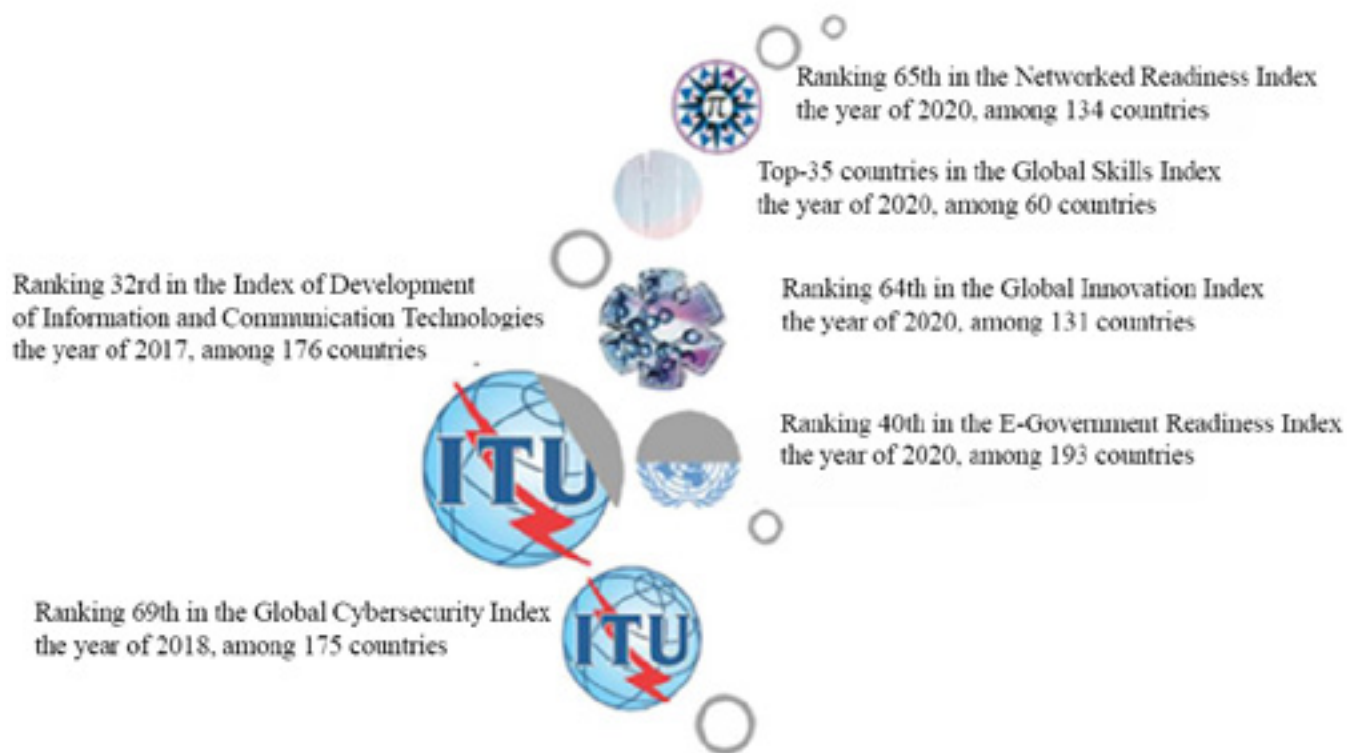


Fig. 2. The Republic of Belarus in international ratings

The SSSTI in the comprehensive vector of digital development

In the course of building digital economy in the state, special attention was paid to transformation of the scientific domain. Thus back in 2006, the Concept for the List of works on development of the State System of Scientific and Technical Information of the Republic of Belarus (SSSTI) was elaborated, which defined goals and objectives of SSSTI, as well as directions of research and development work (R&D) on its building up.

The key objectives for SSSTI building up were:

- Creation of high-speed information and communication infrastructure of the state system of scientific and technical information;
- Creation of automated systems of scientific and technical information;
- Development of information resources of the state system of scientific and technical information and their integration into the world scientific and technical infosphere.

Over the past 14 years, 138 R&D activities in the above areas have been accomplished. Along with direct research and development initiatives, addressing most of the issues of digitalization of science, substantial work on support and upgrade of the infrastructure of STI libraries has been carried out. An interlink for all digitalization efforts of SSSTI became scientific-information and scientific-educational computer networks, maintenance and development of which is annually carried out by the state organizations (see table).

Today, the SSSTI represents itself an information and communication basis of the National Innovation System (NIS). The work which has been performed, allowed the Republic of Belarus to suc-

cessfully accomplish the first phase of digital transformation, i.e. the transfer of a number of existing processes to the digital sphere - automation of retrieval, processing and storage of STI, as well as setting up a digital infrastructure for data transfer.

In the course of these works an infrastructure of information-communication and scientific-educational computer networks (environments) with high resolution of broadband universal access to the Internet and world networks has been created. Also, the conditions for the introduction of electronic services into libraries of STI, as well as for the use of various information systems and databases to work with STI online have been set up. Moreover, in the state and scientific agencies a number of automated information systems and databases have been deployed and put into operation, which allowed to automatically process arrays of information, and to improve the processes of monitoring and analysis of scientific and scientific-technical activities.

However, transition at this phase has led to one of the crises of digital development: the work done on automation has rooted a number of problems prevailing in the real world and set up additional questions regarding the procedures of data handling. The fragmentation of information systems and digital data has led to information overload, forced multitasking of people working with STI, and the need for frequent switching.

The main characteristics of the existing SSSTI have become:

- accumulation of big data;
- accumulation of information systems and resources duplicating functions and data;
- digitization of paper documents;

Key areas of digitalization of SSSTI in 2016-2020

<p>USICN</p>	<p>A developed information-communication infrastructure of STI was created: the Unified Scientific Information Computer Network of the Republic of Belarus (USICN), as well as the scientific information networks of the Ministry of Education, Ministry of Health, Ministry of Economy and the BASNET network of the NAS of Belarus, which ensures autonomous access to global computer networks through the all-European scientific network GEANT, were being maintained and modernized on a permanent basis. Now 203 organizations are connected to the SSSTI networks (which comprise the NAS of Belarus, the Ministry of Economy, the Higher Attestation Commission, the State Committee on Science and Technology and Ministry of Health, the Ministry of Education), and 72 information resources and systems are put on the web.</p>
<p>STI libraries</p>	<p>The digital infrastructure of science & technology information libraries of Belarus has been formed: electronic catalogs, electronic libraries, electronic delivery of documents and books is functioning, databases (DB) of own generation are maintained routinely. The largest SSSTI libraries are: the Republican Science & Technology Library (comprising 160 DBs, more than 180 thousand users per year), the Central Scientific Library of the NAS (the electronic catalog of which contains more than 1.6 million records, as well as 1.8 million records in its DB and also access to global DBs), the Belarus Agricultural Library of the NAS (40+ DBs, more than 10 thousand records available in the EC). The National Electronic Catalogue of Science & Technology Libraries (more than 8 mln records).</p>
<p>Research and Technological Development</p>	<p>Since 2006, 75 automated information systems and databases have been set up, and 32 R&(T)D projects in information and communication infrastructure have been conducted, and 32 information resources have been created. Most of the processes of STI storage and processing have been automated, systems of automated monitoring of scientific and technical innovation activities have been created.</p> <p>New technologies for data processing, storage and transmission, modern retrieval technologies and new solutions in data security, data management and evaluation technologies have been developed.</p>

- transfer of government information systems and resources to cloud repositories;
- lack of business models to ensure effective use of accumulated digital STI arrays;
- electronic copies of documents on the Internet, upsurge of electronic documents, publications and journals;
- increase in the number of users of computer networks;
- deeper isolation of the Belarus scientific community from the global exchange of scientific publications, etc.

Despite the fact that the development of SSSTI was guided by the key strategic state documents in the field of digitalization and informatization, some strategic documents on the development of SSSTI had not been provided, which led to certain problems affecting its development.

Works done in the field of SSSTI (automation and digitalization) allowed to accumulate the necessary amount of data for further revision of trends in the development of information technology. As a result, a feasible infrastructure for data storage and transmission, basing on high-speed channels and cloud computing has crystallized, along with the means for data protection of communication channels.

The solution of these problems will be transition to a new phase of digitalization of science, i.e. the revision of existing mechanisms of work with STI and the formation of advanced business models of functioning of SSSTI in the digital domain.

Development of SSSTI in 2021-2025. Building up a digital knowledge infrastructure

Thus, by the end of 2020, we may observe two interrelated trends in the context of the

synergy of the SSSTI and the digital economy of the Republic of Belarus. The first one is the high-quality information and communication infrastructure created over the years in the country, which provides an effective basis for innovation and digital transformation of almost all sectors of economy. The second is the arrays of digital scientific and technical data accumulated by the SSSTI. These conditions create a favorable climate for combining several key models of post-industrial society: digital economy, knowledge economy and information economy, and, consequently, for considering information and knowledge as a priority resource of state development.

Today SSSTI is a domain, which is widely exposed to digital changes, and at the same time it is a sphere, which most clearly reflects achievements in science and innovation. Modern conditions for building up the information society and shaping of the SSSTI as a database of relevant and comprehensive information, requires setting as a goal for the SSSTI within 2021-2025: ensuring of on-the-spot informational interaction and access of subjects of STI to necessary STI by establishing of uniform digital sphere of a scientific domain [3, 4]. Thus in such a way, in tight interrelation of NIS and SSSTI in a new digital format, it becomes possible to build a qualitatively new model of generation, distribution and use of knowledge, and its embodiment in new products, technologies, services in all spheres of life of society.

In order to ensure the consistency of further development of SSSTI for 2021-2025 the program-targeted approach was adopted, which makes it possible to fix the main goals and objectives of the development of STI system in the country within the State Program Of Innovative Development of the Republic of Belarus and The Plan Of Measures For The Development of the NIS.

The purpose of development of STI for the period 2021-2025 in these documents was to ensure the on-the-spot informational interaction and access of subjects of NIS to the necessary STI by establishing of uniform digital sphere of the scientific domain.

To achieve this goal it was necessary to solve the following tasks:

- building up a system of national digital science and technical content and its promotion to the global infosphere;
- expansion of opportunities for prompt access to digital foreign STI resources;
- development and widespread implementation of modern technologies for processing, storage, retrieval and transmission of STI;
- modernization and development of digital infrastructure of science and technical libraries, information centers and funds;
- building up a system of information and analytical support for decision-making in science and technology, public administration, and the economy.

The mechanisms for addressing these issues are:

1. In order to build up a system of national digital scientific and technical content and its promotion into the global infosphere it is necessary to ensure:

1.1. creation of a system of regulatory support for electronic scientific and scientific-technical publications, which includes revision the of existing legal regulatory acts and elaboration of a guide on publication of electronic STI materials;

1.2. promotion of financial, scientific-methodological and organizational conditions for stimulation of activity on creation

of electronic scientific and technical materials, their distribution in accordance with the world best practices of "open access", "open science", and international standards of identification and description of electronic resources;

1.3. creation of a national portal of STI, comprising national information resources on scientific and scientific-technical activity;

1.4. establishing a national information platform for electronic publishing of science and science-technical materials;

1.5. creation and distribution of educational content on STI issues (work with bibliographic and abstract DBs, creation of electronic publications, abstracting, using mechanisms of description and identification of information resources).

2. To expand the opportunities for operational access to digital foreign STI resources it is necessary to:

2.1. to establish a unified national center (URC), which provides access of subjects of the National innovation system to global information resources of STI, including full-text and factual databases, databases of scientific citation indexes;

2.2. to frame a system of authorized access and operational information for users of the ERC, which provides a description, cataloguing and abstracting of available and the most significant global information resources.

3. For the development and large-scale implementation of modern technologies of processing, storage, retrieval and transfer of STI it is necessary to ensure:

3.1. development and implementation into the STI system of technologies for processing of big data, artificial intelligence, vir-

tual and augmented reality and other modern technologies for handling information;

3.2. creation from the scratch, and development and maintenance of existing information systems, DBs and other STI resources, improvement of access to them, taking into account their further integration with the Unified Identification System for legal entities and individuals, changes in the volume and types of STI, mobility of users, etc.;

3.3. development of telecommunication infrastructure of scientific information and scientific educational networks, providing functioning of modern services (video conferencing, delivery of high-resolution multimedia content, virtualization of users' workspace, etc.), information security and fault-tolerance.

4. To modernize and develop the digital infrastructure of science and technical libraries, information centers and foundations it is necessary to ensure:

4.1. development and implementation of new methods and technologies for maintaining and integrating electronic information resources, electronic libraries and archives, including aggregation of information from different sources, management of information flows, ensuring work with data in digital formats changing in real time;

4.2. promotion of conditions for the development and integration of open STI repositories and electronic libraries, equipping them with modern search engines and a unified metadata system;

4.3. modernization of digital infrastructure of science and technical libraries and STI centers.

5. To form a system of information and analytical support for decision-making in

science and technology, public administration and economy, it is necessary to ensure:

5.1. development and implementation of technologies for automated retrieval, aggregation and analysis of information from distributed sources, including open information resources of the Internet;

5.2. formation of a range of information and analytical services to support decision-making for the innovative development of certain sectors of the economy;

5.3. application of the results of fundamental works in the field of SSSTI when making managerial decisions in the state activity.

All of the above initiatives are aimed at creating a digital infrastructure of scientific and technological data and will form the basis for improvement of information environment of innovations in the country, high quality publicity of government activities, the basis for science development and its popularization in the country, as well as popularization of national scientific and technological achievements in the world.

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