

Management of digitization of infrastructure projects and programs

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Abstract

The purpose of the article is to develop systemic approaches to improving the process of managing digitization of infrastructure projects based on strategic management. The article describes the feature of digitalization of infrastructure projects and programs, as well as the process of managing changes in infrastructure projects. System analysis of the implementation processes of infrastructure projects, programs and project portfolios was carried out. The advantages of the implementation of digitization of infrastructure projects and programs are highlighted. A PEST analysis was developed for digitalization of infrastructure projects. In the course of the study, a conceptual model-scheme for the formation of change management parameters in infrastructure projects was proposed, which allows for the forecasting of all possible options for the development of infrastructure projects.

Keywords

infrastructure project, digitalization, PEST analysis, digital trends, artificial intelligence, Information technologies

1. Introduction

The development of infrastructure projects and programs is important for the economic growth and social welfare of the country. Infrastructure includes everything from roads, bridges, railways to energy systems (hydroelectric plants, critical infrastructure facilities) and communication networks, and its efficiency directly affects the efficiency of the national economy and the quality of life of citizens. Today, in Ukraine and the world, there is a rapid but uneven development of science, technology, information technologies and management methods. Digital transformation consists in radical changes in modern trends of political and economic processes, social interactions and future prospects.

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Digital technologies shape civic activity and influence the external image of the state and the analysis of the implementation processes of infrastructure projects, programs and project portfolios. The main causes of the problem include the use of different methodologies and standards, which complicate adaptation when planning and implementing infrastructure projects.

2. Analysis of recent research and publications

Leading domestic and foreign scientists, including S. Bushuyev [3], O. Zachko [7], A. Tryhuba [13], N. Bushuyeva [4], O. Duda [5], were engaged in the management of digitalization of infrastructure projects and programs. M. Nazaruk [2] and others. So, in particular, Professor S. Bushuev in his scientific works examines the organizational maturity of projects and analyzes the success of its implementation [3]. In the studies of A. Tryhuba and R. Ratushny, in the context of a safety-oriented approach, the processes of designing fire extinguishing systems for the public are considered. They developed a model of projects for the creation of fire extinguishing systems in the territories of communities, planned the territorial placement of fire and rescue formations in development projects of administrative territories, and presented a conceptual model of project management for the technological development of an integrated industry [13]. The choice of effective methods of analytical processing of large data in information systems was studied by scientists O. Duda, N. Kunanets and others [5]. Information technologies for modeling processes are reflected in the works of M. Nazaruk [2]. The scientific school of O. Zachka investigates models of infrastructure project content management that are adapted to modern changes, and digitalization of personnel management of project-oriented organizations in the field of safety is also studied in depth [6]. Scientific research by Professor I. Babaev highlights the issues of priority management in project portfolios in complex and dynamically changing environments [1]. Professor N. Bushuyeva's scientific research is devoted to the problems of management of competence-driven IT projects [4]. According to A. Ivanusa [7], an infrastructure project includes a set of management actions that are implemented with the aim of creating a unique project product that unites the IT sphere, social spheres, the sphere of education, transport and safety. The fundamentals of infrastructure project management, guided by world trends [9] and IT project management competencies [3] are considered. After analyzing the works of well-known scientists, we can say that a special niche in this field has been allocated to the digitalization of infrastructure projects.

The purpose of the article is to develop systemic approaches to improving the process of managing digitization of infrastructure projects based on strategic management.

The results of the study are aimed at the development of a PEST analysis for the digitalization of infrastructure projects and the development of a management model for infrastructure projects and programs.

3. The bulk of research

Infrastructure is critical to sustaining an economy as it provides the necessary conditions for doing business, as having a developed infrastructure can attract investment, help create jobs and reduce the cost of logistics and transportation of goods. Quality infrastructure affects the quality of life of citizens by providing access to education, health care, clean water and safe transportation. It also promotes equal access to resources and opportunities, increasing the overall level of social justice. Infrastructure development with climate resilience and environmental sustainability in mind is critical to minimizing the impact of extreme weather events. Modern infrastructure projects and programs integrate "green" technologies and practices aimed at reducing the carbon footprint. Developed infrastructure can increase the competitiveness of the national economy on the global market, improving production efficiency and providing more favorable conditions for international trade. Infrastructure projects are often catalysts for technological innovation, as they require the introduction of the latest technologies to improve efficiency, reduce costs and minimize environmental impact.

The implementation of digitalization in infrastructure projects and programs is becoming increasingly relevant due to the number of advantages it provides, promoting efficiency, transparency and innovation. Let's consider the main advantages of implementing digitalization in infrastructure projects and programs in Table 1.

Table 1

Advantages of implementing digitization in infrastructure projects and programs

Advantage	Justification
Increasing efficiency	Digital technologies can optimize project management, simplify infrastructure monitoring and maintenance, and significantly reduce costs. Automating processes with the help of digital tools allows you to reduce the time spent on routine tasks and focus on more important aspects of project management.
Improving data quality and decision-making	With the use of sensors, IoT, and big data, project managers can obtain real-time information about the health of the infrastructure in real time, which allows to quickly respond to problems, plan maintenance and optimize resources, which ultimately improves decision-making.
Ensuring transparency and accountability	Digital tools allow for high transparency of project management. Information on project progress, financial flows and results are easily accessible to all stakeholders, reducing corruption risks and increasing accountability.
Increasing resilience	Digitization helps infrastructure projects to be more adaptive

to change	and resilient to changing conditions, including climate change, technological change, and socio-economic fluctuations.
Promotion of innovation	Digital technologies open up new opportunities for infrastructure innovation, such as smart grids, automated energy management, and the integration of renewable energy sources.
Environmental sustainability	Digitization helps to reduce the environmental impact of infrastructure projects through the optimization of resource use, efficient waste management and reduction of CO2 emissions.

Digitalization management of infrastructure projects and programs is a key aspect of modern infrastructure management, as it allows to increase efficiency, transparency and accountability of processes. Digitization can cover a wide range of activities from the use of intelligent data management systems to the application of advanced technologies such as the Internet of Things (IoT), artificial intelligence (AI), blockchain and big data. Managing digitalization of infrastructure projects and programs covers several key aspects. First, it is important to clearly define the goals of digitization, understanding which business processes can be improved through digitization, and establish key performance indicators (KPIs) to measure the effectiveness of digital initiatives. Second, it is necessary to integrate the latest technologies, such as IoT to monitor and manage infrastructure assets in real time, and artificial intelligence to analyze data and make informed decisions. Third, ensuring data safety and privacy is critical, including the development and implementation of safety policies and the use of blockchain technologies to ensure data transparency and immutability. Fourth, it is important to ensure staff training and development, in particular through continuous training and professional development of the team, and the introduction of a culture of innovation and continuous improvement. And fifth, it is necessary to regularly monitor projects for compliance with established KPIs and analyze and report results to adjust strategies and improve processes. The specified measures together will help effectively manage the digitalization of infrastructure projects and programs, increasing their effectiveness and compliance with modern requirements.

Managing the digitization of infrastructure projects requires clear planning, constant monitoring and flexibility to adapt to new technological trends. The use of digital technologies not only increases the efficiency of operational management, but also ensures greater resilience of the infrastructure to external challenges.

Digitization opens up new opportunities for improving the socio-economic status of both developed and developing countries. To use this potential properly, it is critical to improve the digital infrastructure, invest in the development of digital technologies and train specialists who can adapt to new working conditions. It is also necessary to pay attention to the creation of reliable data protection mechanisms and cybersecurity. In addition, countries should develop policies that promote innovation and support

technology startups, while ensuring equal access to digital resources for all population groups.

In the context of Ukraine, digitalization has its own characteristics compared to global trends, as it focuses on the development of new types of services based on the collection and analysis of data from various physical objects, and does not include radical changes in production systems, as envisaged by the concept of Industry 4.0 . In Ukraine, the understanding of Industry 4.0 is often limited to the purchase of imported equipment, ignoring the aspects of full digital integration and the creation of innovative products and services. According to PwC data, the majority of IT companies in Ukraine are quasi-product companies with their headquarters and main sales market abroad, while maintaining production in Ukraine. As for the hardware, it remains underdeveloped and focused on the production of components for equipment of older generations.

The reform of local self-government is noted for its relevance and opportunities, in particular, with the help of IT, there is a change in the approaches to the management of territorial communities by elected heads and the implementation of promising projects [11].

Therefore, it is critically important for Ukraine to rethink its vision of digitalization and Industry 4.0, focusing on the creation of innovative products and services that embody digital integration and interaction, as well as on raising the standards of business culture for effective competition in the global market. The IT sector continues to develop rapidly, which allows many countries, including Ukraine, to strengthen their positions in the international arena.

The life cycle of the infrastructure facility and projects is depicted in Figure 1.

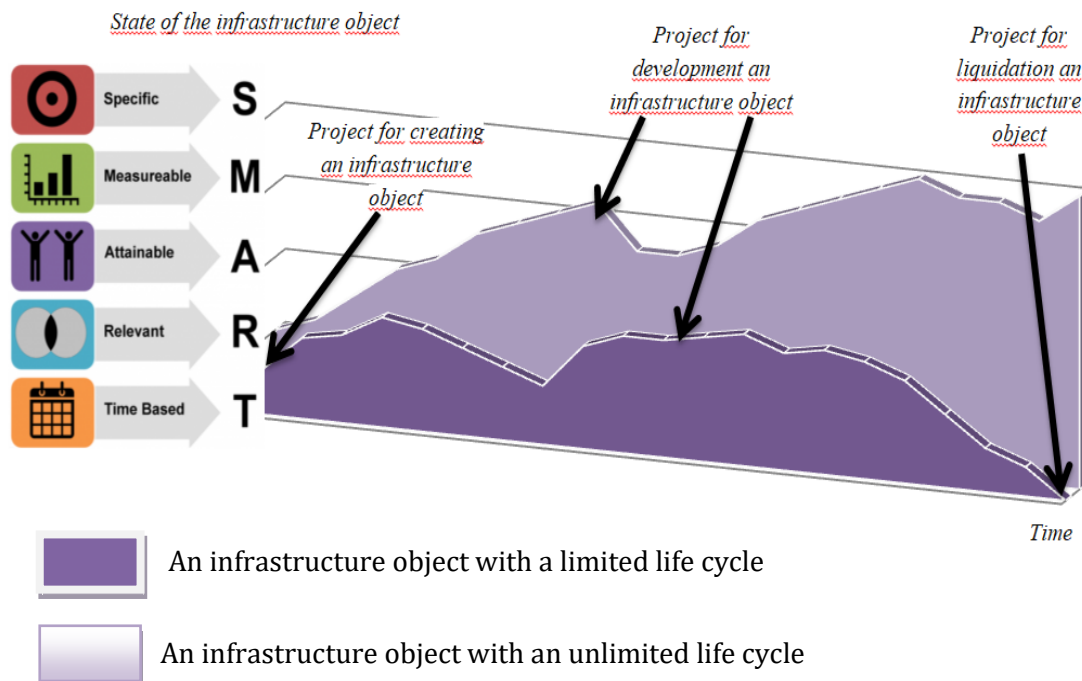


Figure 1: The life cycle of infrastructure objects and projects

In the perspective of 2032, Ukraine has the opportunity to focus on building a stable infrastructure for data processing, which will allow a detailed analysis of the state of the digital economy. This development will become the basis for the implementation of strategies that will be based on reliable information. In this context, Ukraine may also consider integration with the European Statistical System (ESS), which will provide high-quality data for the development of realistic and evidence-based policies.

Digital infrastructure, together with data, is an important driver for the development of digital innovation. The state plays a key role in the creation of both hard and soft infrastructure. A broad understanding of infrastructure includes the need to develop clusters that would unite research and intelligence centers, laboratories, incubators, accelerators, educational institutions, venture funds, innovation teams, technology business and industry. The management concept model of the infrastructure project and programs is presented in Figure 2.

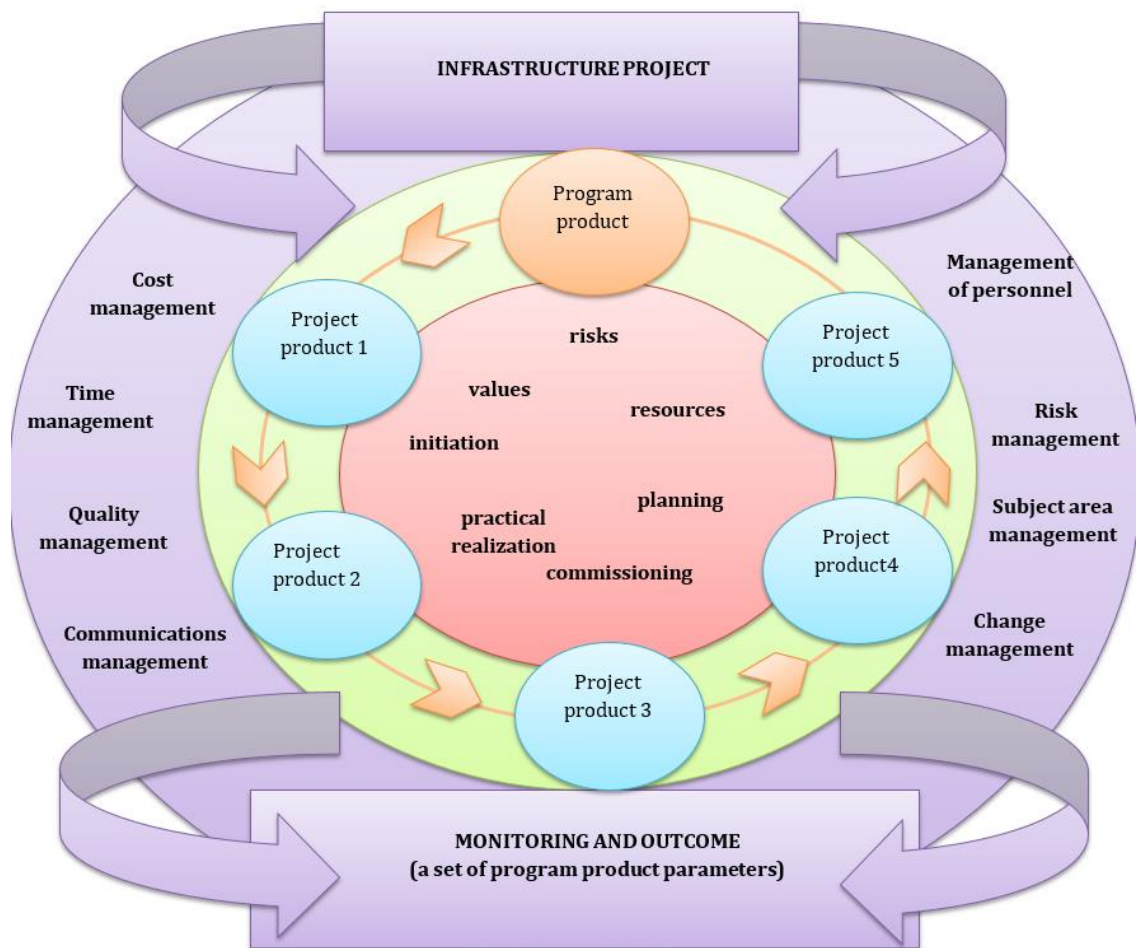


Figure 2: Infrastructure project and program management concept model

Application of a certain type of "project standard" consists in detailed planning of infrastructure projects [6]. An increase in the number of emergency situations, changes in

human life associated with war, all these events create a powerful load on critical infrastructure projects [8].

PEST analysis is a tool that helps to assess the external environment in which a certain project or program operates. The development of a PEST analysis for the digitalization of infrastructure projects and programs can help to understand how external factors affect the implementation and success of the use of digital technologies in this area (Fig. 3).

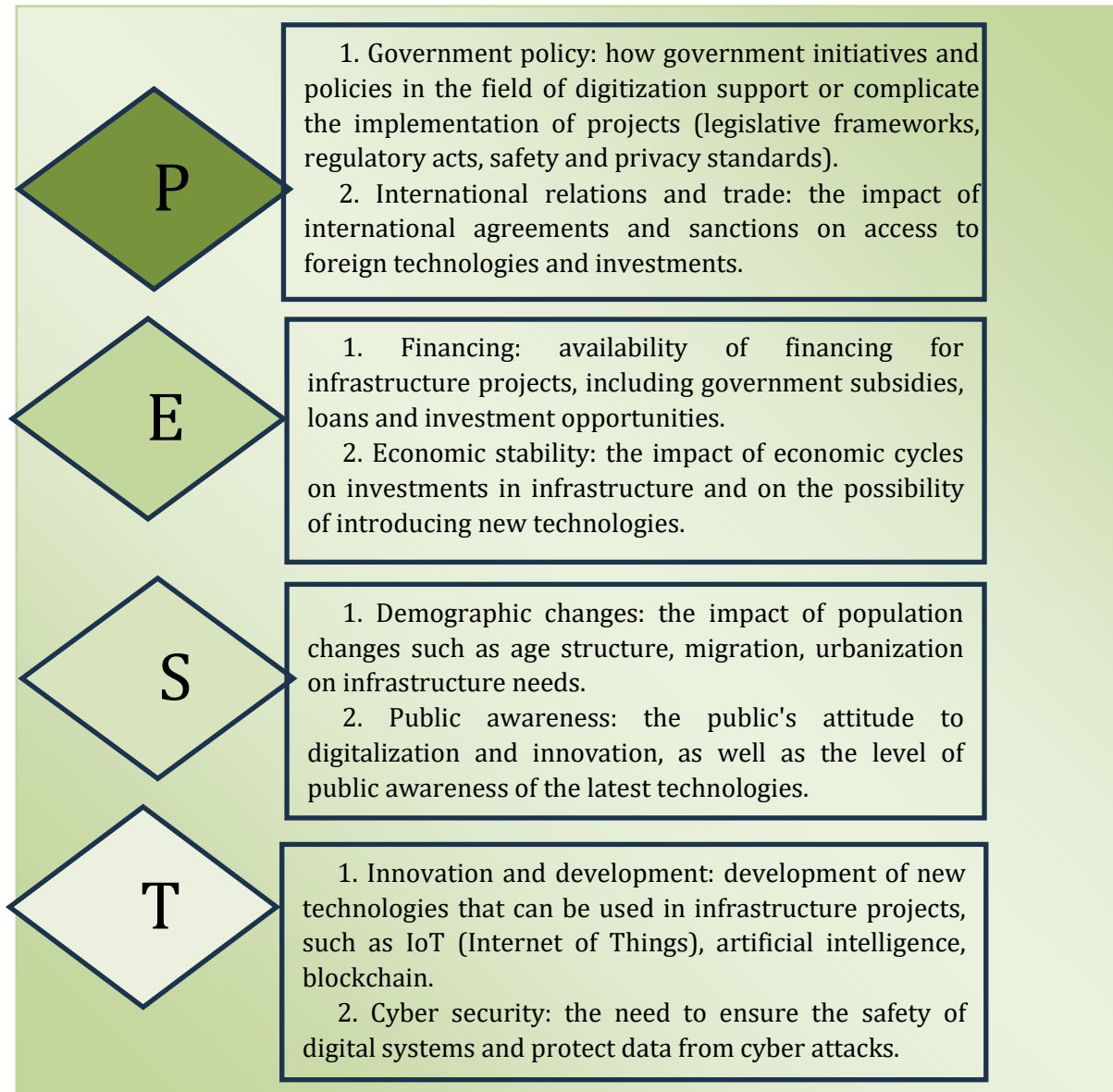


Figure 3: PEST analysis for digitalization of infrastructure projects and programs

Let's analyze the mentioned factors in more detail. In particular, adaptation to political conditions plays a key role in digitalization, as political support, regulation and legislation directly affect the possibilities of adoption and use of digital technologies. A stable political environment, active government initiatives to develop digitalization, and established safety and

privacy standards can significantly increase these opportunities, while a PEST analysis identifies potential risks and determines courses of action in such a climate.

Economic factors, which include access to finance, economic trends, inflation and currency fluctuations, also have a significant impact on the cost and potential returns of infrastructure investments. Understanding the economic context is important for planning budgets and forecasting the financial results of technological projects.

Social aspects, including demographic changes, educational level, cultural characteristics and public opinion, also significantly influence the adoption of new technologies. Such aspects shape the workforce, consumer demands and willingness to accept innovation, which is critical for designing infrastructure projects that are socially acceptable and responsive to public needs.

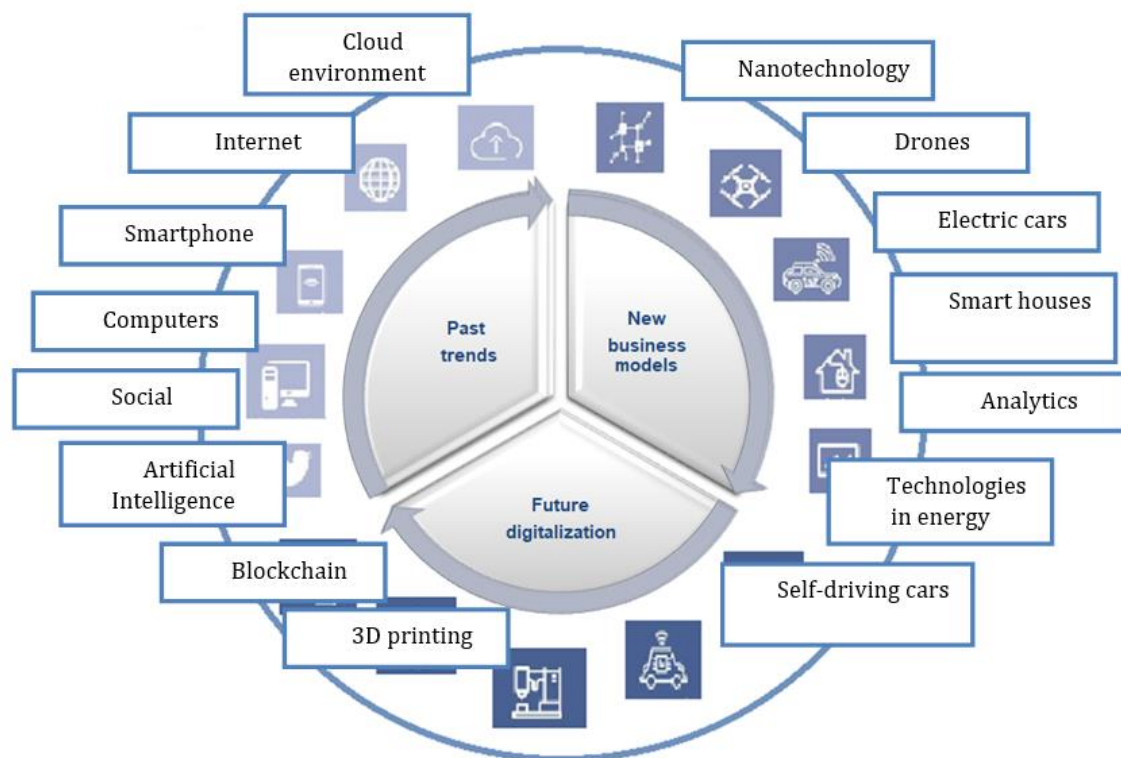


Figure 4: Trends in the development of global digital trends

Finally, technological trends, including the rapid development of the latest technologies, open up new opportunities and create threats to infrastructure initiatives. Understanding these trends through a PEST analysis allows you to identify innovative opportunities and potential cybersecurity challenges, thus ensuring the sustainability and efficiency of digital systems.

Therefore, the PEST analysis provides a holistic view of the external conditions that can affect the successful digitalization of infrastructure projects, helping developers and managers to adapt to changing conditions and optimally allocate resources. By analyzing these factors, companies and government can develop more effective strategies to develop digitalization in infrastructure projects and programs, adapt to changes in the environment and minimize risks.

Achieving effective socio-economic development of regions depends on the level of their financial support, which is based on the income of local budgets [10]. To solve complex socio-economic problems, they attract creative and promising citizens who have real ideas for projects for their future implementation. The analogy can help identify potential opportunities for rural development [12]. Trends in the development of global digital trends are highlighted in Figure 4.

4. Conclusions

The following principles of activity management are of particular importance for infrastructure projects and programs: proper planning and control, effective team, quality of execution, attention to the needs of stakeholders, risk management and change control. Adherence to these principles in the process of project management in the information technology industry will significantly increase the effectiveness of projects.

In modern conditions, the management of infrastructure projects often faces various problems that make project management ineffective and the implementation of ideas unprofitable. The most common problems of project management are the lack of qualified personnel, unclear management responsibilities, and the lack of a clear model for achieving strategic goals and objectives.

Quality management of the digitalization of infrastructure projects ensures innovation, the importance of taking into account the stability of the system during the selection of components and parameters of infrastructure project management for the proper formation of a safe infrastructure project with a set of separate control elements.

Prospects for further research are aimed at researching the peculiarities of safety-oriented management of infrastructure projects, taking into account the conditions of martial law in the regional dimension.

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