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Implementation of Digital Transformations in Railway Transport

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Abstract

It is established that the decrease in the rate of innovative modernization of railway transport leads to an increase in the technological gap between the level of development of Ukrainian and world railways. In order to deepen the integration of Ukrainian railway transport into the global transport and logistics system, the expediency of ensuring the implementation of high-quality innovative and technological digital changes in the activities of the Ukrainian railway company is proved. The processes of digitalization in railway transport are studied and key directions for implementing digital changes in this area are highlighted. The expediency of using Internet of Things technologies, the use of which in railway transport activities will contribute to improving the operational efficiency and safety of railway transportation and improving the customer experience, is proved. The stages of implementation of Internet of Things technologies in railway transport are revealed. Information, technological, operational and economic advantages of introducing internet technologies in railway transport are outlined.
KEY WORDS: *railway transport, transformation, digital innovations, internet of things technologies, implementation stages, effects*

1. Introduction

The war that has now engulfed the territory of Ukraine has dealt a heavy blow to the national economy and business. During the military conflict, the country lost almost a fifth of its territory, where a significant share of the country's industrial and resource potential was concentrated. Critical infrastructure, including railway transport, is being destroyed on a large scale, and exports and domestic consumption are sharply reduced. The main problems facing domestic business today are the destruction of production and transport capacities, problems with logistics, rising energy prices, reducing investment, imports and exports, reducing the profitability of the population and its purchasing power. It is these factors that hinder the recovery of economic activity of enterprises in all sectors of the economy, including railway transport. According to the results of 2022, JSC "Ukrzaliznytsia" transported 150.6 million tons of cargo, which is 52.1% less than in 2021 [1]. The largest reduction was experienced by the volume of transportation of iron and manganese ores – by 59.1%, coal – by 41.2%, ferrous metals – by 57.6%, construction materials – by 65.3%, which was the result of the loss of industrial capacity of the country and the narrowing of demand for these products in foreign markets, the restriction of the work of many enterprises due to the danger of their functioning, the freezing of a large number of construction projects, etc. At the same time, the lowest rate of reduction is typical for railway transportation of grain and ground products – by 14.1%, which was the result of the implementation of measures to organize "grain corridors", diversify grain supply routes for export, as well as increase the storage and processing capabilities of the current year's crop [2]. The financial results of the railway company also worsened: according to preliminary estimates for 2022, the net loss amounted to UAH 10.8 billion, and in 2023 this value may reach UAH 20.2 billion [1].

In addition to the threats caused by the conduct of hostilities on the territory of the country, and overall macroeconomic instability, a number of systemic problems that have not been resolved over the years also complicate the work. Among them: high physical and moral deterioration of rolling stock, railway infrastructure facilities, production and repair facilities, loss of transit potential, reduced innovation and investment activity, imperfect personnel policy, reduced customer loyalty and their reorientation to other types of transport services.

The decline in the pace of innovative modernization leads to a growing technological gap between the level of development of Ukrainian and world Railways. In order to deepen the integration of Ukrainian railway transport into the global transport and logistics system, it is necessary to ensure the implementation of high-quality innovative and technological, primarily digital, changes in the activities of the Ukrainian railway company.

2. More Information

Digitalization is now perceived as a key trend in the development of global railways and a security tool for

implementing reform changes in the railway industry. The introduction of digital solutions improves the quality of services and services in railway transport and contributes to the development of a new system of customer relations, which is based on personalization of services. In addition to the policy of interaction with the client, digitalization in railway transport also covers a fairly significant number of operational processes: the creation of unified digital platforms in the field of freight and passenger transportation, as well as the direct operation of railway infrastructure; the implementation of robotization of many operational processes; the introduction of electronic tickets and contactless travel control systems; the development and implementation of railcar monitoring systems through the use of satellite communication systems; application of contactless inspection and monitoring systems for rolling stock, as well as railway tracks; introduction of digital means of communication and automation, as well as video surveillance systems; application of intelligent systems for monitoring the driver's actions; use of BIM technologies for the design and maintenance of railway infrastructure, etc.

Analyzing the activities of the railway company, it can be concluded that the key results in the direction of digitalization are the sale of tickets through electronic self-service ticket offices, online booking and purchase of tickets, registration of electronic cargo transportation documents, use of corporate web portal and e-mail, the use of electronic signature and encryption certificates, etc. Traditional digital solutions used in railway transport are automated control systems, software for processing operational, statistical and financial information, and information support for the operational activities of railway transport.

At the same time, the need for artificial intelligence, machine learning, big data analysis, and the introduction of the Internet of things is ignored, which today has already opened up a number of opportunities for improving or radically reengineering the business processes of almost any company or entire industry. The introduction of digital solutions in the railway industry will overcome the problems associated with a high share of labor-intensive routine operations, poor quality of delivered goods, disappearance and damage of cargo during transportation, lagging behind schedules, lack of uniform standards for information exchange between many participants in railway transportation.

Today, significant potential lies in the use of intelligent transport systems, automation and robotization of operational processes, artificial intelligence technologies, Big Data, Blockchain and the Internet of things. It is these technologies that should form the basis for creating breakthrough technological solutions in the transport sector. According to the analytical study [3], 87% of respondents prefer artificial intelligence, 84% – Big Data Processing, 82% – the Internet of things, 76 % – “cloud” technologies and technologies for using mobile applications.

Most of these technologies are widely used in the activities of global railway companies. The processes of transformation of the global transport and logistics space indicate the introduction of integrated and local digital solutions focused on changing the business models of railway transport development and modernizing its key business processes. The world experience of digitalization of railway companies testifies to such main directions of introduction of digital innovations in railway transport enterprises as [4-6]:

– improvement of railway transport safety (including installation of on-board and track devices for safe identification of rolling stock, introduction of digital technologies for monitoring the condition of railway infrastructure and rolling stock facilities, etc.);

– implementation of common train traffic management standards (including compliance with technical solutions of the European train traffic management system ETCS and the use of digital signaling, transition to new generation radio communication technologies, etc.);

– improvement of operational management processes of railway transport enterprises (including introduction of digital technologies for forming train schedules and improving the efficiency of rolling stock operations, transition to new microprocessor centralization systems, transition to interval train traffic control systems, etc.) ;

– development of digital infrastructure for railway transport development (including the creation of digital enterprises for the manufacture of rolling stock and components, digital laboratories for the creation of technical and technological solutions, the formation of digital train traffic control centers, the development of service infrastructure for digital systems, etc.);

– improving the processes of diagnostics of the technical condition of rolling stock of railway transport enterprises (including the creation of intelligent rolling stock management systems; the use of on-board systems for monitoring the interaction of rolling stock and tracks; the use of digital technologies for optimizing the management of rolling stock repairs, monitoring its condition at any stage of operation; the introduction of analytical digital platforms for monitoring and diagnosing the condition of rolling stock, etc.);

– application of digital technologies of personnel management at railway transport enterprises (including introduction of electronic personnel document management, development of digital social and intellectual personnel centers for personnel development, personalization of digital centers of employees; development of digital platforms for personnel training, etc.);

– expanding the list of digital services for passengers at railway transport enterprises (including the introduction of mobile applications for passengers with the possibility of expanding their functionality, improving the quality of broadband coverage with the transition to the 4th and 5th generations, etc.);

– improvement of operational management processes of railway transport enterprises (including transition to electronic document management, remote control of operational processes, introduction of predictive analytics, simulation modeling and visualization technologies, implementation of technological solutions in the field of cybersecurity, etc.);

– improving the processes of interaction between railway transport enterprises and customers in the field of

freight transportation (including the formation of digital platforms for interaction between stakeholders, the introduction of digital forwarding services, the introduction of smart contracts, etc.);

– application of digital technologies for the development and implementation of investment projects at railway transport enterprises (including the development of digital platforms for the implementation of investment projects; implementation of Project digital solutions, etc.);

– introduction of energy-efficient and resource-saving technologies at railway transport enterprises (including the introduction of intelligent energy management systems, digital resource monitoring technologies, etc.);

– implementation of eco-oriented digital technologies at railway transport enterprises (including the introduction of technologies for monitoring pollutant emissions and related environmental costs, etc.).

Digital solutions based on the Internet of Things technologies are of particular interest, which makes it necessary to analyze in more detail the features of their implementation in railway transport.

Currently, IoT technologies are used to varying degrees in many areas – finance, logistics, construction, transport – for specific purposes, from organizing the functionality of "smart homes" to creating a "smart transport system" and building "smart cities". In particular, for example, to optimize the movement of urban transport, special sensors measure traffic congestion, calculating the need and potential location for the construction of a new transport interchange.

The global Internet of Things market is projected to grow from $662.21 billion in 2023 to $3,352.97 billion by 2030, at a CAGR of 26.1% during the forecast period [7]. The global IoT in transportation market size was estimated at USD 85.21 billion in 2021 and is expected to hit around USD 498.47 billion by 2030, poised to grow at a compound annual growth rate (CAGR) of 21.69% during the forecast period 2022 to 2030 (Fig. 1) [8].

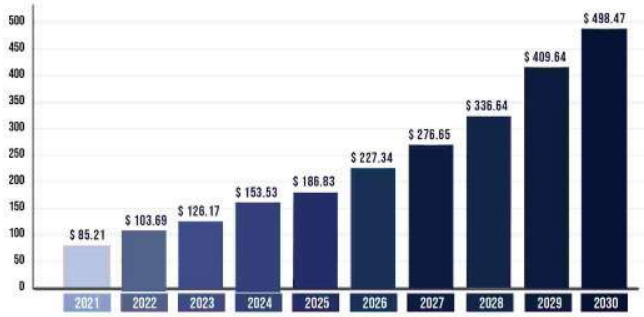

Fig. 1 IoT transportation market size, 2021 to 2030 (USD billion) [8]

It is in the field of logistics that the use of Internet of things technology has significant potential. Because in the transport and logistics environment, millions of objects are stored, moved, entered and removed from systems, and interact with each other, which requires an automated monitoring and control system. Unlike the currently used automation systems in logistics, the Internet of things has the ability to self-learn, collecting and analyzing data across the entire supply chain to generate new ideas and ways to solve problems. The growth in the speed of wireless networks, the development of big data, and the reduction in the cost of sensors, devices, and components are pushing industries and businesses to implement the Internet of things.

Internet of Things technologies in the transportation industry are primarily used to improve operational efficiency, security, and customer experience. IoT in Transportation involves the integration of connected devices, sensors, and data analytics to gather and analyze real-time data on vehicles, drivers, and infrastructure. This data is used to optimize transportation operations, improve safety, and reduce costs. Examples of IoT in Transportation applications include vehicle tracking, predictive maintenance, real-time traffic monitoring, driver behavior monitoring, and automated fleet management. The market for IoT in Transportation is driven by the increasing demand for intelligent transportation systems, as well as the growing adoption of connected devices and IoT technologies across industries. Additionally, the market is expected to grow as new technologies and solutions are developed to address the unique challenges and opportunities of the transportation industry [9].

In the field of freight transportation by rail, the Internet of things should be considered as a network that combines physical devices and devices, rolling stock and locomotives, infrastructure elements, individual cargo units and other objects equipped with electronics, software and sensors that have a network connection, which allows you to harmoniously combine the objects of the system with each other and with the external environment through a digital platform for collecting, transmission and analysis of information using cloud and fog computing for timely adoption of current operational and management decisions by network users in order to improve the performance of business processes of the system related to freight transportation by rail.

The introduction of such technologies should be carried out in stages (Fig. 2):

– At the first stage – to form a cross functional project team in railway transport;
– The second stage is to analyze IoT technologies that are appropriate to use in railway transport;
– On the third stage – to study the factors of macro - and microenvironment of railway transport functioning;
– On the fourth stage – to determine the directions of implementation of IoT technologies in railway transport;

– On the fifth stage – to create a system of indicators for evaluating the effectiveness of implementing IoT technologies in railway transport in the context of key areas;

– At the sixth stage – to implement pilot projects and monitor the effectiveness of their implementation.

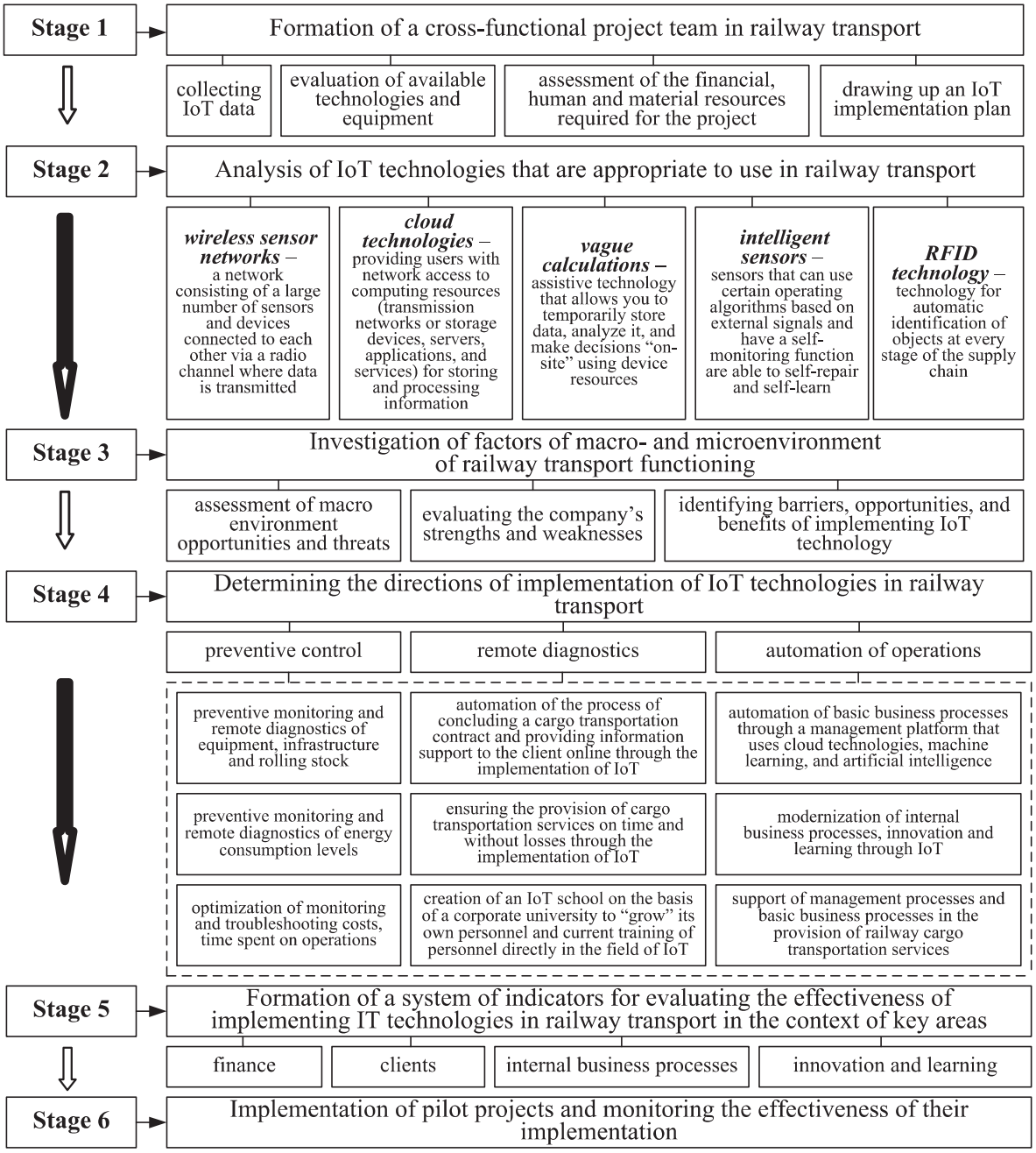

Fig. 2 Stages of implementing IoT technologies in railway transport

The introduction of Internet of Things technologies will provide significant information, technological, operational and economic benefits for railway transport enterprises. In particular, among the information advantages should be highlighted: data availability (data is available in real time both for performing operational activities and making forecasts, and for customers to obtain information about the state of the service); speed of data processing (IoT objects not only quickly collect data, but also quickly turn it into valuable information for end use); the effect of "big data" (in the process of accumulating historical data, systems learn to determine the necessary actions automatically), and so on. Technological advantages are: the ability to store a significant amount of data (with the development and availability of cloud services, aggregation and data storage have become easily accessible); the availability of technologies (technologies that required large investments are now more accessible (for example, RFID); wireless networks cover huge territories, and where there is no access to Wi-Fi, IoT facilities can use other systems). Among the operational advantages, you should pay attention to: rational use of resources (resources are spent if necessary due to constant monitoring by the IoT system, high transparency of actions, automation and data availability; equipment downtime, energy consumption, repair time are reduced); reduction of errors (human factor, equipment failures, emergency situations – their effects are minimized due to automated systems for performing and monitoring operations

and threat forecasting systems); unified standardization (all system objects can interact with each other and with the outside world based on common rules, standards, and procedures), and so on.

Among the economic benefits, first of all, it is necessary to highlight: cost optimization (by reducing defects and defects, downtime, rational use of resources and a high level of Service); increased customer satisfaction and loyalty (customer satisfaction affects the overall value created by the business; for example, loyalty increases, customers make repeated purchases, market share increases, sales grow), etc.

3. Conclusions

It is established that the war, which has now engulfed the territory of Ukraine, has dealt a heavy blow to the national economy and business. Railway transport is also in a difficult financial and economic situation, whose activities in recent years have been characterized by a steady decline in freight traffic volumes, an increase in the deterioration of rolling stock and railway infrastructure facilities, a decrease in innovation and investment activity, a deterioration in customer loyalty and their reorientation to services of other types of transport. The decline in the pace of innovative modernization of railway transport leads to a growing technological gap between the level of development of Ukrainian and world Railways. In order to deepen the integration of Ukrainian railway transport into the global transport and logistics system, it is necessary to ensure the implementation of high-quality innovative and technological digital changes in the activities of the Ukrainian railway company. The processes of digitalization in railway transport are studied and key directions for implementing digital changes in this area are highlighted. The expediency of using Internet of Things technologies, the use of which in railway transport activities will contribute to improving the operational efficiency and safety of railway transportation and improving the customer experience, is proved. The stages of introduction of Internet of Things technologies in railway transport are revealed. Information, technological, operational and economic advantages of introducing internet technologies in railway transport are outlined.

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