ATLANTIS PRESS
Advances in Economics, Business and Management Research, volume 105
1st International Scientific and Practical Conference on Digital Economy (ISCDE 2019)

Digital management railway

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***Abstract* — The article describes the results of the digital railway control system as a complex system study. The article shows the difference between the terms digitization and digitalization. The connection between the digital control system and the digital economy is revealed. The article describes the twelve main characteristics of the digital economy in relation to the digital management of the railway. The article proves that all twelve principles of the digital economy are being transformed into the principles of digital railway management. The place of the digital railway control system among other systems is shown. The basic technological components of the digital control system of an iron drogue are described. The principles of digital traffic control are described. The content of the radio relay information field as an essential component for digital control is disclosed. The relationship of digital management with digital logistics is shown. The article proves that the implementation of digital railway management should occur through the creation of a special system. The role of the Internet of things technology in the development of digital management is described.**

Keywords — management, digital management, railway, complex systems, digital economy, information space

I. Introduction

After the fourth information revolution [1], a "new economy" arose, which is also called the "digital economy". The economy associated with the digital revolution was also called the network economy. However, in 1994, Don Tapscott in the book "Digital Economy: Promise and Peril in the Age of Networked Intelligence" [2] singled out the digital economy from the previous network economy. Thus, the digital economy can be considered as a cluster and the result of the development of a new economy. The digital economy has spawned digital technology in various fields. These technologies transform and modernize many industries, business, transport and logistics. Digital technology has led to the advent of digital control [3]. Digital management has found widespread use in transport, which led to the creation of a digital railway and intelligent logistics [4].

Therefore, digital railway management is one of the realizations of the digital economy. We should note the terminological discrepancy. The English term “digitalization” corresponds to the Russian terms “цифрование”, “дигитализация”. In Russia, the term "digitalization" is standardized in GOST R 52438-2005 as a technology for converting graphic information into a discrete digital form.

In the digital economy, the term “digitization” is used. In Russian it literally means the narrow meaning of digitization ("отцифровка"). Therefore, in the field of economics, it is given another Russian equivalent, the non-standardized term “цифровизация”. From a technological point of view, this is permissible and justified, since the term “цифровизация” covers the management and application of various digital technologies, and not just the digitization of graphic information.

Classical digitalization in geoinformatics and design involves obtaining discrete information for processing it on a computer and storing it in a database. That is a fairly simple and narrow concept. According to Don Tapscott digitalization has a broader meaning. Accordingly, the Digital Railway (DR) as a technology has emerged complementary with the technologies of digital transport [5], digital logistics [6], digital communication in transport [7], digital business [8]. Its continuation is the emergence of transport cyber-physical systems [9].

As a matter of fact, digital railway management (DRM) is not a technology, but an integrated management system that uses digital technologies as the main one. Digital railway management is the result of the emergence and development of the digital economy. A close concept to this management complex is the sophisticated digital railway (DR) technical system. Digital railway is a complex system because it includes other complex systems: complex technological systems [10], complex technical systems [11], complex organizational systems, complex organizational and technical systems, technology of the Internet of things [12] and other systems. This set of systems can only be controlled using digital methods. Digital railway control is an add-on to digital rail. DR [13] is an object which is controlled by DRM. DRM and DR as an integrated complex are connected with the digital economy and their analysis must be connected with the features of the digital economy.

II. Research Methodology

The basis of the study is a system analysis, comparative analysis and qualitative analysis.

III. The results of the examinations

3.1. Digital economy as a methodological basis of the DRMS.

The digital economy as a global system includes smaller systems, which include the DR and DRM. This gives reason to apply system analysis to study these three phenomena.

After 1994, in the following 1995, 1996, 1997, D. Tapscott wrote three more books with the same title "Digital Economy: Promise and Peril in the Age of Networked Intelligence". In each book, he developed his ideas and made changes, but the basic principles set forth in [2] remained unchanged. Their attributive interpretation changed while maintaining the essential interpretation

In all his books, D. Tapscott gives twelve basic characteristics of the digital economy: knowledge, digitization, virtualization, molecularization, integration/networking, disintermediation, convergence, innovativeness, prosumption, awareness, globalization, discordance. These signs are accepted by the world community. DRM and DR are organically connected with these principles.

Let us dwell on some features that are relatively rarely analyzed in the literature. The most important term is digitization. The key difference from digitalization in this term is knowledge. Digitalization, according to D. Tapscott,v is a technology [2], as a result of which knowledge is acquired and stored in digital form. In the old economy, where the information was analogous or physical, communication was possible only due to the actual communication of people. In the new economy, the digital form provided by digital devices allows, as soon as possible, to freely move a huge amount of information and knowledge between people in different parts of the world. On the railway, this principle is implemented in the application of intelligent transport systems and transport cyberphysical systems.

Virtualization [2] in the digital economy means a complex of technologies. With virtualization, you can turn real situations into virtual situations. On the railway, this principle is implemented in unmanned control technologies. This ensures the efficiency of analysis and decision making. This provides information compression and the cognitive effect of the visibility and perception [14] of large amounts of information, which in conventional technologies create an information barrier and a big data problem for a person.

Molecularization [2] is a figurative concept, namely it means that traditional large inert structures give way to more adaptive and small structures. In the old system, the norm is when people come together to make decisions. In the new economy, it will be a “distributed organization” that will drive the “heavy organizations” out. The latter are more difficult to change themselves and adapt to dynamic conditions in the new economy. Partially, startups can serve as an example of molecularization.

Disintermediation [2] is a process in which the actions of intermediaries are significantly reduced. An example is warehousing or online trading. This process requires a closer relationship between enterprises and consumers directly. This process requires the use of digital communication technologies. on the railway, this principle is implemented as a digital railway and digital control.

Convergence [2] is the dominant sector of the economy that is created by converging and integrating computing, communication, and content. This principle is implemented through integrated digital control on the railway.

Presumption [2] is a process that replaces the mass production of a traditional economy with the mass customization of (computer) products in a digital economy. This process erases the differences between manufacturers and customers. However, it requires a high information culture from the client. For example, this means various government electronic services: purchase of electronic tickets; registration via computer; electronic room reservation. Moreover, each consumer is a member of the information highway, creating and sending a message as an order or determining their opinion about the product or service that they buy. On the railway, this principle is implemented by creating an information space and an information radio relay field.

Discordance [2] is a negative process associated with the stratification of customers in the field of information culture. For any new phenomenon, there is a resistance of the environment, part of society and slow adaptation to the new. As a result, technological conflicts and dissipative processes arise. In the new century, the gap between technologically literate - “haves” and technologically not literate - “have-nots” is growing and may cause serious problems for society in the future. New changes in the economy make it possible to create new types of organizations, where the use of information technology to work in the field of knowledge will increase the efficiency of consumers and the effectiveness of the organization. With digital control, this principle is implemented by incorporating the Gap analysis methods into the DRM

3.2. The place of digital railway control among management systems.

A systematic approach requires the organization of digital control in the form of a system. This leads to the need to create a digital railway management system (DRMS). How a complex technical and technological system of digital railway control is connected with other complex control systems. Figure 1 shows the relationship between the DRMS and other systems.

The digital economy serves as the methodical and methodological basis of the DRMS. Digital transport is a more general concept and includes the DRMS.

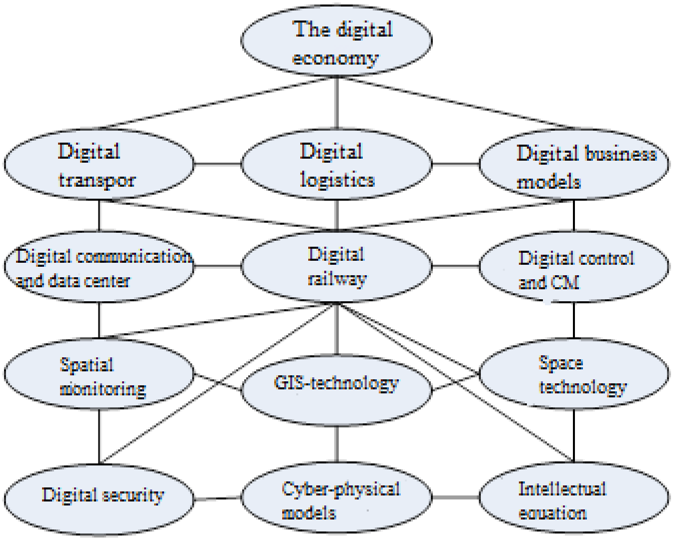

Fig. 1. The place of the DRMS among complex technical and technological systems.

Currently, there is a need for a unified transport policy, and this requires the DRMS to be complementary to other types of digital transport. As a reflection of this fact, the European Union created the European Railway Traffic Management System (ERTMS), including the European Train Control System (ETCS) and GSM-R mobile networks to provide communication between trains and mobile blocks [13]. In the application aspect, the DRMS is subordinate to the interests of digital logistics and digital business.

Digital communication is mandatory for the DRMS. Its peculiarity is that it creates the possibility of radio surveillance in addition to video surveillance in conventional vehicles. Essentially, an additional information field appears in digital transport [15]. Its essence is explained below. Digital railway requires new digital control technology. DRMS is a spatial object, therefore, it requires the use of geographic information technologies, comic observation technologies and integrated spatial monitoring. At the same time, geodata should become the basis of spatial management [16]. Many management situations preclude the possibility of a person's prompt response as a slow decision-making system. Therefore it is important to use elements of intelligent control or intelligent transport systems for management.

Digital communication actualizes the problem of information security in two aspects of unintentional human errors and deliberate sabotage or external threats. For an effective information security policy, cyber-physical systems are used as systems for identifying and repelling external and internal threats. Cyber-physical systems are used in two aspects: as a means of information security and control. In the second case, they are transformed into transport cyber-physical systems.

3.3. Some technological solutions of DRMS

Information field in the radio range. Figure 2 explains the essence of constructing the information field [15] in the radio range. To implement this technology, the entire railway line must be equipped with telemetry stations. In this case, the moving object is always in the area of the information field.

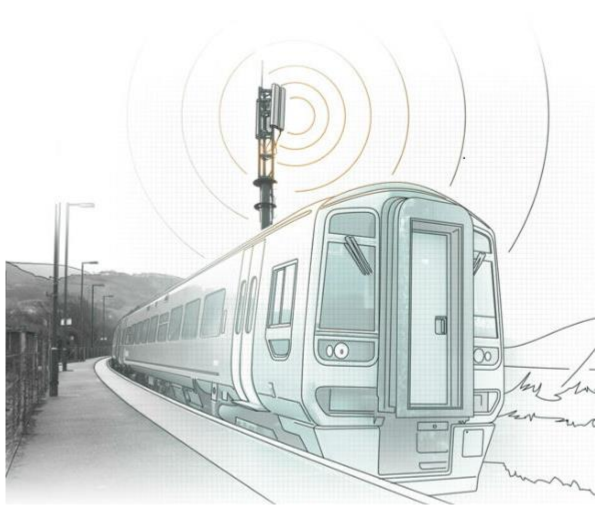

Fig. 2. Radio Information Field

The technology of using the information field is not related to satellite navigation, but complements it. In Russia, such a radio information field exists in specially protected areas: nuclear power plants, military training grounds, airfields. Therefore, the transformation of this technology for the railway does not present complex technological problems. The information field in the radio range includes direction finding of a moving object, taking into account its movement along the track, a digital model of which is known. To implement this technology, mobile vehicles and each car should be equipped with radio frequency tags.

Moving block signaling. This technology is illustrated in Fig. 3 and Fig. 4. Normal movement can be defined as signal-block or discrete.

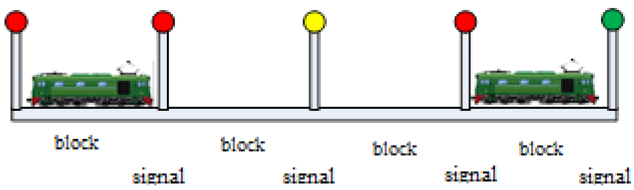

Fig. 3. The principle of ordinary movement.

Between trains there are blocks, the movement of which is allowed by optical signals and additional signals. If the signal is enabling, the movement occurs. With a prohibiting signal, the vehicle is standing still.

In the technology of mobile signaling blocks (Fig. 4), a mobile object contains an internal information-computing system and represents a system of mobile signal blocks that carries out information interaction with other objects. Such a movement can be defined as more continuous.

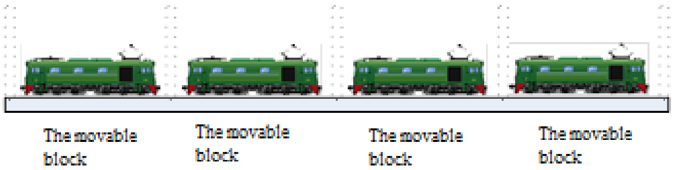

Fig. 4. The principle of using mobile signaling units

A system of moving signal blocks is determined in real time by computers as safe zones around each train [13]. The mobile unit allows trains to come closer, while maintaining the required safety limits, thereby increasing the overall throughput of the line. The definition of a block requires knowledge of the exact location of a given train, as well as the speed of all trains at any given time, and constant communication between the central alarm and the cab alarm system. This is called integrated or integral control. In the digital aspect, such a mechanism requires a transition from point-to-point digital models of objects to interval control models. The mobile unit effectively maintains a secure “envelope” of the empty track around each train (Fig. 4), which moves with this train. This envelope can be adapted to match the speed of a particular train, optimizing line capacity in different situations.

3.4. Digital Logistics and DRMS.

Digitalization is one of the top priorities for the railway sector and its future. The challenge for the railway sector is to offer its customers highly efficient and attractive transportation options and make the most of the opportunities offered by digital transformations. The growth of digital data leads to the need to increasingly apply Big Data technology [16], capture and analyze data, optimize their operations and optimize the supply chain.

Automation of the construction of the supply chain and optimization of the incoming and outgoing movement of goods, allow optimal use of available resources, reduce waste. Mobile solutions provide greater transparency of operations. A digital inventory and supply chain management system facilitates end-to-end visibility for inventory, orders, and deliveries. Along with Big Data, a new term “data wealth” has appeared in business. Logistics companies use data related to the movement of their goods and trucks to identify patterns related to customer trends, determine what works well, disclose market information and receive competitive advantages

Logistics companies use digital technology not only to increase the efficiency of operations, but also to analyze operations and their transformation. The use of robots in large warehouses and the handling of dangerous goods is already widespread, without a driver, and with remote control.

The next important detail in digital logistics is the use of drones [17], especially for delivering the last mile. The US government is already conducting a pilot traffic monitoring system based on unmanned aerial vehicles. In countries such as Spain, France, the Czech Republic and others, there are several research projects studying the use of unmanned aerial vehicles for traffic control. The widespread use of unmanned aerial vehicles will significantly accelerate work, reduce difficulties, stress and inefficiency (Fig. 4)

Fig. 5. UAV application for loading and unloading

For example, AmazonPrimeAir is already shipping [17] with unmanned aerial vehicles, less than 30 minutes before customers place an order. When this technology becomes widespread, logistics will change significantly.

IV. Discussion of Results

In a number of works, DRMS is mistakenly called a model. In the aggregate of features, DRMS is a complex technical and technological system. Reducing a complex system to a model is incorrect. In a number of works on the center, the data organization technology for the DRMS is not given attention, although according to ISO/IEC 9126-1. 2001 and GOST 28195–89 data organization is one of the three quality components of any information systems. Information systems are an integral part of the DRMS. In a number of works on DRMS, as applied to Russian conditions, they miss an important factor - coordinate transformations. For small countries like the UK, this problem does not exist. For such countries, the earth is flat. For countries with a large territory, coordinate transformations from one zone to another are a prerequisite for accurately determining the location of the vehicle in a single coordinate environment. The problem of a unified time is associated with it.

V. Conclusions

Digital railway management is an innovative technology that improves the efficiency of transport in any country. It will increase the capacity of the railway. Digitalization in the broad sense includes automation and integration of all types of transport. Within the framework of the DRMS program, this technology is becoming available. Internet of Things (IoT) technology is essentially a technological system and it creates the conditions for digital management. Digital IoT applications increase responsiveness and management efficiency. It is advisable to implement the DRMS project as a project of a complex integrated system with the inclusion of transport cyber-physical systems. De facto cyber-physical systems displace obsolete intelligent transport systems.

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