# Assessing the prospects of distributed ledger technology (DLT) development as an element of digital ecosystem of railway transport

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**Abstract.** Purpose: to evaluate the practice of implementing projects for digitalization of the life cycle management processes of railway infrastructure facilities based on distributed ledger technologies (DLT). Methods: general scientific methods such as observation, analysis, comparison, generalization and analogy were used. As a result of the conducted research: the main characteristics of the distributed ledger technologies, which determine the parameters and scope of their use in life cycle management of railway transport facilities, have been systematized; the effects of the implementation DLT as an element of the digital railway transport ecosystem have been identified; recommendations for the implementation and rollout of design solutions using DLT in the railway transport area have been developed. Conclusion: as a result of the study, recommendations for the implementation and rollout of the solutions using DLT have been developed. The findings and conclusions may be useful for railway companies, government agencies and other participants in the railway transport and logistics market when planning and implementing projects for optimizing asset life cycle management.



## 1 Introduction

The key trend of recent years is the digitalization of all areas of organizations activity. Changes in the external environment and the counterparty rules, and the acceleration of economic processes speed-up determine the needs to create new business models for managing companies using innovative technological capabilities. The transport industry is no exception here. For JSC Russian Railways, ensuring effective and balanced development for the long term is closely linked with the introduction of digital technologies. The "Digital Transformation Strategy of JSC Russian Railways until 2025" (DTS-2025 , Strategy) defines priority areas and targets for the implementation of digital technologies by JSC Russian Railways in accordance with the objectives of the company's Long-term Development Plan [1]

In the adopted Strategy, Russian Railways JSC adheres to a platform approach to digital transformation. Figure 1 shows seven digital platforms that cover all segments of the

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Holding's activities. Based on it, digital services brings about economic effects, such as income growth, forming of the new market segments, cost optimization, and productivity increase. [2]

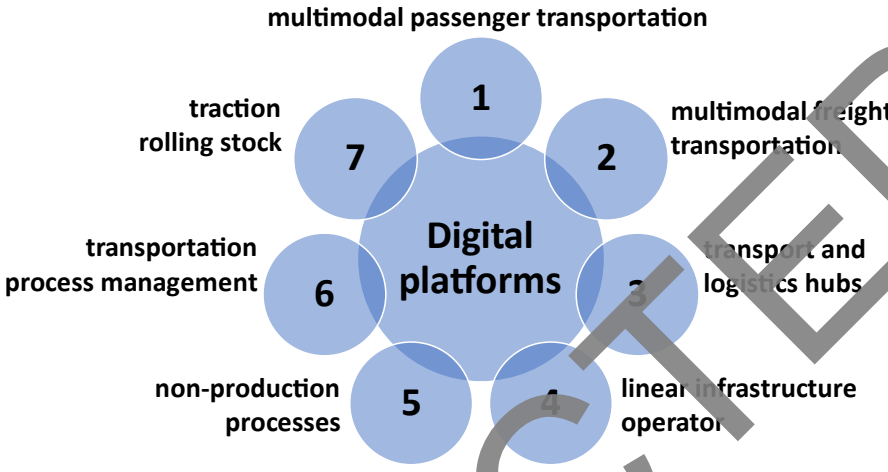


**Fig. 1.** Digital platforms in the "Digital Transformation Strategy of JSC Russian Railways until 2025". Source: made by authors

A digital platform is a set of interconnected technological solutions, that provide an environment for interaction between two or more groups of participants for the exchange of information, services, and values. Thus, digital platforms have become one of the keys elements of the railway transport digital ecosystem.

This article discusses one of the areas of use of the Linear Infrastructure Operator platform. Within it JSC Russian Railways is developing digital services of a distributed ledger based on blockchain in the area of supply chain management in construction, reconstruction and repairs of infrastructure, as well as in the life cycle management of freight cars and their parts. The purpose of the article is to systematize the characteristics of distributed ledger technologies for use in life cycle management of the railway transport facilities, to evaluate the effects of using the DLT as an element of the digital railway transport ecosystem, and to develop recommendations for the implementation platforms based on this technology.

The economic aspects of the implementation of innovative digital technologies (in particular blockchain) in transport have been studied in a number of works. So N.A. Zhuravleva analyzed the directions for increasing the efficiency of transport systems and creating new business models based on the introduction of advanced digital technologies [3,4]. Tretyak V.P. connects the economic nature of digital platforms with the development of quasi-integrated structures [5]. In the works of Volkova E.M., positive effects are highlighted and methodological approaches to the economic assessment of the use of digital technologies in urban transport systems are clarified [6,7]. The economic effects of introducing a service for monitoring smart contracts for freight transportation, implemented on a distributed data registry platform, are considered in the works of I. M. Guly [8,9]. The World experience of implementing blockchain projects in the transport and logistics sector is presented in the work of I.A. Ermakova and S.S. Kuzminykh on the use of distributed registry technology as one of the principles of digital supply chain management [10], as well

as in the work of O.N. Pokusaev, V.P. Kupriyanovsky, D.E. Namiota, V.S. Lazutkina, A.V. Zazhigalkin, and P.V. Kupprianovsky about the experience of using blockchain technologies in digital railroads projects in Germany [11].

At the same time, it should be noted that the issues of practical implementation ~~the~~ distributed ledger technology in the area of supply chain management and life cycle management in railway transport are not fully disclosed and require a more detailed analysis.

## 2 Materials and methods

To achieve the goal of the study, a number of tasks were set that were solved using the following scientific research methods:

- based on the analysis and systematization of scientific research on the development of innovative digital technologies, the main characteristics of the blockchain and types of organization of the blockchain network were formulated;
- comparative analysis and generalization of international practice in the use of DLT made it possible to identify the most favorable areas of application of this technology and determine the specific for using it in various business areas;
- based on a generalization of the practice of implementing DLT projects in JSC Russian Railways the advantages of digital distributed ledger technology and the usage areas in railway transport have been identified.

Scientific data concerning the chosen problem, data from Russian and foreign scientific publications about the development of digital platforms based on a distributed ledger, data from open sources about JSC Russian Railways, corporate standards, and other regulatory documents were used as information bases for the research.

## 3 Results

To assess the practice of implementing distributed ledger technology (DLT), it is important to consider the basics of blockchain technology, which determine the scenarios and specifics of its usage in various business areas.

Blockchain is a distributed database, the main components of which are a block, a block chain, a smart contract and a network.

The block contains a list of transactions entered into the register for a certain period. The block size, transaction accumulation period, and the event that triggers the block entry differ in each specific situation.

Chain of the blocks. One block of data is linked to another using a hash checksum - a unique number obtained as a result of the mathematical hashing operation on the data of the next block. Successively adding such blocks using the hash sum of the previous block combines all the data into a chain. Changing the data of the recorded blocks is impossible, as this will entail changing the hash sums and violating the integrity of the block chain.

Blockchain network consists of nodes. They can be thought as servers there execut programs based on the algorithm which ensure the protection of the entire system. Each node stores a copy of all transactions that have been recorded on the blockchain.

Smart contract. A computer algorithm that determines the terms (essentially the rules for data processing) of the agreement between the parties certified by a digital signature, recorded and executed in the blockchain network.

It is necessary to note the following characteristics of blockchain-based DLT:

Decentralization. The blockchain network operates on the principle of peer-to-peer transactions, when there is no central data storage server, and each network node acts as a client and server for other nodes (peer - to - peer or p2p network). All records are stored by

each participant in the system. The loss of data at one node in the blockchain network will not affect the integrity of the whole system and the data at other nodes. The data will be saved as long as at least one participant has it.

Transparency. Any participant can track all transactions in the system and clearly determine where the information came from.

Confidentiality. All data is stored in encrypted form. To access information you need to know a unique digital signatures.

Reliability. Any attempt to make unauthorized changes will be rejected due to inconsistency with previous entries.

Consensus. Data added to the system is verified by other participants. For a transaction to be valid, all participants must agree on its execution.

There are various types of blockchain network organization:

- public blockchain network. Any user can join such a network, an example of which is the well-known Bitcoin network. The public blockchain controls the entire community of network participants at once, and its data can be read by any connected user. The disadvantages of such a network include high computing power requirements and a low level of transaction confidentiality;

- private blockchain network. Unlike public blockchain, it is controlled by one or more organizations. They determine who can join the network, execute the consensus algorithm, and the level of access of participants to data. Organizations can form a blockchain consortium by agreeing on responsibility for network administration and the rights to carry out transactions. These criteria are important when using blockchain in enterprise environments.

Thus, blockchain allows you to quickly process transactions, share information in a distributed environment without intermediaries, execute smart contracts, guarantee a high level of database security, and system resistance to hacker attacks. Blockchain is interesting where reliability, transparency, trust, and the exclusion of fraud or data theft are needed. Using this technology it's possible to reduce transaction costs, optimize business processes for data exchange between participants, and reduce reconciliation costs and losses due to data discrepancies.

Blockchain technology could help the world's largest investment banks cut their infrastructure costs by $8 billion to $12 billion a year by 2025, according to a report from Accenture consulting company. Thanks to this technology, banks can reduce infrastructure costs by an average of 30%, and operational costs, such as trade, by up to 50% [12].

Significant experience has been gained in the usage of blockchain technology. For example, IBM developed the IBM Blockchain platform, using which Home Depot accelerated its approval processes by giving customers and suppliers access to shared shipment data across the supply chain in real time. If a deviation occurs in any point of the supply chain, participants can immediately solve the problem [13].

The Renault, Simoldes, Faurecia, and Knauf groups have collaborated to develop and implement the XCEED (eXtended) blockchain platform Compliance End-to-End Distributed ) to certify the compliance of all vehicle components, from design to production, quality control of components, and the absence of counterfeit products [14].

In 2018, Maersk and IBM developed the TradeLens platform, which was made available to all companies operating in the shipping and logistics industries and was supported by large transport companies that account for more than 60% of global container traffic. The system became neutral and open to all companies involved in transportation, and made it possible to introduce digitized document flows into global logistics chains, which simplified cargo clearance. However, the project did not reach commercial efficiency as an independent business model and was stopped [15].

According to Gartner research, blockchain-based digital ecosystems have high potential for optimizing supply chain and asset lifecycle management by reducing transaction costs, creating new value streams for participants, reducing the cost of goods and services, and increasing security and trust between members [16].

The classic approach to managing an organization's assets (EAM-Enterprise Asset Management) focuses on processes within the enterprise and allows for maximizing their efficiency by improving the use of production assets and reducing operating costs [17]. The basis of the EAM concept is the idea of a production asset as an element of business that has its own life cycle and is capable or unable to generate positive cash flow. The profitability of an enterprise largely depends on the efficiency of use of production assets. Using EAM systems, a company can create a database and plan equipment maintenance and repair, keep records and analyze the costs of their maintenance.

However, modern technologies and, in particular, blockchain make it possible to expand the control and assets life cycle management beyond the perimeter of the company's business, to include in the management all its stages and related data (for example, when an asset was sold, but warranty obligations remain, or when it is needed to check the origin, certification, quality and history of transfer of ownership of the object before purchasing). Blockchain allows you to organize trusted interaction between all participants in the process. They will have access to the original version of agreements, documents and reliable data from a common source, guaranteeing their immutability. Thus, organizations can spend less time on routine manual operations for document reconciliation, negotiations and approvals with counterparties, devoting more time to core processes and business development.

The analysis of the global and local practice of using blockchain technology allows us to highlight the following main application areas:

- distributed ledger (digital registries of objects, registries of electronic voting, register for copyright or property rights);
- supply chain management in logistics using smart contracts (automation of electronic document flow with recording of legally significant actions, monitoring the history of movement and transfer of ownership, eliminating human factor risks, building logistics platforms);
- application in the financial sector (digital financial assets issuing, cryptocurrencies, providing international payments).

For JSC Russian Railways, the first and second areas are of particular interest. Within these areas Russian Railways is implementing a number of projects, including the "Service for the life cycle control of freight cars using blockchain technology" (DLT FC) and "Service for the life cycle control of rails using blockchain technology" (DLT Rails), which are detailed below.

"Service for the life cycle control of rails using blockchain technology" (DLT Rails) provides a trusted space for interaction between all participants in the life cycle of a given element of the railway transport infrastructure. These include:

- metallurgical plants - manufacturers (JSC "EVRAZ ZSMK", PJSC "ChMK"),
- rail welding enterprises (8 divisions of LLC "RSP-M")
- JSC Russian Railways, which is represented by the Directorate for Diagnostics and Monitoring of Infrastructure and the Directorate of Track and Facilities of the Central Infrastructure Directorate (342 track and infrastructure distances)

The DLT Rails service is based on a common information database for all, which provides:

- integration of systems of JSC Russian Railways and external participants with constant synchronization of data between nodes of the blockchain network;

- interaction between the DLT and the EC ASUI transaction system for rail maintenance at Russian Railways for transferring data on deliveries, rail lashes, and data about changes in technical or operational characteristics of rails;
- up-to-date information about rails for participants throughout the entire life cycle of the rail from receipt from the manufacturer to scraping (technical documentation, condition, inspections, control of work performed, availability of rails at the warehouses).

Control of the sequence of operations with rails is carried out according to the operating model of condition control by life cycle stages: rail data is automatically received from the manufacturer, than the rails are welded into a lashes in the RSP-M companies, and after that laid on the track by the infrastructure distances. The rail passport in the DLT includes data on the type and category, melting and welding, the area of operation of the rail, the chemical composition, physical and mechanical properties, wear and flaw detection. The service ensures the impossibility of falsifying/changing data in the system and authentication of participants.

Another example of the implementation is the "Service for the life cycle control of freight cars using blockchain technology" (DLT FC). The DLT FC is designed to store and reflect reliable information about operations with a freight car and its parts (assemblies) at various stages of the life cycle. Currently, the system is implemented for freight cars and for such parts such as: wheelsets, side frames, bolsters and connecting beams, welded frames, and automatic coupling devices (automatic coupler, traction clamp, draft gear).

All main operations in the life cycle of parts are subject to registration in the DLT FC:
- Manufacturing – Sales – Purchase – Shipment and delivery;
- Installation on freight car - Removal;
- Outgoing and incoming shipment to/from repair - Repair;
- Acceptance and transfer to/from responsible storage;
- Prohibition of operation - Exception.

In addition, the following main operations of the life cycle of a freight car are recorded in the DLT FC:
- Assigning a number to a new freight car;
- Registration of the passport and equipment of the freight car;
- Access to the freight car infrastructure;
- Inspection of a freight car for loading;
- Maintenance of a freight car;
- Transfer of a freight car to a non-working fleet;
- Forwarding the car to the place of repair;
- Transfer of freight car equipment;
- Registration of changes in the passport of a freight car;
- Completion of freight car repairs;
- Admission to the freight car infrastructure;
- Prohibition on the operation of a freight car;
- Exception of freight car.

The platform solves the problem of simplifying the interaction between all market participants presented in Figure 2, reducing their transaction costs through transparency and process automation.

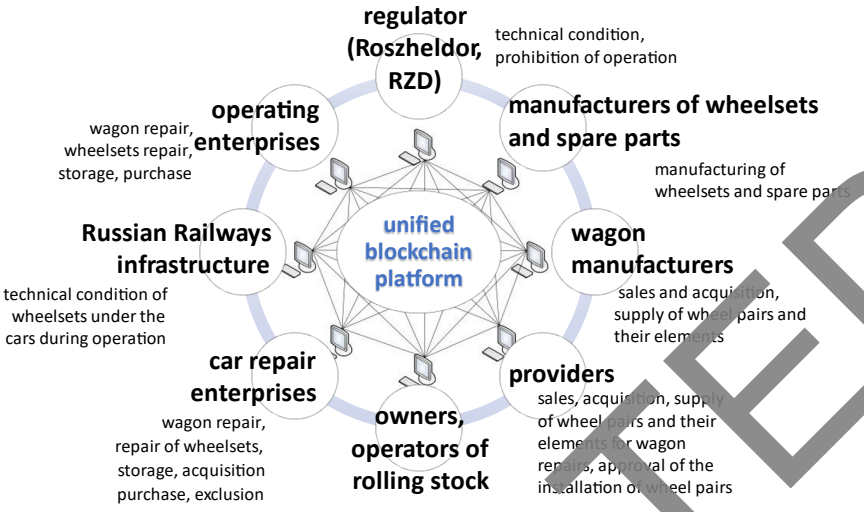


**Fig. 2.** Participants of the DLT FC. Source: made by authors

Thus, on the basis of the DLT FC, there are conditions for the implementation of an industry solution to eliminate counterfeit products in the market for spare parts for freight cars and improve the safety of railway transportation by reducing the admission of counterfeit parts into operation under freight cars.

Based on the analysis of the practice of implementing the DLT Rails and DLT FC projects, the following general characteristics can be identified:

1. The technology allows for an end-to-end process the life cycle control of the objects. At the same time, conditions for monitoring the legality of objects, checking quality guarantees, and providing transparency of history.

2. During the process of introducing DLT with data accumulation, the ability to analyze the characteristics of objects and data on condition and operation increases. At the same time, information comes from a common trust source to all interested parties with clear control over the volume and possibilities of use by each participant.

3. An industry ecosystem is being formed, which is characterized, on the one hand, by a reduction in transaction costs for each participant, which is ensured by:

- accelerating information exchange processes by changinges document flow into digital electronic form and optimizing the costs of document flow in general;
- the emergence of the opportunity for interested participants to work on the ecosystem marketplace for buying/selling objects.

On the other hand, the most important role in the formation of a trusting environment is played by the reliability and transparency of data with the information security of each participant in the process. In this way, building a digital industry ecosystem can bring benefits to all stakeholders and reduce the cost of asset lifecycle management as a whole.

The development and implementation of DLT have a number of features, based on which the following recommendations for similar projects implementation can be identified.

First of all, they are related to information security issues. This includes the coordination of roles and access of participants to system data, the protection of information when connecting via the Internet, and the ability to open access to data and coordinate their publication for trusted participants.

The implementation of projects is accompanied by a large number of organizational issues related to the need to involve external organizations to launch the project, develop technical solution design, and agreement for the system maintenance cost sharing between participants.

The software products being developed must meet import independence requirements, comply with Russian cryptography standards and insure the restrictions of acceptable licensing policies in case of using open source software.

It is especially necessary to emphasize that the active promotion of platforms and the increase in positive results of their use for the formation of effective industry ecosystems is possible only on the basis of mutually beneficial cooperation for all participants.

In conclusion, it should be noted that due to the scale and importance of Russian Railways, the results of projects within the digital transformation are relevant not only for the company, but are the driving force behind the transformation of the whole country transport industry. This also applies to platforms based on distributed ledger technology discussed in the article. The application of the experience gained, practices, developed digital solutions, and services is in demand not only by Russian Railways and its subsidiaries, but also by external market participants.

## 4 Discussion

The study of theoretical materials and analysis of the practice of implementing projects based on DLT allows us to identify a number of problems that cannot be solved unambiguously and require further research.

With an increase in the number of organizations involved in the implementation of the assets life cycle management, the system of economic interests of stakeholders becomes more complex, which in turn leads to difficulty in promoting the platform and reduces the effectiveness of its use. This is manifested, among other things, in the increase in the time frame for changes and amendments (many participants, long approval process).

Complete digitalization of processes is hampered by the insufficient development of the legislative framework and industry standards, as fully electronic passports of objects have not yet replaced paper ones.

The effects of implementing DLT projects are delayed, depend on scale and cannot be fully assessed immediately after implementation. It takes time to connect a significant number of participants and fill the system with a sufficient amount of historical data.

## 5 Conclusion

The article identifies the advantages of blockchain digital technology and its areas of application in railway transport, such as distributed ledger (digital registries of objects, registries of electronic voting, copyright or property rights) and supply chain management in logistics using smart contracts.

The results of implementation, using the example of the DLT FC and DLT Rails projects, highlight the following:

- reducing transaction costs for all participants in the asset life cycle process interacting on the platform by accelerating the processes of collecting and exchanging information, creating a trusting environment of interaction due to the reliability and transparency of data;
- building a digital industry ecosystem, the development of which can bring benefits to all stakeholders.

Recommendations for the implementation and rollout of solutions using DLT have been developed. The results and conclusions may be useful to JSC Russian Railways, government

agencies, and other participants in the railway transportation market when planning and implementing projects in the optimizing asset life cycle management area.

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