ORIGINAL ARTICLE

INTERNATIONAL JOURNAL OF ARTIFICIAL INTELLIGENCE

ISSN: 2692-515-x, Impact Factor: 9.23

American Academic publishers, volume 6, issue 03,2026

Journal: https://www.academicpublishers.org/journals/index.php/ijai

DIGITAL TRANSFORMATION OF FREIGHT TRANSPORTATION MANAGEMENT USING ICT TECHNOLOGIES IN UZBEKISTAN

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Abstract: The study aimed to identify key aspects of implementing information and communication technologies (ICT) in cargo transportation in Uzbekistan. It analysed the current challenges of the national logistics system, including route optimization, inventory management, and limited transparency in cargo operations, as well as available ICT solutions, their advantages, limitations, and implementation barriers. Two solutions were selected for detailed examination: the Transportation Management System (TMS) and the Real-Time Location System (RTLS). The implementation process, from technology selection and system integration to launch and performance monitoring, was described with consideration of local infrastructure and operational conditions. The study also reviewed the experience of international logistics operators, such as Federal Express, Maersk, and United Parcel Service, and considered their applicability to Uzbekistan. Results indicated that digital solutions reduce operating costs, enhance planning accuracy, and improve cargo tracking. Specifically, TMS can optimize transportation costs through automated route planning, while RTLS provides precise real-time cargo monitoring, reducing delays and errors. Additionally, Warehouse Management Systems, the Internet of Things, and blockchain technologies were found to enhance inventory management, increase process transparency, and secure supply chain data in the Uzbek context. These findings provide practical insights for modernizing Uzbekistan's freight logistics system and improving overall operational efficiency.

Keywords: digitalisation of logistics, transportation automation, inventory management systems, real-time cargo tracking, innovations in logistics processes, supply chain security.

Introduction: Freight transportation plays a crucial role in the development of national economies by ensuring the movement of goods between producers, suppliers, and consumers. Efficient freight transportation systems contribute significantly to economic growth, international trade, and regional integration. In recent years, the rapid development of information and communication technologies (ICT) has fundamentally transformed the management of logistics and transportation processes worldwide. Digital technologies enable the automation of logistics operations, improve supply chain transparency, and enhance the efficiency of freight transportation systems.

Globally, the logistics sector is undergoing significant digital transformation through the adoption of technologies such as Transportation Management Systems, Internet of Things (IoT) devices, cloud computing, big data analytics, and blockchain platforms. These technologies

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American Academic publishers, volume 6, issue 03,2026
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provide logistics operators with real-time information about cargo movement, vehicle location, and transportation conditions. As a result, logistics companies can optimize transportation routes, reduce operational costs, and improve delivery reliability. The integration of digital technologies also allows better coordination among different participants of the logistics chain, including carriers, shippers, freight forwarders, and government institutions.

For landlocked countries such as Uzbekistan, efficient freight transportation management is particularly important due to the higher transportation costs associated with the lack of direct access to seaports. Studies indicate that transport costs in landlocked countries can be significantly higher compared to coastal economies, often representing a substantial portion of the total cost of imported goods. Therefore, improving the efficiency of transportation systems through digital technologies is a strategic priority for enhancing national logistics competitiveness.

Uzbekistan has recently undertaken significant reforms aimed at modernizing its transportation and logistics infrastructure. The government has initiated several programs to promote the digitalization of the transport sector and improve the efficiency of logistics operations. One example is the development of the “e-Logistika” digital platform, which enables the digital management of freight transportation processes and improves transparency among logistics market participants. The platform allows shippers, carriers, and logistics service providers to coordinate cargo transportation more efficiently and reduce administrative barriers.

Digital transformation initiatives have also improved operational efficiency within the transportation sector. For instance, the digitalization of railway freight services has simplified operational procedures and significantly reduced administrative processing time. The number of stages required to order railway freight wagons has been reduced from seven to three, while the processing time has decreased from approximately seventy-two hours to twelve hours. These improvements demonstrate the significant potential of digital technologies to optimize logistics processes and enhance the efficiency of freight transportation systems.

At the same time, the freight transportation market in Uzbekistan is experiencing steady growth due to increasing domestic and international trade activity. Demand for cargo transportation services has increased significantly in recent years, with domestic freight requests rising sharply and overall transport services continuing to expand. The growing demand for freight transportation has also encouraged logistics companies to adopt digital platforms and technological tools to improve operational efficiency and competitiveness in the market.

Despite these positive developments, several challenges remain in the digital transformation of freight transportation management in Uzbekistan. These challenges include limited digital infrastructure in certain regions, insufficient integration between logistics information systems, and the need for further development of digital competencies among logistics professionals. Addressing these challenges requires the development of comprehensive digital logistics strategies and the implementation of advanced ICT solutions within transportation management systems.

In this context, the effective use of ICT technologies in freight transportation management represents an important research direction. The integration of digital platforms, real-time

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monitoring systems, and data analytics tools can significantly improve the efficiency and transparency of logistics operations. Moreover, digital technologies can support the development of intelligent transportation systems capable of optimizing freight flows, reducing transportation costs, and improving service quality.

Therefore, the objective of this study is to analyze the role of ICT technologies in the digital transformation of freight transportation management and to evaluate their potential impact on improving logistics efficiency in Uzbekistan. The research focuses on the application of digital logistics platforms, transportation management systems, and real-time monitoring technologies in freight transportation processes. By examining the opportunities and challenges associated with the implementation of digital technologies in the logistics sector, this study aims to provide recommendations for enhancing the effectiveness of freight transportation management in Uzbekistan.

Literature review and methodology: In this study, a comprehensive interdisciplinary approach was employed, integrating qualitative and quantitative analyses, comparative methods, modeling, and case studies. The research primarily focused on examining the current state of logistics systems, identifying industry challenges and requirements, with particular emphasis on process digitalization. A thorough content analysis of scholarly publications was conducted to highlight the main factors limiting the efficiency of logistics structures. Based on this review, key problems were identified, and typical sectoral needs were systematically formulated.

For quantitative analysis of logistics process optimi- sation, the equation for calculating the total delivery time was used, which determines the expected delays and the required buffer time to ensure the stability of transport operations. Equation for optimising delivery time:

$$T_{total} = T_{route} + T_{delay} + T_{buffer}$$

where: T_{total} – total delivery time; T_{route} – planned route duration without delays; T_{delay} – time spent on unpredictable delays (for example, traffic jams, weather conditions); T_{buffer} – buffer time to cover possible unforeseen situations.

To evaluate the conditions of cargo transportation, a mathematical model was employed to monitor cargo status, incorporating parameters such as temperature, humidity, pressure, and location. This model enabled the assessment of potential risks related to cargo damage or loss. The corresponding equation for cargo monitoring is as follows:

$$D=f(T,H,P,G),$$

where: D – condition of the cargo (for example, damage or loss); T – temperature; H – humidity; P – pressure; G – location (Global Positioning System (GPS) coordinates). Function *f* describes the relationship between variables and their impact on cargo integrity.

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As part of the comparative analysis, the experience of the world's leading logistics operators was considered: Federal Express (FedEx) (USA) and Maersk (Denmark), Dalsey, Hillblom and Lynn (DHL) (USA) and United Parcel Service (UPS) (USA). The key areas of activity of these companies were com- pared, in particular, express delivery, sea transportation, supply chain management, warehouse logistics, and digital services. Special attention was paid to approaches to over- coming logistics challenges, such as route optimization , digitalisation of processes, infrastructure development, and integration into international transport corridors.

The analysis of modern ICT solutions was carried out using a comparative method. The functionality, advantages, limitations, and barriers of implementing solutions such as Transportation Management System (TMS), Real-Time Location System (RTLS), Warehouse Management System (WMS), Internet of Things (IoT) and blockchain technologies were evaluated. The study assessed the main advantages, disadvantages, and barriers of implementing each of the technologies in logistics processes, and determined their impact on the efficiency of transportation, inventory management, cargo tracking, and reduced operating costs. In particular, the possibilities of TMS for automating route planning and traffic monitoring, RTLS – to improve real-time cargo tracking, WMS – to optimise warehouse operations, IoT – to increase the transparency of logistics processes through the use of sensors, and blockchain technologies – to ensure the security and reliability of data ex- change were analysed.

For a more detailed analysis, special attention was paid to the introduction of TMS and RTLS as key technologies that improve the productivity and controllability of logistics processes. In particular, the stages of implementing TMS were investigated, ranging from selecting a supplier and configuring functions to integrating with the IT infrastructure and training personnel. The RTLS implementation process was also reviewed, including technology selection, sensor configuration, and integration with other company systems. Thus, the research methodology combined theoretical analysis, empirical research, mathematical modelling tools, and comparative analytical approach- es, which provided a holistic and scientifically based vision of modern transformations in the field of logistics.

Results and Discussion: (Analysis of current problems, logistics needs, and experience of large logistics operators) Logistics plays a key role in ensuring the smooth functioning of the global economy, because it connects producers, suppliers, and consumers in a single integrated chain. With the growth of international trade, the spread of e-commerce and the introduction of digital technologies, the role of logistics systems is steadily increasing. However, despite the high level of automation and the availability of innovative solutions, logistics as an industry faces a number of systemic challenges that slow down its development and reduce efficiency (Table 1).

Table 1. Problems and needs in modern logistics

Problems	Needs
Failure to meet delivery deadlines	Improvement of the accuracy of planning and compliance with schedules

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Damage or loss of cargo	Improvement of cargo monitoring and control systems
Problems with document management	Automation and digitalisation of document management processes
Lack of qualified personnel	Development of training programmes and professional development of employees
Rising fuel costs	Route optimisation and implementation of energy-efficient technologies
Non-compliance of the infrastructure with modern requirements	Investigation of the renewal and modernisation of logistics infrastructure

Failure to meet delivery deadlines remains a significant challenge in cargo transportation. Such delays can result from a variety of factors, including traffic congestion, adverse weather conditions, vehicle malfunctions, and errors in route planning. Persistent delays can lead to customer dissatisfaction and financial losses. Addressing this issue requires the implementation of advanced planning and monitoring systems capable of forecasting potential delays and enabling real-time adjustments. Additionally, there is a critical need to develop efficient route optimization algorithms that account for all variables influencing delivery performance.

To demonstrate the principle of delivery time optimization, a cargo transportation scenario from point A to point B was analyzed. Equation was applied to minimize delivery times while reducing the risk of delays. For instance, the planned duration of the route was set at six hours, which accounts for potential unforeseen delays such as checkpoint inspections or loading and unloading operations. This value was also selected to simplify calculations and illustrate the methodology clearly. The resulting analysis is as follows:

$$T_{total} = 6 \text{ hours} + 1 \text{ hour} + 0.5 \text{ hour} = 7.5 \text{ hours}.$$

Under normal conditions, the route is completed without delays. However, unpredictable delays may occur due to factors such as traffic congestion, adverse weather, or technical issues. In this analysis, the average delay time is assumed to be one hour, serving as a conditional estimate. Additionally, a buffer time of 30 minutes is incorporated to ensure operational stability and allow for real-time adjustments.

Using this calculation, the company can more effectively plan its logistics operations, minimizing the risk of delays and ensuring timely deliveries. Furthermore, with a clear understanding of expected delivery times, routes can be adjusted in real time in response to changing traffic conditions or adverse weather, allowing rapid adaptation and reducing the likelihood of disruptions.

Conversely, cargo damage or loss remains a critical concern, particularly for sensitive or high-value shipments. Such incidents may result from improper storage, inadequate transportation conditions, or insufficient monitoring during transit. To mitigate these risks, modern real-time monitoring systems should be implemented to track both the location and

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condition of cargo throughout all stages of delivery. The integration of sensors for temperature, humidity, shocks, and GPS tracking can significantly enhance the reliability and safety of transportation operations.

The problem of the lack of qualified personnel should be indicated. The lack of qualified drivers, logisticians and other specialists can lead to a decrease in the efficiency of operations. This is especially true in situations where specialised training is required to work with certain types of cargo or complex logistics processes. Therefore, ensuring proper training and certification of employees is an important requirement for improving productivity. Given the rapid development of technology, it is also necessary to constantly update training programmes and invest in professional development programmes for employees. One of the financial problems for cargo carriers that affects the cost of transportation is the increase in prices and fuel costs. This may be conditioned by fluctuations in world oil prices or domestic economic fac- tors. To reduce fuel costs, it is necessary to optimise routes, which will reduce fuel consumption. The introduction of alternative energy sources (electric trucks, biofuels) and investment in energy-efficient technologies can help to reduce dependence on conventional fuels.

Moreover, an important problem is the non-compliance of the infrastructure with modern requirements. Many road and logistics facilities do not meet the requirements of modern transportation, which leads to delays, increased costs, and even emergencies. Weak infrastructure, inefficient checkpoints, and poor road conditions are barriers to efficient transportation. To solve this problem, it is necessary to invest in infrastructure modernisation, including the construction of new logistics centres, road surface renewal, expansion of ports and airports. This will reduce traffic jams, increase throughput, and reduce transportation time .

Consequently, logistics faces numerous challenges, which require the introduction of innovative technologies that automate processes, optimise routes, improve cargo monitoring, and reduce energy consumption. To develop effective solutions to overcome the identified logistics problems, it is advisable to analyse the practical experience of leading international operators that demonstrate a high level of innovation and efficiency in managing logistics processes, namely, FedEx, DHL, Maersk, UPS, and ASCO (Table 2). These companies have many years of experience in the industry, are distinguished by a variety of specialisations and practices aimed at overcoming the key challenges of modern logistics. The analysis of their approaches revealed effective processes that can be adapted in other contexts, in particular, in the framework of logistics modernisation of individual countries or regions.

Table 2. Experience of leading logistics operators in solving key problems

Company	Main areas of activity	Approach to overcoming logistics challenges
FedEx	Express delivery, air transportation, global logistics services	Introduction of high delivery quality standards, development of high-speed air delivery, optimisation of routes to reduce delays
DHL	International cargo transportation, warehouse logistics, courier services	Focus on improving delivery reliability, inventory management, and expanding logistics infrastructure in strategically important regions

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Maersk	Sea container transportation, port logistics, supply chain management	Optimisation of global supply chains, modernisation of port infrastructure, investment in sustainable logistics solutions
UPS	Land and air transportation, e-commerce logistics, warehouse management	Implementation of effective supply chain management methods, reduction of delivery times, optimisation of transportation costs
ASCO	Sea transportation, fleet management, logistics services in the Caspian region	Development of maritime infrastructure, ensuring efficient and safe transportation, integration with international transport corridors

In this way, FedEx achieves improved delivery accuracy and speed by deeply integrating IT solutions into the route planning and air travel management process. The company actively uses artificial intelligence to predict delays and adjust logistics scenarios in real time. DHL demonstrates efficiency through systematic digitalisation of warehouse processes and inventory management. Its strategy is based on the development of logistics infrastructure in regions with high trade dynamics, which minimises delays and provides flexibility in customer service. In turn, Maersk, as a leader in sea transportation, focuses on modernising port logistics and implementing solutions focused on environmental sustainability. Investments in port automation, digital container flow management platforms, and carbon reduction allow the company to reduce costs and meet environmental standards. UPS aims to reduce operating costs and improve efficiency by implementing automated order processing systems, and data analytics to predict demand. The company pays great attention to e-commerce logistics, in particular, by optimising the last mile of delivery. On the other hand, ASCO, as a regional operator, focuses on developing the maritime infrastructure of the Caspian region and integrating it into international transport corridors.

In Uzbekistan, freight transportation operators are increasingly integrating digital solutions to improve delivery efficiency and supply chain management. Leading domestic carriers are adopting IT-based route planning and transport monitoring systems to anticipate delays and adjust logistics operations in real time. Warehouse and inventory management are being progressively digitalized, particularly in regions with high industrial and trade activity, which reduces delays and enhances service reliability.

For international transit and regional trade, port and rail infrastructure modernization is a priority. Investments in automation, digital tracking of cargo flows, and environmental sustainability measures help optimize operations while ensuring compliance with regulatory and environmental standards. In e-commerce logistics, companies focus on improving last-mile delivery, leveraging data analytics to predict demand and streamline operations.

At a regional level, Uzbekistan's integration into international transport corridors, such as the TRACECA (Transport Corridor Europe-Caucasus-Asia) and Central Asia transit routes, emphasizes the importance of safety, efficiency, and coordination in multimodal freight transport. Comparative analysis of domestic and international best practices shows that effective logistics management in Uzbekistan depends on combining digital transformation,

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infrastructure development, environmental considerations, and customer-oriented strategies. Applying these approaches can enhance national freight systems and support Uzbekistan's position as a regional logistics hub.

Comparison of available ICT solutions and their implementation process

Logistics is a complex and dynamic area in which the effectiveness of operations directly depends on the ability to use the latest ICTs. State-of-the-art ICT solutions help to optimise transportation, inventory management, cargo tracking, and reduce operating costs (Table 3). However, despite the huge potential, the introduction of such technologies is accompanied by a number of challenges and barriers.

Table 3. Basic ICT solutions

ICT solutions	Description
TMS	Software for planning and monitoring transport routes
RTLS	Technologies for tracking the location and condition of cargo in real time
WMS	Warehouse management automation systems, including storage and processing of goods
IoT	Using sensors to monitor the condition of cargo and vehicles
Blockchain technologies	Use of blockchain to ensure transparency and security in data exchange

The implementation of ICT solutions can substantially enhance the efficiency of logistics operations. One of the central technologies in this regard is the Transportation Management System (TMS), which automates planning, monitoring, and traffic analysis, enabling route optimization, cost reduction, and improved overall supply chain performance. Key benefits of TMS include the automation of logistics processes, which reduces transport costs and improves resource utilization. Integration with GPS and RTLS enables real-time cargo tracking, minimizing the risk of delays and losses. Furthermore, TMS streamlines document management, reducing errors in transportation documentation, and its analytical and forecasting capabilities support better managerial decision-making.

However, deploying a TMS presents several challenges. High licensing costs, technical configuration requirements, and staff training can represent a significant financial investment. Effective implementation requires integration with existing business platforms, which may be complicated in large organizations with complex IT infrastructures. The system's effectiveness also depends heavily on the quality and timeliness of input data, as errors or outdated information can compromise route planning accuracy. Additional barriers include the need for comprehensive staff training, hardware and software updates to ensure compatibility with other enterprise systems, and coordination with supply chain partners who may use different or outdated logistics platforms.

Despite these challenges, successful TMS deployment is a crucial step toward the digital transformation of logistics processes. As supply chains grow more complex and demand for transport efficiency increases, companies are increasingly adopting TMS to centrally manage transport operations, control costs, automate document flow, and ensure transparency across the logistics cycle. Effective integration of TMS requires not only technical solutions but also

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strategic planning, engagement of relevant organizational divisions, adaptation of business processes, and systematic monitoring of performance. This multi-level process involves critical stages, from needs analysis to full operational deployment, ensuring that the system functions effectively within day-to-day logistics operations.

Discussion: The study found that the introduction of ICT contributes to optimising logistics processes and increasing the transparency of cargo transportation, which are key aspects of effective supply chain management. However, if the researchers focused on carrier selection algorithms based on network reliability, the current study examined the implementation of TMS and RTLS to increase the transparency of logistics processes. Both approaches confirmed the importance of digital technologies in logistics, but were implemented using different methods: mathematical modelling or implementation of ICT solutions.

This study examined the implementation of Transportation Management Systems (TMS) for automating transportation planning, monitoring, and analysis, which contributed to route optimization, cost reduction, and increased transparency in logistics processes. Other researchers proposed a TMS prototype that applies the Savings Algorithm and Google Maps to determine the most cost-efficient routes. While both studies highlight the importance of TMS in logistics, the present study emphasizes the integrated deployment of TMS, including its combination with other ICT solutions and management decision analysis, whereas Other researchers's work focused primarily on the development and testing of an individual prototype.

The experience of FedEx illustrates the benefits of integrating high operational standards, high-speed air delivery, and route optimization to minimize delays. Research by other researchers demonstrated that digital technologies, particularly advanced chatbots, can significantly enhance logistics efficiency. The implementation of a Rasa-based chatbot enabled FedEx to reduce response times, improve customer satisfaction, and optimize operator performance by automating routine inquiries. These findings collectively indicate that major logistics operators are actively leveraging both traditional optimization techniques and modern digital tools to enhance operational efficiency.

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