IMPROVING THE EFFICIENCY OF ROAD AND TRANSPORT INFRASTRUCTURE MANAGEMENT BASED ON INTELLIGENT SYSTEMS

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Annotatsiya. Mazkur maqolada intellektual transport tizimlari (Intelligent Transport Systems – ITS) asosida yo‘l va transport infratuzilmasini boshqarish samaradorligini oshirish masalalari tadqiq etilgan. Transport oqimlarini monitoring qilish, harakatni boshqarish, logistika jarayonlarini optimallashtirish hamda transport xizmatlari sifatini yaxshilashda ITS texnologiyalarining o‘rni va ahamiyati tahlil qilingan. Shuningdek, Surxondaryo viloyati misolida mavjud transport infratuzilmasi holati baholanib, transport oqimlarini boshqarish va logistika samaradorligini oshirishda aqlli transport tizimlarini qo‘llash istiqbollari asoslab berilgan. Tadqiqot natijalari ITS texnologiyalarini joriy etish transport harakati xavfsizligini oshirish, tirbandliklarni kamaytirish, logistika xarajatlarini qisqartirish hamda yo‘l va transport infratuzilmasidan foydalanish samaradorligini yaxshilashga xizmat qilishini ko‘rsatadi.

Kalit so‘zlar: intellektual transport tizimlari, ITS, logistika boshqaruvi, transport infratuzilmasi, transport oqimlari, raqamli transport, aqlli mobil tizimlar, transport logistika, harakatni boshqarish, transport samaradorligi.

Abstract. This article investigates the issues of improving the efficiency of road and transport infrastructure management based on Intelligent Transport Systems (ITS). The role and significance of ITS technologies in traffic flow monitoring, traffic management, logistics process optimization, and the improvement of transport service quality are analyzed. Furthermore, the current

state of transport infrastructure in the Surkhandarya region is assessed, and the prospects for the application of intelligent transport systems to enhance traffic flow management and logistics efficiency are substantiated. The research findings demonstrate that the implementation of ITS technologies contributes to improving road safety, reducing traffic congestion, lowering logistics costs, and increasing the efficiency of road and transport infrastructure utilization.

Keywords: Intelligent Transport Systems (ITS), logistics management, transport infrastructure, traffic flow, digital transport, smart mobility, transportation logistics, traffic management, transport efficiency.

Today, the efficient functioning of the transport system is considered one of the key factors of a country's economic development. The level of transport infrastructure development directly affects the efficiency of logistics systems, as well as the speed and safety of freight and passenger transportation. Therefore, the use of Intelligent Transport Systems (ITS) in modern transport management has become increasingly important.

An Intelligent Transport System (ITS) is a complex engineering framework and an innovative approach to modeling transport systems and managing traffic flows.

ITS is based on the application of modern information and communication technologies in transport infrastructure management. It enables the monitoring of traffic flows, optimization of transportation processes, efficient organization of logistics operations, and improvement of road safety.

Intelligent Transport Systems represent a set of advanced technologies that facilitate the efficient management of transportation systems through information exchange among transport infrastructure, vehicles, and control centers.

ITS encompasses the following key areas:

- real-time monitoring of traffic flows;

- automated traffic management;
- enhancement of road safety;
- optimization of logistics processes;
- efficient utilization of transport infrastructure.

The implementation of intelligent transport systems can provide comprehensive socio-economic benefits across multiple sectors, including the following advantages [1,2]:

- reduction in travel time, improvement of driver productivity, and mitigation of traffic congestion;
- enhancement of environmental protection measures;
- reduction in the cost of road infrastructure development and maintenance;
- promotion of industrial development and creation of employment opportunities.

These systems enable the rapid collection of traffic-related data, and through its analysis, the overall efficiency of transport systems can be significantly improved.

In recent years, Uzbekistan has paid considerable attention to the modernization of transport infrastructure and the digitalization of the transport sector. Several projects aimed at implementing intelligent transport technologies have been launched to improve traffic management, ensure road safety, and optimize logistics operations.

Nevertheless, several challenges still exist in the implementation of ITS technologies within the country:

- certain elements of transport infrastructure are not sufficiently equipped with modern technologies;
- traffic management systems have not yet been fully automated;
- the level of adoption of digital technologies in transport infrastructure management remains relatively low.

Surkhandarya Region is located in the southern part of Uzbekistan and is considered one of the country's strategically important regions due to its position at the intersection of international transport corridors. Major transportation routes connecting Uzbekistan with Afghanistan and other neighboring countries pass through this region.

Despite its strategic importance, several challenges remain within the region’s transport infrastructure:

1. Insufficient Modernization of Road Infrastructure

Some roads in the region are outdated and do not fully meet the requirements of modern traffic volumes and transportation demands. As a result, road capacity, travel speed, and traffic safety are adversely affected.

2. Underdeveloped Traffic Management Systems

The level of implementation of modern Intelligent Transport System (ITS) technologies for monitoring and managing traffic flows remains relatively low. Existing traffic control mechanisms are not sufficiently equipped to ensure efficient traffic regulation and rapid response to changing traffic conditions.

3. Limited Digitalization of the Transport System

The transport system has not yet been fully digitalized, and the capabilities for real-time monitoring and analysis of traffic flow data are limited. This hinders effective decision-making, traffic forecasting, and the optimization of transport and logistics operations.

Addressing these issues through the implementation of Intelligent Transport Systems and digital technologies would contribute significantly to improving transport efficiency, enhancing road safety, and supporting the sustainable development of the region's transport infrastructure.

Figure 1 illustrates the conceptual model of road and transport infrastructure management based on Intelligent Transport Systems (ITS). This model delineates the comprehensive process of data acquisition, processing, and subsequent decision-making derived from diverse elements within the transport ecosystem.

At the core of the schematic diagram lies the centralized data processing hub powered by Artificial Intelligence (AI) technologies. This center serves as the primary governance mechanism, responsible for aggregating, analyzing, and synthesizing multi-source data streams from the transport infrastructure to formulate real-time control commands.

The left section of the model categorizes the primary data acquisition sources. These encompass smart traffic sensors, closed-circuit television (CCTV) surveillance cameras, global positioning system (GPS)-equipped vehicles, and various digital monitoring devices. Utilizing these instruments, critical parameters —such as vehicle geolocations, spatial velocities, network congestion levels, and real-time traffic flow dynamics—are systematically gathered in real-time.

The aggregated data streams are subsequently processed via advanced AI algorithms to evaluate current traffic conditions, forecast potential bottlenecks and congestion patterns within the transport network, and synthesize optimized traffic management strategies. Such an approach significantly enhances the adaptability and operational agility of the transport system.

The right section of the diagram depicts the primary operational outcomes and system functionalities. Specifically, these include traffic flow optimization, adaptive traffic signal control to maximize road capacity, preemptive priority routing for emergency and specialized vehicles, predictive fleet maintenance scheduling, and continuous structural health monitoring of the road infrastructure.

Furthermore, the integration of intelligent transport systems facilitates the optimization of logistics workflows, reduces operational expenditures, and elevates the overall quality of transportation services. Consequently, this leads to heightened efficiency in traffic flow management, augmented road safety, and a substantial increase in the utilization efficiency of existing transport infrastructure.

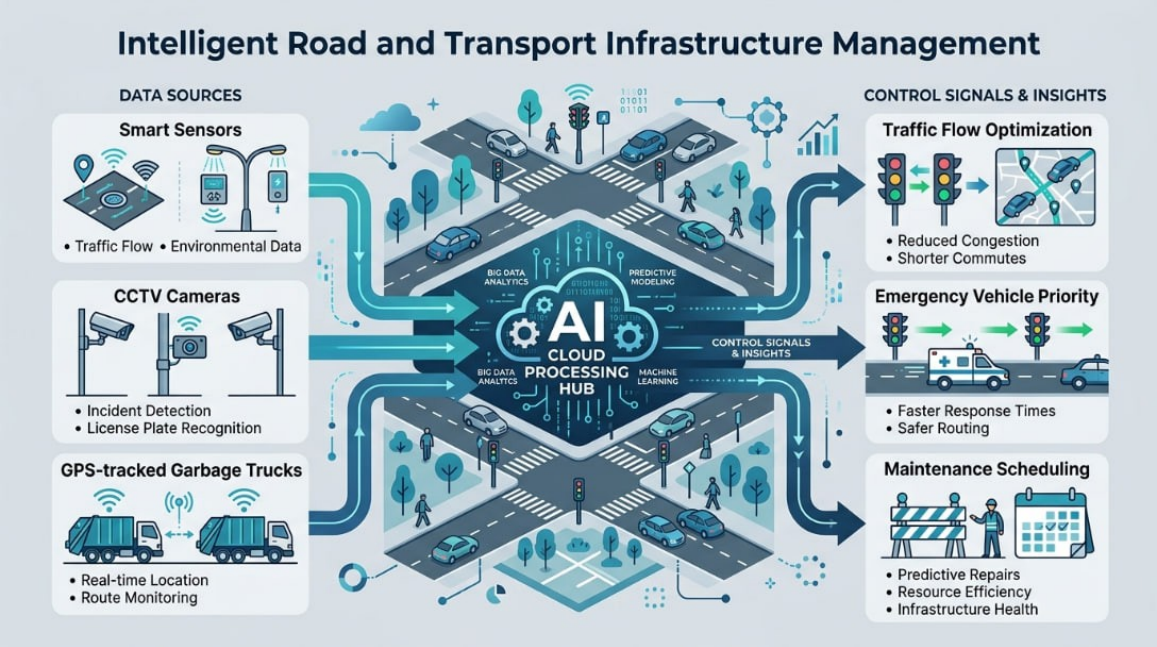

Figure 1. A conceptual model for managing road and transport infrastructure based on intelligent transport systems.

The mechanisms for implementing logistics management improvements based on Intelligent Transport Systems (ITS) and their effectiveness are presented in Figure 2.

The application of Intelligent Transport Systems in traffic flow optimization and management is aimed at maximizing the utilization of transport networks, enhancing the efficiency and safety of transportation processes, and improving the level of convenience for transport users and drivers. In addition, ITS facilitates rapid access to emergency medical services and contributes to reducing the construction and maintenance costs of road infrastructure.

Management capabilities using intelligent systems	
Implementation methods	Efficiency
Monitoring traffic flow	real-time monitoring of traffic flow on road infrastructure and digitization of data.
Automated management	reducing traffic congestion, optimizing signaling and road markings through intelligent control systems.
Optimization of logistics processes	improving transport efficiency by managing freight and passenger flows
Integration of multimodal transport systems	integrating road, rail and public transport systems into a single platform.
Improving transport safety	enhancing safety through early detection and real-time monitoring of traffic accidents.

Figure 2. Management capabilities using intelligent systems

As a result, ITS provides users with a higher level of information accessibility and safety while improving the quality of interaction among all participants in the transportation process. Developed countries such as the United States, Japan, Germany, France, and China have been widely implementing these technologies in transport management for the past 20–30 years [4,5].

To ensure effective management of transport infrastructure in the Surkhandarya region, it is advisable to implement the following measures:

- ✓ introduce its technologies for traffic flow management;
- ✓ install intelligent monitoring systems on highways and major roads;
- ✓ digitalize logistics processes;
- ✓ manage transport infrastructure using modern information technologies;
- ✓ integrate the transport system into a unified digital platform.

Conclusion. In conclusion, the implementation of Intelligent Transport Systems plays a crucial role in ensuring efficient transport infrastructure management, optimizing logistics processes, and maintaining the sustainable operation of transportation systems. The use of ITS technologies in the modernization of transport infrastructure contributes significantly to improving transport efficiency, enhancing road safety, reducing congestion, and increasing the overall effectiveness of transport and logistics operations. Therefore, the wider adoption of intelligent transport technologies should be considered a strategic priority in the development of modern transportation systems.

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