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Intelligent Transport Systems Challenges and achievements

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Introduction

With the increase in the number of vehicles in megacities, the problem of average traffic speed and traffic congestion is acute the problem of average traffic speed and traffic congestion is becoming acute. Many of the world's cities have been stuck in traffic jams for years, but only a handful of them have been able to to untie this traffic jam. It is not always possible to build a new road or widen an existing highway, so it is necessary to solve the problem of traffic congestion with the help of modern technologies.

Intelligent Transportation System (ITS) is a system that uses innovative developments in modeling transportation systems and traffic flow regulation. Intelligent transportation systems help to solve the issue of traffic congestion through effective management of traffic light facilities, means of regulation and monitoring of road traffic, systems for informing road users about the situation on the roads.

The development of intelligent transportation systems (ITS) is becoming one of the most important tools for increasing the competitiveness of the transportation complex and the economy as a whole. Today it is the technologies of transportation processes are becoming the main tool in increasing efficiency of the transportation complex.

Key words: Intelligent Transportation System (ITS), management of transport systems, payment transport systems, road traffic, automated control system.

1. The role of innovative technologies in transportation development

Today, the introduction of innovative technologies is one of the promising and topical issues in the conditions of digital transformation and formation of transportation systems all over the world **(fig. 1):**

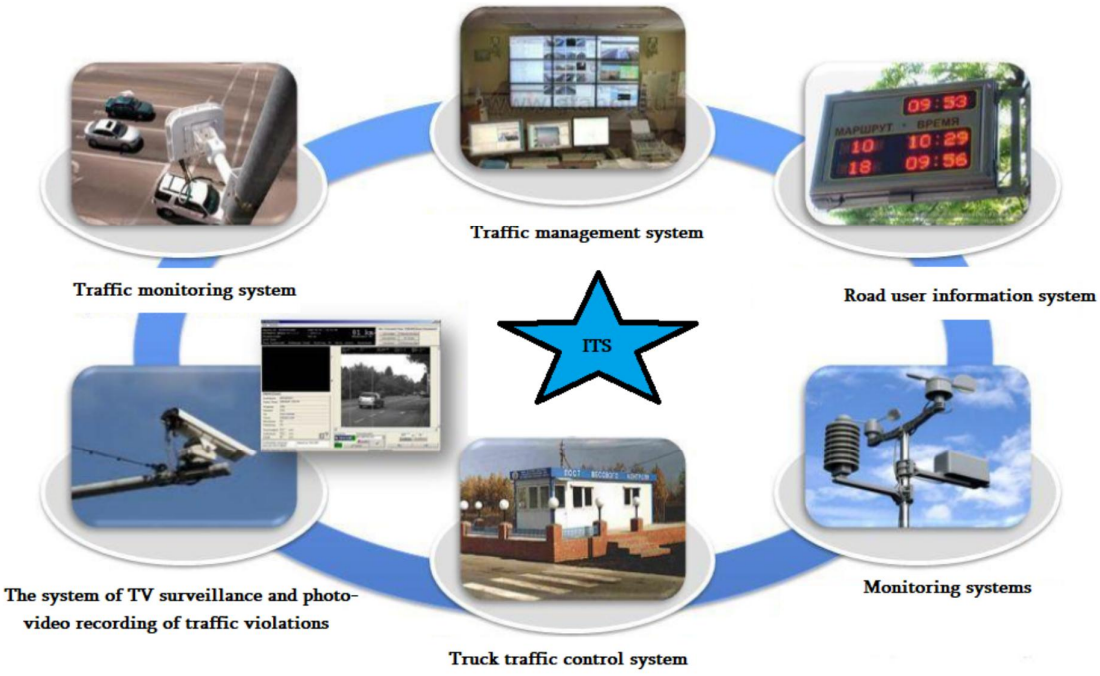

Fig.1. Intelligent Transportation System Development Program

Intelligent transportation system (ITS) is an intelligent system that uses innovative developments in the modeling of transportation systems and traffic flow regulation, providing end users with greater information and safety, as well as qualitatively increasing the level of interaction between traffic participants compared to conventional transportation systems.

Definition of ITS in various sources:

- Integration of modern information and communication technologies and means of automation with transport infrastructure, vehicles and users, focused on improving the safety and efficiency of the transportation process.

- A control system that integrates modern information and telematic technologies and is designed for automated search and acceptance for implementation of the most effective scenarios of management

of the transport and road complex of the region, a particular vehicle or a group of vehicles in order to ensure a given mobility of the population, maximize the indicators of road network use, improve the safety and efficiency of the transport process, comfort for drivers and transport users.

- Systemic changes aimed at: 1) providing various innovative services for different modes of transportation; 2) achieving sustainable mobility through improved efficiency, safety and environmental friendliness of transportation. ITS is thus seen by key stakeholders as a "bridge" to bridge the current sustainability gap between transportation systems.

Although in fact ITS may include all modes of transport, the European definition of ITS according to Directive 2010/40/EU of July 7, 2010 interprets ITS as a system in which information and communication technologies in the field of road transport (including infrastructure, vehicles, system participants, and road traffic management) are applied and which also has the possibility of interoperability with other modes of transport.

Interest in ITS has emerged with the advent of traffic congestion problems as a result of combining modern modeling, real-time control, and communication technologies. Traffic congestion appears worldwide as a result of increasing motorization, urbanization, and both population growth and increasing density. Traffic congestion reduces the efficiency of road transportation infrastructure, thus increasing travel time, fuel consumption and pollution.

ITSs vary in the technologies used, ranging from simple vehicle navigation systems, traffic light control systems, traffic management systems, various signage systems (including information boards), license plate recognition systems and vehicle speed recording systems, to video surveillance systems, to systems that integrate information and feedback streams from a large number of different sources, such as parking guidance and information (PGI) systems, and weather services, Moreover, ITS can apply predictive technologies based on modeling and historical information.

Various types of wireless communication can be used in ITS. For example, long-range (DMV) and short-range (VHF) radio communications can be used.

For short distances, IEEE 802.11 (Wi-Fi) wireless communication, especially the IEEE 802.11p (WAVE) standard, can be used. Also, for example, the DSRC standard promoted by the American Public Smart Transportation Organization and the U.S. Department of Transportation is used in the United States. WiMAX, GSM, 3G, 4G or 5G technologies can also be used [1].

Current developments in embedded systems technology enable the use of real-time operating systems as well as higher-level applications that enable the application of artificial intelligence. The growing power of processors used in embedded systems, as well as their increased compatibility with processors in personal computers, is leading to increased code reuse and the transfer of more intelligent services from the PC level to the embedded system level.

3. Transportation service

Within the framework of the development of transportation service it is required to analyze and to supplement the known and currently existing classifications in the sphere of railroad transportation services.

It's necessary to determine the main and secondary criteria of classification of these services. of these services. The WTO (World Trade Organization) classification was created in order to obtain data of economic statistics, namely, to reflect the cost of railroad transportation services.

Statistics, namely the reflection of the value of services in the balance of payments of the country. Therefore, it only traded (included in international trade transactions) transportation services are reflected **(fig. 2):**

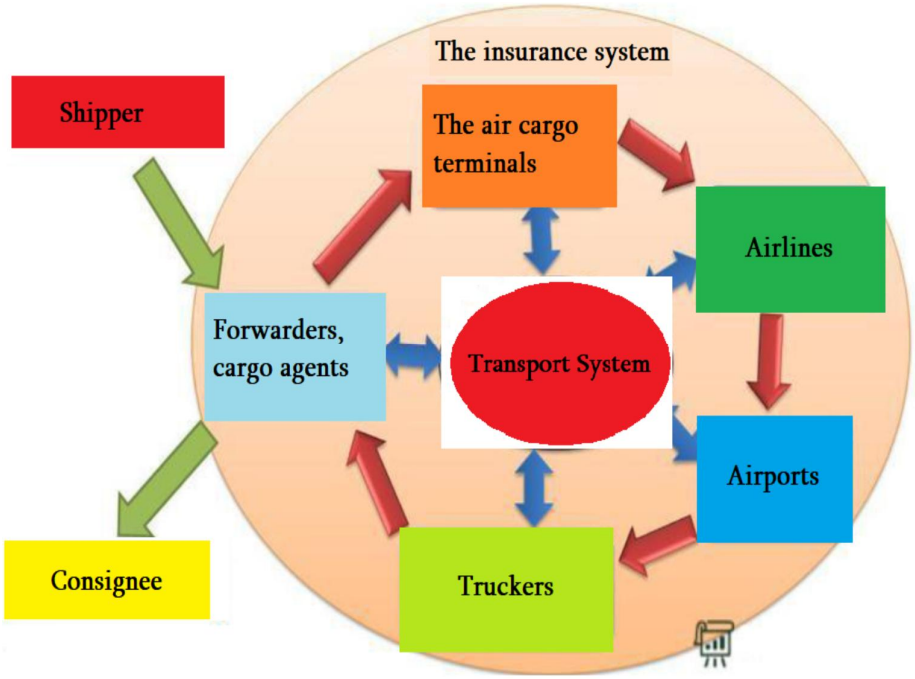

Fig. 2. The model of process integration in a multimodal in transportation system

3. ITS problems and ways to solve them

Creation of a national ITS is a complex cross-sectoral task, and the experience of the most dynamically developing countries - EU countries, USA, Japan, China - shows that a clear government policy is very important in this issue, as well as the existence of a long-term strategy for ITS development, which makes it possible to combine and coordinate the efforts of the state and business, and various sectors of the economy. For example, in the USA, as the first step in ITS development, the Congress adopted the Efficient Intermodal Transport Complex Act, which instructed the US Department of Transportation to create a National ITS Architecture, develop a standardization program and promote the use of ITS technologies. To solve these tasks, the Department of Transportation created the ITS Program Directorate, and significant financial resources were allocated from the state budget [2].

One of the most innovative technologies, Radio Frequency Identification (RFID) technology holds a significant position among the technologies designed for the optimal management of existing processes.

RFID Augmentation in Navigation and Safety:

The application of RFID in Intelligent Transport Systems is expanding beyond traditional realms. Navigation systems leveraging RFID tags embedded in road infrastructure offer real-time information to vehicles, enhancing route optimization and contributing to overall road safety. In emergency situations, such as accidents or adverse weather conditions, RFID-enabled communication can alert drivers, improving response times and mitigating risks.

Public transportation systems are witnessing a revolution with RFID technology. Contactless smart cards, integrated with RFID, streamline passenger access, reducing queues and transaction times. Moreover, real-time tracking of public transport vehicles enhances service reliability, allowing passengers to plan their journeys more efficiently. These advancements contribute to the overall appeal and sustainability of public transportation.

The integration of Smart Contracts into Intelligent Transport Systems extends beyond transactional automation. Blockchain's decentralized nature provides a foundation for governance systems that involve multiple entities. Regulatory compliance, licensing, and standardization in the transport sector

can be facilitated through decentralized decision-making processes enabled by Smart Contracts. This not only ensures compliance but also fosters a collaborative and transparent regulatory environment.

Smart Contracts in Fleet Management - The use of Smart Contracts extends to fleet management, offering a secure and automated framework for monitoring vehicle health, scheduling maintenance, and managing fuel consumption. Smart Contracts can autonomously trigger maintenance schedules based on predefined criteria, optimizing the operational efficiency of transport fleets. Additionally, they facilitate transparent communication between vehicle sensors and maintenance providers, ensuring timely interventions and reducing the risk of breakdowns [3-4].

While the integration of RFID and Smart Contracts presents numerous advantages, challenges persist. Concerns about data privacy, standardization across diverse systems, and the upfront costs of implementing these technologies remain areas of consideration. However, ongoing research and collaborative efforts within the industry are addressing these challenges.

Looking forward, the synergy between RFID and Smart Contracts in Intelligent Transport Systems is likely to witness continued innovation. Advancements in machine learning and artificial intelligence will further enhance the capabilities of these technologies, offering predictive analytics for traffic patterns, maintenance needs, and even anticipating potential disruptions.

Fleet management, a critical component of modern transportation systems, is undergoing a revolutionary transformation with the integration of Smart Contracts. These self-executing and tamper-resistant contracts, underpinned by blockchain technology, are reshaping how fleets are monitored, maintained, and optimized for operational efficiency.

One of the primary applications of Smart Contracts in fleet management is the automation of maintenance schedules. Traditional maintenance processes often rely on predefined timelines or mileage intervals, leading to either under-maintenance or unnecessary servicing. Smart Contracts, equipped with predefined criteria such as engine hours, mileage, or diagnostic data, autonomously trigger maintenance schedules. This proactive approach ensures that vehicles receive timely and precisely tailored maintenance, minimizing the risk of unexpected breakdowns and extending the lifespan of the fleet.

Smart Contracts bring transparency to the record-keeping process in fleet management. Maintenance records, service history, and compliance documentation are securely stored in a decentralized

blockchain, ensuring an immutable and tamper-resistant audit trail. This not only facilitates regulatory compliance but also simplifies the auditing process, reducing administrative burdens and enhancing trust between fleet operators and regulatory bodies.

Efficient fuel management is a critical aspect of fleet operations. Smart Contracts can be employed to monitor fuel consumption, optimize routes, and streamline fueling processes. Integration with IoT devices and sensors allows Smart Contracts to track real-time fuel levels and trigger fueling processes automatically when predefined thresholds are reached. This not only reduces fuel wastage but also enhances overall fuel efficiency, contributing to cost savings for fleet operators.

Smart Contracts facilitate transparent and decentralized communication between vehicles and maintenance service providers. When a vehicle's sensors detect issues requiring attention, Smart Contracts can automatically communicate with authorized maintenance providers. This seamless communication ensures that maintenance needs are addressed promptly, minimizing downtime and enhancing operational efficiency. The decentralized nature of blockchain ensures that communication is secure and tamper-resistant. Smart Contracts play a pivotal role in enhancing fleet safety and compliance. By automating and enforcing compliance regulations within the contracts, fleet managers can ensure that vehicles adhere to safety standards, regulatory requirements, and environmental policies. Automated alerts and notifications can be triggered if a vehicle deviates from compliance, allowing for timely interventions and corrective actions. While the integration of Smart Contracts in fleet management presents numerous benefits, challenges such as data privacy concerns, standardization across diverse systems, and the initial investment in technology adoption need to be addressed. Ongoing research and collaboration within the industry are crucial to overcoming these challenges.

The marriage of RFID and Smart Contracts in Intelligent Transport Systems is shaping a future where connectivity, efficiency, and sustainability converge. As these technologies continue to evolve, their transformative impact will undoubtedly redefine the landscape of transportation in the XXI century, ushering in an era of intelligent, adaptive, and seamlessly interconnected transport ecosystems [5-6-7].

The European Union has developed an interstate program of research and development works on ITS creation, which is financed by the EU, individual EU states, and private business. Much attention

is paid to the integration of intellectual potential, a large number of performers of different profiles are involved in the implementation of projects. For example, 44 companies participated in the already completed European project "Ddrive-C2X", which included the development of technologies and technical means of warning drivers of various types of danger and assisting them in various situations, and there were 11 supporting partners **(Fig. 3):**

Fig. 3. Development of intelligent transportation systems - a new stage

Intelligent transportation systems are being implemented on more and more on more and more roads around the world. These systems can significantly facilitate and optimize traffic both in urban and intercity traffic. intercity transportation. Such goals require the solution of a large number of theoretical and practical challenges.

Conclusions

The analysis of the best foreign experience in research on ITS creation allows us to identify the key conditions for success, which include:

- the leading role of state structures and financial support from the state for ITS development irrespective of the level of the tasks to be solved, subjects and objects of management, involved in ITS;

- application of public-private partnership (PPP) mechanisms for research and development, i.e. cooperation of financial and organizational capabilities of business and governmental authorities.

of business and state transport management bodies transportation;

- an integrated approach, which is expressed, first of all first of all, in involving a wide range of specialists from different fields in solving the tasks of ITS creation a comprehensive approach is expressed, first of all, in the involvement of a wide range of specialists from various fields of activity in solving the tasks of ITS creation - transportation engineers, leading automobile manufacturing companies, manufacturers of traffic control equipment, communication specialists, software developers, etc.

Creation of ITS should become a priority task of the Ministry of Transport of Russia, as lagging behind in their development will significantly reduce the competitiveness of our transportation complex. In addition to reducing its functional efficiency related, in fact, to the tasks of passenger and cargo transportation, the issues of ensuring the safety of all road users will not be solved.

Creation of ITS is the most important task ensuring high efficiency of the transportation complex functioning and a strategic direction in ensuring its safety. It is necessary to intensify work in this direction under state management.

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