Research on the integration of intelligent transport systems

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Abstract. In article top trends and the directions of application of the intellectual transport systems (ITS) are considered and analyzed. Now, proceeding from the analysis of world practice, it is possible to draw a conclusion that application of the intellectual transport systems as systems which provide adaptive and expected management of safety and the traffic organization in the transport and road system of regions will lead to the growth of transport services quality level. Development of the intellectual transport systems methodologically is based on system approach as the intellectual transport systems are formed as systems, but not separate services. Methods of creation of the intellectual transport systems are based on the principles of operating transport systems modernization and reengineering.

1. Introduction

Modern intelligent transport systems combine communication, telematics and information management technologies. Their goal is the search and implementation of the most effective traffic management solutions to improve traffic safety and reduce stress levels.

The multilevel system of influences on the traffic flow forms intelligent transport systems.

The first level is controlling the movement of an individual vehicle. The second level is to ensure coordination of the movement of several vehicles moving together in passing and oncoming directions. The third level consists of a traffic management network (city, highway, etc.).

At each of the indicated levels, two main functions are introduced: monitoring and application of control action by intelligent transport systems. In addition, it is necessary to implement the coordination function between all three levels of intelligent transport systems.

2. The relevance of introducing intelligent transport systems in a megalopolis

The trend of modern cities is to increase the level of motorization, as a result, the presence of parking spaces on the roadway, which inevitably leads to a decrease in the level of road safety, as well as the throughput of the road network. An integral part of the transport system of large cities are intersections. Monitoring traffic and pedestrians refers to the management of transport systems [1].

The construction and use of automatic traffic control systems on the street-road network of large cities allow to improve indicators [2, 3]. The task of traffic regulation is not only to increase safety, but also to simultaneously increase the operational effect of a particular production process [4]. Understanding that the digital transformation of roads as a basis for life safety, social and economic development, becomes relevant and timely.

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After analyzing the experience of using indirect traffic management systems in other countries, it was revealed that in the USA much attention is paid to control technology, namely to such components: message structure, frequency of information and the impact of this structure on decisions made directly by the driver, within the framework of such basic components as:

- detection;
- perception;
- readiness for action [5].

The main goals of intelligent transport systems: improving the quality of life of the population, improving road safety, developing intermodal transport, international transport corridors, reducing the negative impact of transport on the environment, reducing transportation costs in the cost of services, choosing the best logistics support for the provision of transport services, improving quality and competitiveness creating favorable conditions for private investment, supporting the adoption of operational decisions on rule, the implementation of the transit potential, improving the efficiency of the transport system [6]. The most important of them are presented in Figure 1.

![Intelligent Transport Systems goals](image)

**Figure 1.** The most important of intelligent transport systems goals.

Since the integration of the subsystems of indirect control of traffic flows affects the efficiency of the road network of large cities, there is a need to develop and improve this area.

Intelligent transport systems are most actively developing in the central part of Russia; in Moscow, such systems help reduce traffic congestion, and as a result, improve the environment due to reduced transport downtime, and can also optimize individual public passenger transport routes. The subsystem of informing about situations that present difficulties in traffic, slowing down the flow of traffic is an effective way to warn drivers of a traffic jam [5]. Intelligent transport systems also received their distribution in the constituent entities of the Russian Federation: Ryazan, Kaluga, Leningrad and Ulyanovsk regions [7]. Thus, if drivers and passengers are informed about the traffic situation in a timely manner, indirect losses from downtime can be avoided, which leads to such an adverse effect as a decrease in the profit of individual enterprises associated with transport.

There are many aspects in the direction of movement towards intelligent transport systems; they can be classified according to the following criteria: comfort and energy efficiency.

Given the demand by the international community for the dynamic development of transport infrastructure, the tasks of increasing energy efficiency and safety of both individual vehicles and the transport system as a whole are relevant and promising [8]. Currently, the development of smart energy-efficient systems for road transport has a positive trend.

During operation, for every 1,000 kilometers, the car requires an energy consumption of approximately 240…350 k /h. Such energy costs are associated with the consumption of operational
materials, spare parts, and technological processes during maintenance and repair. When carrying out major repairs, costs range from 96 to 131.2 kW/h per engine.

Analytical estimates show that, depending on the type, one passenger car requires 100,000...150,000 k /h of energy consumption for the period of its life cycle (from manufacture to disposal); truck – 150,000...500,000 kW/h; the bus – 300,000...600,000 kW/h. An average passenger car consumes approximately 9.3 tons of fuel during its operation, and its production costs another 2 tons of fuel [8].

As one of the promising methods for generating energy, generators operating on the piezoelectric effect are considered. For example, using the kinetic energy of automobile transport, it is proposed to use overhead strips of electric-generating road pavement, which allow the piezoelectric transducers of the wheels of the car (inside the pavement) to generate a sufficient amount of electric energy to provide autonomous lighting of the route [9]. As a result, one kilometer of the roadway can produce up to 500-kilowatt hours [10, 11].

To optimize the processes, “New Energy Technologies” has developed a device for collecting the kinetic energy of transport and converting kinetic energy into electricity. The piezoelectric generator is designed as a speed bump.

3. Management of the movement of an individual vehicle

Internal (autonomous) systems are based on information received from a directly intelligent vehicle. They are widely used in cars and trucks to increase active safety. These include various systems increasing stability, examples in Figure 2.

![Figure 2. Systems to improve active safety](image-url)

One of the effective options for the implementation and development of telematics systems in road transport is the introduction of satellite navigation technologies to solve the main technical problems
of transport management [12]. The stimulation of work in the field of navigation support in Russia was promoted by the Decree of the Government of the Russian Federation of March 7, 1995 No. 237 “On the implementation of work on the use of the global navigation satellite system GLONASS in the interests of civilian consumers.” In 2010, the Order of the Ministry of Transport of the Russian Federation (dated March 9, 2010 No. 55) was issued “On Approving the List of Types of Automobile Vehicles Used for the Carriage of Passengers and Dangerous Goods to Be Equipped with GLONASS or GLONASS / GPS Satellite Navigation Equipment”. This order noted that vehicles are equipped with GLONASS, GLONASS / GPS equipment in order to increase the safety and efficiency of road transport of passengers and dangerous goods.

Currently, there is a change in the status of a transport unit from an independent subject of traffic, towards a predictable subject of transport and information space, which is a distinctive feature. Therefore, the development of a telematic complex of road infrastructure is a priority in this area. Leading car manufacturers are exploring new use cases and telematics business models, such as user-based insurance and personal car sharing.

Over the past decade, scientists and engineers in the automotive industry have achieved good results in the development of devices and systems that ensure the safety of pedestrians and other unprotected road users. Modern cars are able to detect not only pedestrians but also vehicles while activating the brake system with the highest possible braking performance.

For example, Google developed an unmanned vehicle. This system uses information collected by the Google Street View service, video cameras, a LIDAR sensor that is installed on the roof, radars in the front of the car, as well as a sensor connected to one of the rear wheels, which helps in determining the position of the car on the map. [13]. In the process of testing cars with this system in 2010, it was found that the car drove about 1,600 km completely autonomously, 225.308 km with partial human participation [13]. This direction has been developed in subsequent years. In 2016, an agreement was signed between Google and Fiat Chrysler on cooperation, the purpose of which was the release of one hundred self-governing Chrysler Pacifica [13].

The desire to minimize accident rate is also characteristic of manufacturers of components and systems of commercial vehicles.

4. Ensuring coordination of the movement of several vehicles
All road users, as well as infrastructure, need to exchange a large amount of data in real-time. Based on them, an alert algorithm is generated. Despite the complexity of the task, such a communication system – ITS Connect was invented by Toyota. The Japanese manufacturer has prepared a system of interaction with other road users, and moreover, with objects of transport infrastructure. The automaker introduced the innovation system in October 2015. At the heart of the system is a cloud network that interacts with cars and allows them to transfer data. For example, ITS Connect adjusts the work of cruise control, warns drivers about approaching ambulances and police, helps to maneuver at intersections equipped with communications.

Figure 3. ITS Connect tasks.
Together with the Swedish Ministry of Transport, Volvo has created a project to combat accidents on icy roads. The essence of the project lies in the fact that a car falling on how many sections, through internal mobile communications Volvo Cars transmits information about it to the data center, where then this information is transmitted to nearby cars. In addition, information about the icy section of the road is sent to the road service. The data obtained allow road services and contractors to better plan and maintain roads in the winter, as well as respond quickly if necessary.

5. Management of network traffic flows

The introduction of new technologies in the traffic management system will create centralized monitoring of the road situation. Currently, saturation with the intellectual technology of traffic control systems is necessary to ensure the interconnected functioning of vehicles in the stream. Multi-program and adaptive systems of connected traffic control in megacities and adjacent highways that can receive, summarize, analyze, manage, communicate information to all road users about the state of the system, for example, these include road signs with automatically changing information, special dynamic information boards and etc. The analysis of large volumes of data allows for preventative maintenance of equipment and improved territory planning. Intelligent infrastructure requires the integration of several technologies, such as IoT, Big Data, etc. The collected data will allow you to adjust the development of the territory [14]. IoT devices are a key element of the smart city concept. Built-in sensors collect useful data for analysis and obtaining the necessary information. Free exchange of information between complex urban systems will be carried out in real-time; The integration of data analysis will minimize accidents and unintended consequences.

The work of the intelligent traffic management system is aimed at maximum unloading of intersections and improving the safety of urban traffic. The intelligent traffic control system collects information about the movement of vehicles through the city’s video fixation points, then analyzes the data and takes measures to optimize traffic automatically or semi-automatically [6]. Changes in control actions at one particular intersection inevitably necessitate changes in the characteristics of traffic flows at neighboring locations. Therefore, systemic flow control is required.

Despite the complete automation of traffic control, the analysis of information and the adjustment of the operating modes of objects are sometimes carried out manually. In the future, it is necessary to reduce the impact on the operation of these systems.

According to the forecasts of the Massachusetts Institute of Technology, such a sign of a smart city as joint mobility should appear. Based on an empirical study, it is established that in conditions of heavy traffic, two phases of the traffic flow can be distinguished: “synchronized flow” and “wide moving traffic jam”. A three-phase model was also proposed [15]. An autonomous car, according to the present in the navigation system, from a computer, tablet or smartphone will take citizens whose routes cross, to the office, to business meetings, to the hospital, to study and return for passengers with a similar route in the evening. The only thing that will unite passengers is the route. An experiment was conducted by Senseable City Lab. During the year, they tracked 150 million taxi rides in New York. Movement models have been identified and developed efficient car-sharing systems. Experts concluded that the development of transport sharing technologies could reduce the number of taxi rides by 40 %. As a result, the length of traffic jams and the number of harmful emissions will decrease. According to experts, the adoption of the concept of general mobility by cities, four out of five private vehicles would be superfluous, and minimizing the number of cars would lead to the release of parking spaces [14].

The introduction of intelligent transport systems throughout the country is local and uneven, since the systems are not interconnected, fragmented, without proper scientific and conceptual elaboration. There is no systematic approach. A comprehensive application of technologies is needed, which will improve the level of road operation [16].

6. Conclusion

Transport problems are inseparable from problems such as the planning of city infrastructure. [17]
At the present stage of development of road transport complexes, intelligent systems are actively being introduced into traffic flow control systems, vehicle designs, and interactive systems for informing road users and payments for services provided by the transport system to its participants.

The volume and pace of implementation, the effective deployment of communication and the competent stimulation of consumers to new technologies play a significant role for the effective interaction of intelligent transport systems with other projects, for example, related to road construction.

The integrated application of technologies can increase the level of road operation and optimize the costs of servicing individual vehicles, minimize the costs associated with the capacity of the road network.

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