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THE ROLE OF MODERN INTELLIGENT SYSTEMS IN IMPROVING ROAD TRAFFIC SAFETY AND THEIR SIGNIFICANCE IN THE URBAN TRANSPORT SYSTEM

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Annotation. This article analyzes the role of modern intelligent transport systems (ITS) and intelligent highways in ensuring road traffic safety. The study highlights the effectiveness of using information and communication technologies, artificial intelligence, IoT, GPS, video analytics, and telecommunication networks in the context of increasing traffic flow, driver errors, and the growing number of road accidents. The research results include proposals aimed at digitalizing the urban transport system, reducing environmental load, and minimizing road traffic accidents.

Keywords: intelligent transport system, intelligent highway, V2X technologies, Electronic Toll Collection (ETC), Driver Monitoring System, AI Dashcams, ADAS, smart parking, LAN and WAN networks, Emergency Call.

In recent years, ensuring road traffic safety has become one of the most important priorities in the policies of countries around the world. The growth of the population, the expansion of cities, and the increase in the number of vehicles have led to a sharp rise in traffic congestion, road accidents, and environmental problems. Under such conditions, traditional methods of managing traffic processes are losing their effectiveness.

The development of modern information technologies has made it possible to introduce entirely new approaches to the management of transport systems. Among them are **Intelligent Transport Systems (ITS)**, which are based on artificial intelligence, digital networks, video analytics, GPS, sensors, and data processing algorithms. These systems manage traffic flows, improve safety, and provide users with real-time information.

Intelligent transport systems are complex frameworks that utilize information and communication technologies, artificial intelligence, sensors, and network analytics tools to ensure road safety, optimize traffic flow, and reduce the impact of the human factor. The main components of intelligent transport systems are shown in Figure 1.

Traffic safety is not only a technical or organizational issue but also directly related to social and economic stability. Every year, hundreds of thousands of people around the world die as a result of road traffic accidents. To reduce this figure, many countries are implementing ITS technologies. The main problem in ensuring road traffic safety is the **human factor**. According to statistics, more than 60 percent of traffic accidents are caused by driver errors. Therefore, automated control systems that reduce human involvement are considered the most reliable means of improving safety.

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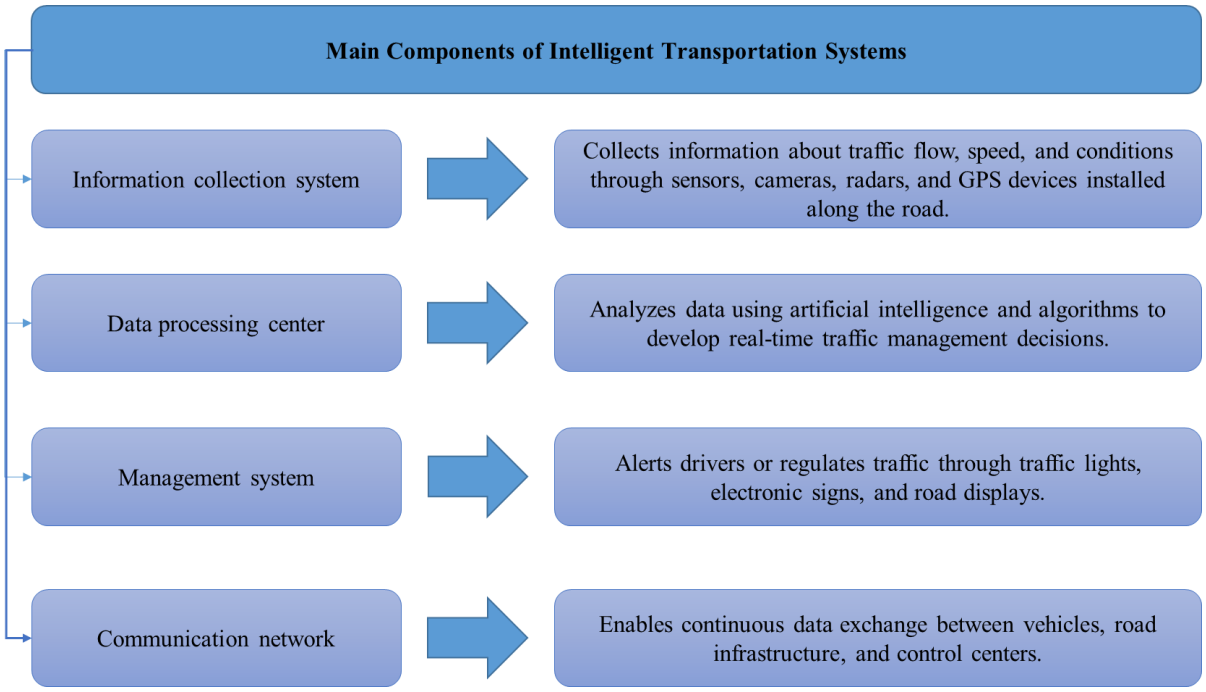

Figure 1. Main components of intelligent transportation systems

ITS systems not only manage traffic flows but also provide specific mechanisms to enhance safety:

- **automatic speed control systems** — detect vehicles exceeding the permitted speed and automatically generate penalty protocols.
- **accident prevention systems** — warn drivers about road conditions, fog, or darkness to prevent collisions.
- **ai-based traffic light control** — changes signal phases in real time depending on traffic density.
- **pedestrian protection systems** — use cameras to detect pedestrian movement and adjust traffic light signals accordingly.

In urban infrastructure, ITS plays an important role in the following areas:

- **reducing traffic congestion:** traffic flows are dynamically managed, and traffic lights are adjusted according to real-time load.
- **improving public transport efficiency:** priority lanes are created for buses and trams, and real-time monitoring systems for passengers are implemented.
- **environmental benefits:** since vehicle idle time is reduced, exhaust emissions are significantly decreased.

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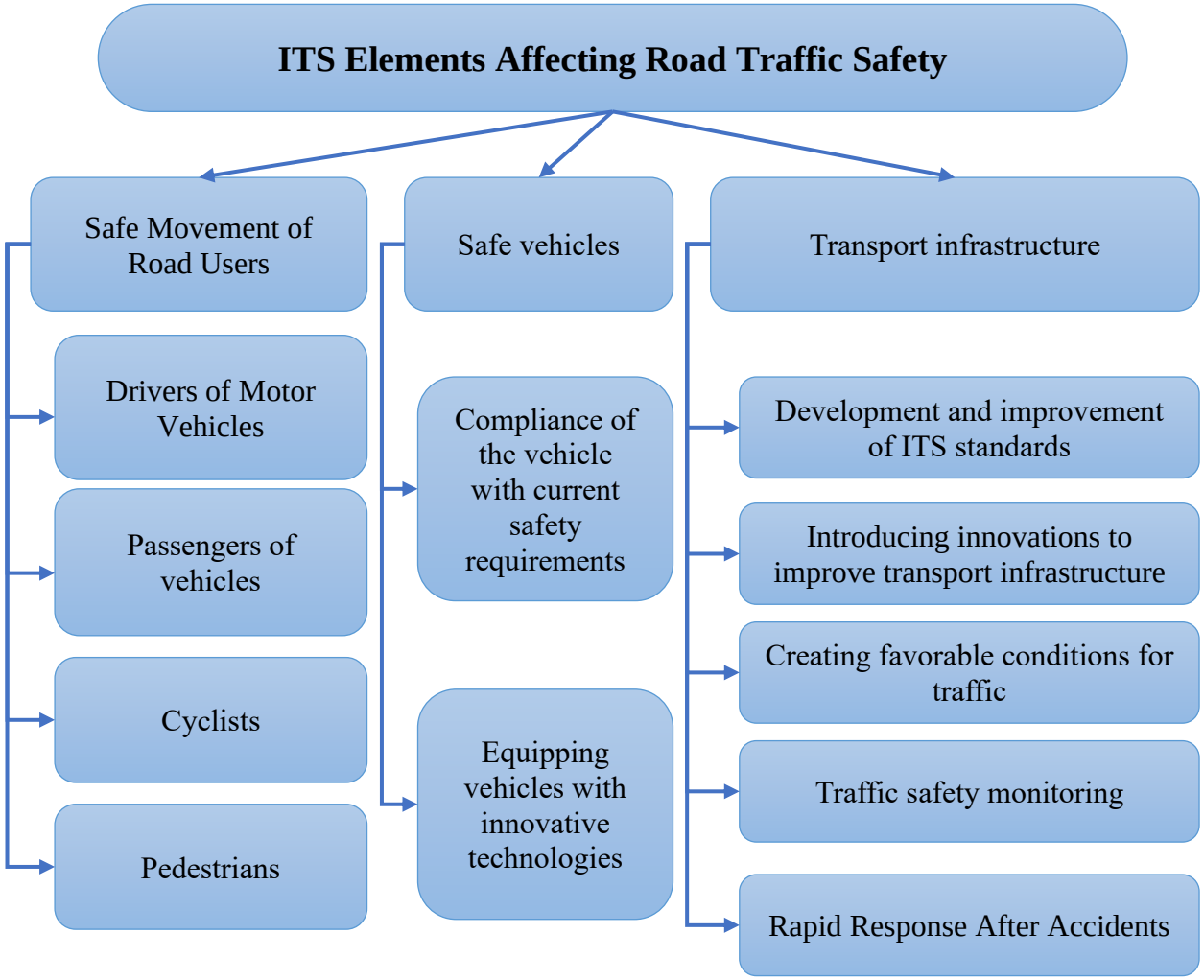
- **convenience for emergency services:** automated systems ensure that roads are cleared for ambulances, fire trucks, and police vehicles.

Figure 2. ITS Elements Affecting Road Traffic Safety



An intelligent highway is a road infrastructure managed through digital technologies, artificial intelligence, and telecommunication systems. Its main objectives are to efficiently manage traffic flow, enhance driver safety, prevent road accidents, and increase the speed and efficiency of transportation processes. Such highways widely utilize smart traffic lights, video surveillance systems, speed control radars, accident monitoring systems, and fast data transmission tools. By reducing traffic congestion on highways, it is possible to decrease harmful gas emissions into the atmosphere and lower transportation costs through time and resource savings.

To ensure communication between vehicles, pedestrians, and road infrastructure, V2X (Vehicle-to-Everything) technology is used as an advanced communication system (Figure 3). This technology includes several types such as V2V (Vehicle-to-Vehicle), V2I (Vehicle-to-Infrastructure), V2P (Vehicle-to-Pedestrian), V2N (Vehicle-to-Network), V2C (Vehicle-to-Cloud), and V2G (Vehicle-to-Grid), enabling vehicles to interact with pedestrians, cyclists, the internet, mobile networks, vehicle service systems, and electric power grids for electric vehicles.

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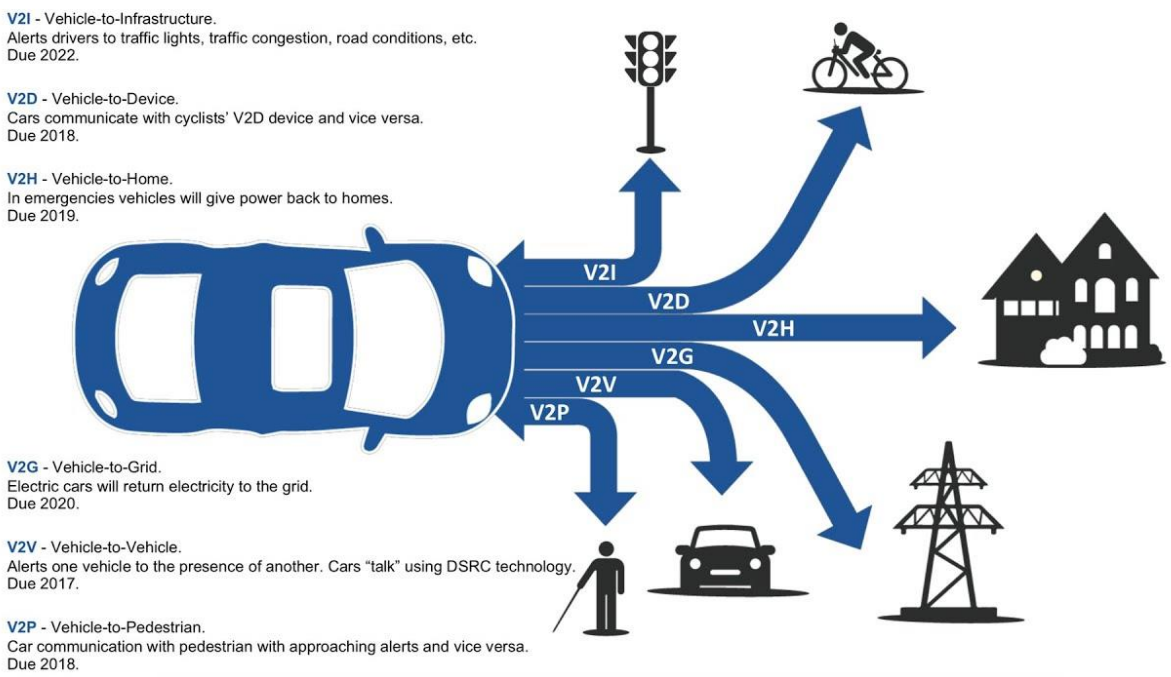

Figure 3. V2V Technologies

The use of Electronic Toll Collection (ETC) or contactless intelligent payment systems on highways has a positive effect on travel time efficiency.

The following systems are designed to ensure driver safety:

1. **Driver Monitoring System (DMS)** – detects and warns of the driver's condition such as drowsiness, inattention, or stress. The driver monitoring and attention tracking systems evaluate driver alertness and, if necessary, issue warnings or automatically activate braking as part of the vehicle's safety system.
2. **Automatic Speed Control** – identifies excessive speed using radars and cameras. Autopilot systems form the basis for safe driving in autonomous vehicles. GPS and IoT technologies enable real-time speed monitoring.
3. **AI Dashcams** – record dangerous driver behaviors and transmit real-time data. The AI dashcam system detects braking, obstacles, or potentially dangerous situations and provides early warnings.
4. **Advanced Driver Assistance Systems (ADAS)** – perform automatic braking and control of longitudinal and lateral vehicle movements. ADAS uses cameras and sensors to monitor the surrounding environment. The collected data are processed by software, which provides alerts or intervenes in vehicle operation when necessary.

In addition to improving safety, **intelligent transport systems** enhance logistics and transportation efficiency. They allow for real-time traffic management, automatic selection of the shortest and safest routes, reduction of traffic congestion, and savings in fuel and time.

Telecommunication environment: LAN and WAN highway networks.
Efficient operation of intelligent highways depends on wireless communication, LAN, and WAN networks. These ensure fast data exchange between vehicles and control centers, real-time monitoring via GPS and IoT devices, driver alerts about hazards, and rapid notification of emergency services in case of accidents or malfunctions.

On roadways and within traffic flow monitoring, intelligent systems control traffic density and speed, track road conditions (icing, risk of slipping), and predict possible adverse events (accidents, congestion, weather conditions) in advance.

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Accident data and rapid response systems record incidents through cameras and sensors. Rapid alert systems send signals to emergency services (ambulance, fire, and patrol) when an accident occurs. The "Emergency Call**"** systems allow drivers to make automatic emergency calls directly from the vehicle.

To monitor compliance with traffic regulations, cameras and radars detect speed violations and other offenses; digital databases automatically verify vehicle and driver information; and AI-based analysis identifies causes of violations and develops preventive measures.

Conclusion. Intelligent highways and modern transport management systems not only ensure driver safety but also organize transportation processes efficiently, reduce accidents, and contribute to the digitalization of road infrastructure. In the context of Uzbekistan, large-scale implementation of such projects brings significant economic and social benefits to the transport sector.

Currently, several initiatives are being carried out in our country to introduce these systems. In particular, according to the Presidential Decree of the Republic of Uzbekistan dated July 12, 2022, No. PQ-316, "On the approval of the National Program 'Safe and Smooth Road' for 2022–2026," the main directions for implementation have been defined. The active application of the above-mentioned systems in the automotive industry will help solve many existing problems. Even the prevention of a few road accidents ensures the peace of families, protects human health, and positively affects the national economy.

The sharp increase in traffic flow, the rising number of road accidents, and driver-related errors can be effectively addressed by introducing modern approaches to traffic safety management. From this perspective, Intelligent Transport Systems (ITS) and intelligent highways are considered important innovative solutions in the transport sector. The widespread introduction of such systems not only ensures the safety of drivers and passengers but also increases the efficiency of transport and logistics processes, stimulates economic growth, and serves as a key factor in forming a sustainable transport system.

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