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Using Intelligent Transport Systems as a Tool for Preventing Criminal Offenses

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ABSTRACT
The article examines intelligent transport systems as an effective tool for preventing criminal offenses in the field of road safety. The author analyzes key factors that hinder the development of intelligent transport systems in Ukraine, including outdated infrastructure, lack of funding, regulatory uncertainty and low public awareness. The potential of intelligent transport systems for automating the recording of violations, increasing the transparency of prosecution and reducing the level of accidents is revealed. It is emphasized that the effective implementation of these systems requires updating legal regulation, technical standardization and close cooperation between state and non-state structures.

KEYWORDS
transport infrastructure, road safety, road transport, intelligent transport systems, criminal offenses, prevention.

1. Introduction

In the context of global expansion of transport infrastructure with an annual increase in motor vehicles, the number of drivers and volumes of road traffic are objectively increasing, and the rethinking of the principles of state policy in the field of ensuring road safety is becoming more relevant. Despite constant technical innovations, the car remains and will continue to be a source of increased danger. It should be noted that according to international statistics, unfortunately, Ukraine occupies the first positions in the ranking of European countries in terms of the level of accidents and road accidents with serious consequences: more than 150 thousand such events occur annually [1].

The greatest danger to road users arises due to the following gaps in the existing street and road network: a small proportion of roads built to the highest technical standard; the absence of ring roads around many cities, towns, villages; deficiencies in the arrangement and improper maintenance of facilities for vulnerable road users (children, disabled people, elderly people, cyclists) – sidewalks, bicycle paths, etc.; insufficient share of road sections for safe overtaking; insufficient level of implementation of intelligent transport systems designed for automatic traffic control [2].

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It should be emphasized that achievements in the field of transport are accompanied not only by positive changes, but also by numerous negative consequences. One of the main problems is the high level of human casualties due to road accidents (hereinafter referred to as road accidents), which are caused not only by technical factors, but also by human errors, poor road conditions and imperfect transport systems.

In order to solve these problems, the international transport community has begun to develop new technological solutions, among which the most significant are intelligent transport systems (hereinafter referred to as ITS). In recent years, ITS has become widespread in the strategic, political and program-target documents of developed countries. The development of ITS involves the introduction of modern information and communication technologies and automated systems into the transport infrastructure, vehicles and interaction with their users. They make it possible not only to effectively manage vehicles, but also entire transport systems, including interaction between various road users [3]. The main goal of ITS is to improve the efficiency of transport use, reduce environmental damage, reduce congestion and increase road safety.

One of the key areas of ITS development in world practice is the reduction of road accidents, which is achieved through the implementation of advanced technologies in the field of road traffic management [4]. For example, within the framework of the international program "High-Safety Vehicles", the use of on-board ITS has reduced the number of road accidents by 40 % and fatalities by 50%. These results indicate the importance of ITS in reducing the number of road accidents and saving people's lives [5]. At the same time, as world experience shows, the introduction of such innovative systems into the practical activities of entities authorized in the field of operation of vehicles and the corresponding infrastructure is accompanied by a number of problems of a technical, organizational, legal, technological, and financial nature. This makes it appropriate to consider the prospects for using intelligent transport systems as a tool for the prevention of criminal offenses.

2. Methodology

The research is based on a comprehensive interdisciplinary approach, combining legal analysis, technical evaluation, and comparative assessment of international best practices. The study employs doctrinal legal methodology to examine the normative and institutional framework governing the implementation of intelligent transport systems (ITS) in the context of traffic safety and crime prevention. The empirical component includes the analysis of statistical data on road traffic accidents and criminal offenses related to traffic violations, with a focus on Ukraine and selected EU countries. A comparative method is used to identify the most effective models and technologies applied internationally for reducing traffic-related offenses through ITS. The study integrates system-structural analysis to evaluate the architecture and functionality of ITS components, including their technical, organizational, and informational subsystems. Content analysis is applied to policy documents, strategic programs, and technical reports to identify implementation gaps and potential areas for reform. Case studies from EU initiatives such as eCall, SAFESPOT, and ADAS are used to illustrate practical outcomes and transferability of technologies. The methodology also includes elements of forecasting and scenario planning to evaluate the prospective impact of ITS deployment on road safety and legal compliance. The validity of conclusions is ensured through triangulation of data sources, regulatory documents, and expert assessments.

3. Result And Discussion

3.1. General characteristics of intelligent transport systems in road traffic coordination

ITS are intelligent systems that use innovative developments in the modeling of transport systems and the regulation of traffic flows, which provide end users with greater information and safety, as well as qualitatively increase the level of interaction between traffic participants compared to conventional transport systems [6]. This is, in fact, a mixture of developments in the computer sphere, information technology and telecommunications together with knowledge in the automotive and transport sectors. Key ITS technologies appear on the basis of the main developments in these sectors. Therefore, ITS can be defined as an integrated automated system that, using intelligent and innovative methods of organization and management, provides transport industry participants with services for coordination,

planning, information, increasing the levels of safety and efficiency of use of transport networks.
The operational task of ITS is to implement and support the possibility of automated and automatic interaction of all transport entities in real time on adaptive principles. The key in the construction of ITS is the complex of road transport, transport and technological, transport and service and information infrastructure. In fact, this complex is presented as a set of subsystems, which provides the function of dispatching, operational and situational coordination of the interaction of the involved services, departments and other entities. To organize such interaction, it is necessary to create regional dispatch centers.
ITS road traffic management is a class of transport systems that ensure sustainable, efficient, economical and safe operation of transport in the street and road environment by providing active elements of the transport system with the properties of adaptive (intelligent) behavior. They are characterized by a complex architecture, which consists of many functional capabilities and the integration of various types of technologies and technical solutions.
An important feature of ITS is their modular structure, which makes it possible to implement individual elements in stages and focus on those that are most important in the given conditions. Within each system, it is possible to distinguish functional subsystems that will be responsible for performing certain tasks. The effective functioning of the entire system depends not only on direct influences on it, but also on cooperation between subsystems [7]. Of particular importance is ensuring road safety through automatic detection and prevention of emergency situations, as well as improving transport efficiency in conditions of increasing demand for transport services [8].
In world practice, there are examples of successful implementation of similar projects. For example, in the EU in 1991, the European Association of Intelligent Transport Systems Market Participants (ERTICO) was created, which is a consortium that includes all leading European manufacturers interested in the development of the ITS market, public organizations, representatives of various ministries and departments, infrastructure communication operators, users and other organizations [9].
Despite the fact that ERTICO was created with the participation of the European Commission and the Ministries of Transport of the EU member states, it is a non-governmental public institution that ensures the implementation of political decisions made by the EU countries in the internal and external markets. The main goal of ERTICO is to develop various programs aimed at the development of European innovative technologies in the field of road infrastructure development, the use of ITS for the purpose of road traffic management, increasing the mobility of the population and cargo, improving the quality of life of people, increasing road safety and reducing the harmful impact of motor vehicles on the environment.
Only the list of ERTICO programs implemented in recent years allows us to judge the contribution of this organization to ensuring road safety in the countries of the European Union:
– Advanced Driver Assistant Systems Interface Specification (ADASIS) – the use of accurate cartographic data in navigation aids to allow the driver to obtain a forecast of the situation on the road while driving;
– Adaptive Integrated Driver (AIDE) – the use of special electronic equipment and software that allows the driver to concentrate his attention at the time of overtaking and turn off the functions of the instruments in the car cabin that distract attention during a complex maneuver;
– The European Road Transport Research Advisory Council (ERTRAC) – a program for coordinating the interaction of European research institutes in the road and transport complex to structure and optimize research work in the interests of the European Union countries;
– eSafety Forum – a European program for the mass implementation of active and passive safety systems, which includes work for the eCall project (emergency call), the creation of electronic maps for use by emergency services, studying the effectiveness of various channels for transmitting information from the car to the operator’s dispatch center, cooperation with participants in the American, Japanese and other telematics services markets to develop priority tasks and international standards for providing emergency assistance to victims of road accidents, harmonization of technical solutions for transmitting information between vehicles and to road infrastructure, organization of informing road users in real time about the situation on the roads via a special radio channel;

– Global System for Telematics (GST) – creation of a technological platform for the development of cooperation necessary for the development of a mass market of open telematic services, primarily providing the collection, transmission, and processing of information for users – road users, ambulance and rescue services;
– HeavyRoute – a program to support fast and safe freight transportation;
– IP PREVENT – a program for the introduction of special electronic devices (Advanced Driver Assistance Systems (ADAS) that allow the driver to receive preventive information about possible dangers while driving and avoid emergency situations;
– MAPS & ADAS (IP PREVENT) – the use of electronic maps to improve road safety;
– SAFESPOT – a program to support the deployment of more "smart" vehicles on "smart" roads;
– SpeedAlerl Forum – informing drivers about compliance with the established speed limit;
– European Security Partnership for the 21st Century (ESP21) – a program for the formation of a comprehensive approach to ensuring a fair, legal, free and safe life in Europe;
– Application of Galileo in the Location-Based Service Environment (AGILE) – a program to ensure the commercial use of the Galileo satellite system;
– Cooperative transport-infrastructure systems (CVIS) – program for the interaction of cars and road infrastructure;
– European Network on ITS Training & Education (ENITE) – program for training ITS specialists;
– EuroRoadS – program for creating a database on European road infrastructure;
– FRAME Forum – program for building an architecture for European ITS;
– Road Charging Interoperability (RCI) – program for the development of toll roads;
– Road Traffic Information Group – program for the development of information support for road users;
– Traffic Message Channel (TMC) Forum – program for informing road users about the real road situation via a specially allocated radio channel;
– CONNECT, SIMBA – national and international programs for the development of the ITS market. Includes programs in Central and Eastern European countries, Brazil, India, China, South Africa and many others;
– Network of National ITS Associations – program for the development international network of ITS Associations [10].

3.2. Technical characteristics of individual intelligent transport systems used in road transport infrastructure

Today, active safety enhancement systems are widely used in cars and trucks [11]. These include stability enhancement systems such as ABS (anti-lock braking), ESP (electronic stability control) – increasing lateral stability), Brakeassist – emergency braking assistance system, as well as systems such as adaptive cruise control (ACC) – adaptive cruise control, forward collision warning (FCW) – collision warning system, lane departure warning (LDW) – lane keeping system, blind spot detection (BSD) – blind spot detection systems.
The Blind Spot Information System (BLIS) (Volvo) [12] consists of 25-frame-per-second cameras mounted on the exterior rearview mirrors and a computer that detects objects entering these zones, each measuring 3 x 9.5 m. In the event of a dangerous approach, the system lights up a yellow LED in the passenger compartment - next to the right or left mirror, respectively. In Japan, pedestrians and cyclists are involved in half of all road accidents. These incidents occur mainly when pedestrians are in the blind spot or on narrow roads and intersections, when their visibility is limited by the driver. Nissan Motor Co., Ltd and NTT DoCoMo, Inc. conducted a study of a system, which determined the position of a pedestrian using a mobile phone equipped with GPS navigation, as well as the position of a car with a navigation system and warned the driver about the presence of pedestrians near the route of movement. A cellular communication system was used to transmit signals. The server receives signals from mobile phones, cars, calculates their mutual position and transmits the processed data to the car's navigation system, warning the driver. The driver receives a warning on the display and a voice message about the presence of a pedestrian.
Driver assistance systems for safe driving DSSS: Driving Safety Support Systems help vehicle drivers

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to obtain information [13], which can be difficult to perceive in difficult traffic conditions (traffic signals, road signs). This information can be transmitted to the car from the road and transport infrastructure using modern ITS technologies.

The Smartway system reduces the possibility of accidents on expressways. The system uses sensors, road-to-vehicle communications and other modern ITS technologies [14] to warn drivers about traffic jams and accidents on the road.

The road sign recognition system works as follows: a special video camera processes the image in front of the car, recognizes road signs and projects the image of the speed limit sign onto the windshield [15] of the car using a "virtual display".

Night vision – the night vision system makes it possible to provide good visibility at dusk and in the dark based on the most modern technical solutions. The basis of such systems are thermal cameras [16], which instead of an optical signal capture data on the temperature of objects. It has been proven that these systems are capable of reliably recognizing a pedestrian, an animal or other living obstacles. Video information and its processing will certainly be the basis of the future concept of an intelligent car. Currently, video information processing methods are not at such a level that everything can be displayed in real time. But given the speed of technology development, it can be assumed that such systems will be standard equipment in cars within a few years.

The night vision system with the function of detecting pedestrians Night View by Toyota in poor visibility conditions [17] provides the driver with the opportunity to see pedestrians, obstacles and the condition of the road in front of the car. Special infrared light sources illuminate the road in front of the car with rays invisible to the eye. The images reflected by infrared rays are processed in an infrared camera and displayed on an LCD display. If a pedestrian is 40-100 m away, his image is highlighted on the display with a yellow flashing frame.

The Pre-crash Safety System uses millimeter-wave radars and cameras. The radar scans the space in front of the car, and the electronic unit calculates the speed of approaching the obstacle [17] (the leading car). When the safety distance is violated, the system warns the driver and, if necessary, activates the braking system. If a collision is inevitable, the system activates the seat belt pretensioners, other car systems may also be activated to reduce possible damage in the event of an accident. Systems with several radars are emerging that scan the space not only in front of the car, but also on the side exits to the intersection, warning of the possibility of a frontal-side collision. The radar installed at the rear activates the control of the seats in the car, setting them in the safest position to reduce the severity of the consequences of a possible accident with a vehicle approaching from behind.

Many accidents can be prevented or the damage caused can be reduced by simply upgrading the road infrastructure. At the same time, making roads safer requires providing safer vehicles for the public, and continuing to improve driver training to ensure readiness for the use of the latest passive and active safety features. New educational programs in European countries aim to comprehensively develop drivers, from knowledge of vehicle design to "internal driving confidence." This will create a qualitatively new generation of drivers [18]. For example, Germany signed a Declaration of Intent presented by the European Commission to introduce an automated emergency call system (e-Call), as part of cooperation in the implementation of an automated emergency assistance system that is uniform throughout Europe. The automatic emergency call system in passenger cars, which makes an electronic emergency call in the event of an accident, is intended to extend the current safety technology in cars. By using injury prediction as part of the automated emergency call system, the efficiency of rescue operations can be increased, thereby increasing the likelihood of survival of victims who are seriously and critically injured [18].

Unlike conventional driver assistance systems, cooperative systems use information that they receive directly or indirectly from other vehicles. For example, if a car is involved in an accident or the driver applies emergency braking, a warning message can be sent to vehicles behind. With oncoming traffic, such a message can even be sent to vehicles moving in the opposite direction to the original one, to give drivers who are approaching a dangerous area an advance warning [18].

It is quite clear that in the context of borrowing the experience of foreign countries, it is worth conducting research into the impact of various elements of road infrastructure on road traffic, detailed diagnostics of hazards for all types of accidents, along with assessing the effectiveness of various measures to improve safety, as well as studying the impact of the use of intelligent transport systems on the level of road safety and predicting the effectiveness of the implementation of such measures.

3.3. Prospects for the introduction of intelligent transport systems in Ukraine to prevent criminal offenses in the field of road safety

The development of ITS creates new opportunities for improving road safety, reducing the harmful impact of transport on the environment and rational use of resources, is a significant tool for the prevention of criminal offenses. This is an important step towards creating a sustainable and safe transport system, which is an important component of the country's socio-economic progress, as well as a step for the development of modern transport infrastructure in the future [19].

Today, in Ukraine, there are separate information systems that solve certain technological tasks, but they are limited in their capabilities due to the lack of unified standards and regulations for their integration into the general transport management system. Therefore, it is important to create a single platform that would allow for effective management of transport flows at all stages of their operation. The creation of such a platform will provide more effective forecasting of road situations and will allow making operational decisions based on the analysis of all indicators of the transport complex. It is especially important to ensure road safety by automatically detecting and preventing emergency situations, as well as improving transport efficiency in the face of growing demand for transport services [20].

The reformulated text in a scientific and official style with a similar volume:

The key problems that hinder the development of ITS in Ukraine include the following:

Insufficient development of transport infrastructure. In a number of regions of Ukraine, there is obsolescence or an insufficient level of development of transport networks, which significantly complicates the effective implementation of ITS. To ensure their functionality, a phased update, modernization and expansion of infrastructure elements is necessary.

Limited financial support. The deployment and implementation of ITS requires significant investment costs. In conditions of limited budget resources, in particular during the period of martial law, the implementation of such projects is complicated by the lack of sufficient state and private funding.

Imperfection of regulatory and legal regulation. The existing legislative framework does not contain clearly defined regulations on the functioning of ITS. This necessitates the creation of an appropriate regulatory environment, including the development of special technical regulations, standards and certification procedures.

Low level of public awareness. A significant part of citizens does not have proper information about the functional advantages of ITS, which reduces the level of public demand for their implementation. A systematic information and educational campaign is necessary to increase the level of understanding and perception of ITS technologies among a wide range of users.

Challenges of technological adaptation. Intelligent transport systems are based on the use of high-tech solutions that require specialized knowledge and qualified personnel. Therefore, an important task is to ensure access to appropriate technical education, training and technical support.

Insufficient involvement of the private sector. The active participation of the business environment in the process of digitalization of transport infrastructure is of strategic importance, however, existing barriers of an institutional and economic nature hinder the development of public-private partnership. It is necessary to ensure favorable legal and financial conditions for investment by commercial structures.

Lack of unified technical standards. The lack of unified technical protocols and solutions in the field of ITS creates difficulties for the integration of heterogeneous systems and limits the possibilities of data exchange. It is necessary to develop and implement national standards, consistent with international practices, to ensure the interoperability of ITS.

The problem of economic efficiency. The development and implementation of ITS must be justified from an economic point of view, taking into account the cost, expected efficiency and stability of the implemented solutions. Conducting a feasibility study should become an integral part of the development of each project.

International integration and scientific and technological partnership. Successful development of ITS in Ukraine is possible only if broad international cooperation is established, which involves harmonization of national standards with international ones, active participation in innovation projects and involvement of domestic scientific institutions and industrial enterprises in this process. This will allow for effective integration of the latest technologies into the national transport system.

Thus, overcoming the above problems requires a comprehensive approach, including institutional modernization, technological adaptation, regulatory support and strategic interaction with international partners.

4. Conclusions

Intelligent transport systems are one of the innovative, potentially effective tools for reducing road accidents and preventing criminal offenses related to violations of traffic rules and vehicle operation, which is achieved through the implementation of advanced technologies in the field of road traffic management.

The main problems hindering the development of intelligent transport systems in Ukraine in the context of preventing road accidents are outdated transport infrastructure, insufficient funding and lack of clear regulatory regulation. Also important are the low level of public awareness of the advantages of intelligent transport systems, the lack of qualified personnel and the lack of technical standardization. Taken together, these factors hinder the introduction of modern technologies that can significantly reduce the accident rate on highways. The prospects for the introduction of intelligent transport systems to prevent criminal offenses in the field of road safety are significant, but depend on a number of conditions. First of all, these systems can significantly increase the efficiency of traffic control by automatically detecting violations of traffic rules, in particular, speeding, driving at a prohibited traffic light signal, crossing a solid marking line, etc. The use of video surveillance systems, automatic license plate readers and data analytics allows for the prompt identification of offenders and minimizes the human factor in law enforcement activities. In addition, intelligent transport systems create the opportunity to form a single electronic database of offenses, which increases the transparency of prosecution and makes it impossible to avoid punishment. In the long term, this will contribute to the formation of a preventive effect, reducing the level of criminal manifestations in the road sector and increasing the general level of legal awareness of road users. At the same time, the realization of the potential of such systems requires adequate funding, updating the regulatory framework and effective interdepartmental coordination.

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