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PROSPECTS AND OPPORTUNITIES FOR USING FOREIGN EXPERIENCE FOR THE DEVELOPMENT OF INTELLECTUAL TRANSPORTATION SYSTEMS IN UKRAINE

Sergiy Gritsenko, Iryna Vinichenko. «Prospects and opportunities for using foreign experience for the development of intellectual transportation systems in Ukraine». *The study aims to determine the prospects and possibilities of using foreign experience for the development of intelligent transport systems in Ukraine. The article deals with the history of the emergence of intelligent transport systems in the world. We have investigated the prerequisites and promising directions for developing the global market of intelligent transport systems: traffic management, road safety, and supervision; cargo management; automotive telematics; parking management; automated vehicles. The main players in the field of business in this market have been identified. It is systematized for the adaptation of countries that are developing due to the features of the European ITS architecture, the US ITS architecture, the Japanese national ITS architecture, which are designed to improve the lives of citizens. Variants of using information and navigation systems in the framework of European projects on the example of cities are proposed. In the example of the European Union, the stages of implementation of the ITS architecture are considered, and how this affects the congestion of roads in large cities. The creation of a unified architecture of ITS allows you to control: the level of transport safety in transport and road traffic; energy consumption and environmental impact; networks of logistics systems for passenger service and cargo handling; management of transport, road construction, and repair works, parking places, collection of road tolls, equipment for improving personal services of road users. We have substantiated the necessity of using an integrated approach to improve the digitalization and intellectualization of transport systems, taking into account their advantages and disadvantages, has been substantiated. Conceptual approaches to the digitization of transport are generalized, closely related to logistics IT systems and the network of local roads. The theoretical basis of the level of intellectualization of the Ukrainian transport systems in comparison with foreign ones has been studied, the expediency of the possibility of developing this sphere in Ukraine with the implementation of the project "Transparent infrastructure" has been proved. The organizational and economic principles of the use of intelligent transport systems of the countries of the world for solving a wide range of problems have been determined: transmission of information in real-time for travelers, namely, traffic*

schedules, information on delays; entrance fee for the passage of vehicles to the area of the city; accident management; an electronic collection of duties. The legislative framework and the National Transport Strategy of Ukraine for the period up to 2030 are considered. The real results of the development of transport systems that are already being implemented in Ukrainian cities are displayed. A network of "smart roads" will be built in Ukraine. To implement this task, high-quality fiber-optic communications are needed, which will pass along the roads, which will allow the introduction of intelligent transport systems. The use of the world's leading experience in the implementation of intelligent transport systems is strategic for Ukraine, determines its competitiveness in the world market, and meets the requirements of integrating the national transport network into the Trans-European transport network.

***Keywords**:* intelligent transport systems, transport strategy, innovations, automated control systems, traffic jams.

Сергій Гриценко, Ірина Вінніченко. "Перспективи та можливості використання зарубіжного досвіду для розвитку в Україні інтелектуальних транспортних систем". *Метою дослідження є визначення перспектив та можливостей використання зарубіжного досвіду для розвитку в Україні інтелектуальних транспортних систем. У статті розглянуто історію виникнення інтелектуальних транспортних систем у світі. Досліджено передумови та визначено перспективні напрямки розвитку глобального ринку інтелектуальних транспортних систем: управління дорожнім рухом; дорожня безпека та нагляд; управління вантажами; автомобільна телематика; управління паркуванням; автоматизовані транспортні засоби. Ідентифіковано основних гравців у сфері бізнесу на цьому ринку. Систематизовано для адаптації країн, що розвиваються, особливості Європейської архітектури ІТС, архітектури ІТС США, японської національної архітектури ІТС, які покликані служити для поліпшення життя містян. Запропоновано варіанти використання інформаційно-навігаційних систем у рамках європейських проектів на прикладі міст. На прикладі Європейського Союзу розглянуто етапи імплементації архітектури ІТС, так як це впливає на завантаженість доріг у крупних містах. Створення єдиної архітектури ІТС дозволяє контролювати: рівень безпеки перевезень на транспорті та дорожнього руху; обсяг споживання енергії та вплив на довкілля; мережі логістичних систем для обслуговування пасажирів та обробки вантажів; управління транспортом, дорожнім будівництвом і ремонтними роботами, місцями паркування, збором дорожньої плати, обладнанням для поліпшення персональних сервісів учасників дорожнього руху. Обґрунтовано необхідність використання комплексного підходу до удосконалення системи діджиталізації та інтелектуалізації транспортних систем з урахуванням їх переваг та недоліків. Узагальнено концептуальні підходи до оцифровки транспорту, які тісно пов'язані з логістичними ІТ-системами та мережею автодоріг місцевого значення. Досліджено теоретичне підґрунтя рівня інтелектуалізації українських транспортних систем в порівняні з зарубіжними, доведена доцільність можливості розвитку цієї сфери в Україні з впровадженням проекту «Прозора інфраструктура». Визначено організаційно-економічні засади використання інтелектуальних транспортних систем країн світу для вирішення широкого кола проблем: передача інформації в режимі реального часу для мандрівників, а саме розкладу руху транспорту, інформації про затримки; вступний внесок на проїзд транспортних засобів у район міста; управління аваріями; електронне стягнення мита. Розглянуто законодавчу базу та Національну транспортну стратегію України на період до 2030 року та відображено реальні результати розвитку транспортних систем, які вже впроваджуються в українських містах. В Україні будуватимуть мережу «розумних доріг». Для реалізації цього завдання потрібний якісний волоконно-оптичний зв'язок, який проходитиме уздовж автодоріг, що дозволить впроваджувати інтелектуальні транспортні системи. Використання провідного світового досвіду в області впровадження інтелектуальних транспортних систем має стратегічний характер для України, визначає її конкурентоспроможність на світовому ринку, відповідає вимогам інтеграції національної транспортної мережі в Транс'європейську транспортну мережу.*

Ключові слова: інтелектуальні транспортні системи, транспортна стратегія, інновації, автоматизовані системи управління, затори.

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Сергей Гриценко, Ирина Винниченко. «Перспективы и возможности использования зарубежного опыта для развития в Украине интеллектуальных транспортных систем». *Целью исследования является определение перспектив и возможностей использования зарубежного опыта для развития в Украине интеллектуальных транспортных систем. В статье рассмотрена история возникновения интеллектуальных транспортных систем в мире. Исследованы предпосылки и определены перспективные направления развития глобального рынка интеллектуальных транспортных систем: управление дорожным движением; дорожная безопасность и надзор; управление грузами; автомобильная телематика; управление парковкой; автоматизированные транспортные средства. Идентифицированы основные игроки в сфере бизнеса на этом рынке. Систематизировано для адаптации стран, что развиваются, особенности Европейской архитектуры ИТС, архитектуры ИТС США, японской национальной архитектуры ИТС, какие призваны служить для улучшения жизни горожан. Предложены варианты использования информационно-навигационных систем в рамках европейских проектов на примере городов. На примере Европейского Союза рассмотрены этапы имплементации архитектуры ИТС, так как это влияет на загруженность дорог в крупных городах. Создание единой архитектуры ИТС позволяет контролировать: уровень безопасности перевозок на транспорте и дорожного движения; объем потребления энергии и влияние на окружающую среду; сети логистических систем для обслуживания пассажиров и обработки грузов; управление транспортом, дорожным строительством и ремонтными работами, местами парковки, сбором дорожной платы, оборудованием для улучшения персональных сервисов участников дорожного движения. Обоснована необходимость использования комплексного подхода к усовершенствованию системы диджитализации и интеллектуализации транспортных систем с учетом их преимуществ и недостатков. Обобщены концептуальные подходы к оцифровке транспорта, которые тесно связаны с логистическими IT-системами и сетью автодорог местного значения. Исследована теоретическая основа уровня интеллектуализации украинских транспортных систем в сравнении с зарубежными, доказана целесообразность возможности развития этой сферы в Украине с внедрением проекта «Прозрачная инфраструктура». Определены организационно-экономические принципы использования интеллектуальных транспортных систем стран мира для решения широкого круга проблем: передача информации в режиме реального времени для путешественников, а именно расписания движения транспорта, информации о задержках; вступительный взнос на проезд транспортных средств в район города; управление авариями; электронное взыскание пошлины. Рассмотрена законодательная база и Национальная транспортная стратегия Украины на период до 2030 года и отображены реальные результаты развития транспортных систем, которые уже внедряются в украинских городах. В Украине будут строить сеть «умных дорог». Для реализации этого задания нужна качественная волоконно-оптическая связь, которая будет проходить вдоль автодорог, что позволит внедрять интеллектуальные транспортные системы. Использование ведущего мирового опыта в области внедрения интеллектуальных транспортных систем имеет стратегический характер для Украины, определяет ее конкурентоспособность на мировом рынке, отвечает требованиям интеграции национальной транспортной сети в Трансъевропейскую транспортную сеть.*

Ключевые слова: интеллектуальные транспортные системы, транспортная стратегия, инновации, автоматизированные системы управления, пробки.

Introduction. The use of information systems in traffic management is associated with the rapid development of modern cities, increasing the number of rolling stock on the streets, new routes, and others. As a result, the amount of information needed for analysis and operational decision-making has grown significantly. The information component has become an integral part of urban life. Therefore, computers and special programs came to the rescue in this area. When organizing and regulating the work of land transport, means of communication and computer control are used. The level of use of information systems in Ukraine is shallow. Further development of urban transport is

not possible without computer technology, namely without intelligent transport systems (ITS). Many cities relied on the experience of developed countries in planning and implementing ITS. However, cities can develop their own approaches that match their own unique characteristics. They have a unique opportunity to use someone's experience and make a short leap forward to use it more effectively. Therefore, it is necessary to form new approaches to understanding intelligent transport systems and study ITS's phenomenon as an economic resource of transport users in the provision of transport services in cities, the development of regional industrial and logistics infrastructure.

The purpose and objectives of the study: to analyze the global intelligent transportation system; to analyze the global and regions market potential and to substantiate the advantage, opportunity, and challenge, restraints, and risks; to analyze the prospects of development in the Ukrainian market intelligent transport system.

Basic material and results. The transport system has a complex, multifactorial, non-stationary flow processes (passenger, material, information, financial), which require research, description, and subsequent optimization based on the use of analytical modeling, adapted to logistics administration [1].

The increase in cities has led to a rapid increase in passenger traffic. The needs of people to move are usually unpredictable, so planning, and in particular forecasting passenger traffic, is one of the most challenging tasks in transport.

ITS is essentially a mix of computers, information technology, and telecommunications with knowledge in the automotive and transportation sectors. Key ITS technologies are emerging from significant developments in these sectors. Thus, ITS can be defined as the application of computer, information, and communication technologies to manage vehicles and networks in real-time, including the movement of people and goods.

ITS covers all functional components: traffic management, commercial vehicle management, vehicle monitoring and control, transit management, emergency services, driver and passenger services, electronic payment services, data archiving, and maintenance and construction management [2].

The global market for intelligent transport systems by 2026 may reach about 78 billion dollars. USA, and in the forecast period from 2019 to 2026 it will grow with an average annual growth rate of about 12%.

The origin of intelligent transportation systems dates back to the 1960s when the Electronic Route Guidance System was developed in the U.S. However, the ITS World Congress in Paris in 1994 accelerated the development and deployment of intelligent transportation systems to enhance the traffic control systems across the globe. Since then, numerous ITS applications have been developed by various organizations worldwide and customized as per specific needs. It has become a global phenomenon, garnering attention from the automotive industry, transportation professionals, and political decision-makers alike. While the conventional ITS stage was focused on creating a technical foundation, the present stage is characterized by the development of feasible ITS products.

Global Intelligent Transportation System Market can be divided into such directions: Traffic Management, Road Safety & Surveillance, Freight Management, Road User Charging, Parking Management, Automotive Telematics, Automated Vehicles.

Key market players operating in the global intelligent transportation system market include WS Atkins PLC, Siemens AG, Thales Group, Nuance Communications Incorporation, Garmin International Inc., Hitachi Ltd., EFKON AG, Iteris Inc., Telenav Inc., TomTom NV [3].

The development of European ITS architecture results from two projects funded

by the European Commission – KAREN (started in 1999) and FRAME [4]. The first European ITS Framework Architecture was produced in November 2000 by the KAREN Project, funded by the European Commission. EU Member States are currently using the European Framework Architecture as a basis for the development of their local, regional, and national ITS architectures. The purpose of the FRAME Projects, launched in the Summer of 2001, is to refine the first version of the Framework Architecture and provide support to its development and application. The aim is to give active assistance to all EU Member States (and applicant countries) wishing to develop their own architectures and to provide an opportunity for them to exchange experience [5].

Frame project includes initial ideas of European ITS framework architecture with the following documentation: European ITS functional architecture; European ITS physical architecture; European ITS communication architecture; European ITS cost-benefit analysis; European ITS implementation study; ITS implementation model [6].

The European ITS Framework Architecture is designed to provide a flexible framework that individual countries can tailor to their requirements. National ITS Architecture projects based on the European ITS Framework Architecture, such as ACTIF (France), ARTIST (Italy), TTS-A (Austria), and TEAM (Czech Republic), therefore have a common approach and methodology. Still, each has been able to focus on local importance aspects and develop them in more detail [7]. The project frame has continued as the E-FRAME FP7 project. There are significant differences between approaches in designing the ITS architecture. US ITS Architecture is based on the physical viewpoint, European architecture relies mostly on users' needs and functional view, while Japanese national ITS architecture uses object-oriented methodology.

The action plan for ITS deployment can be considered the document that initiated stronger and more focused ITS development in the European Union. Although there was a high level of harmonization in strategic research supported by the European Technology Platforms ERTRAC and ERTICO-ITS, the framework for ITS deployment in road transport was still designed [8]. The action plan's preparation included stakeholders' consultation, workshops, online survey (public debate), and discussion groups.

The use of information and navigation systems within the framework of European projects can be shown in the example of the following cities: Bristol (CONCERT - TFIS for better use of the Park and Ride system); Brussels (CAPITALS - TFIS as part of a superior traffic management system in tunnels on the inner ring of the city); London (CLEOPATRA - Determination of the influence of TFIS in the identification of crash sites on the choice of drivers along with the road network and the efficiency of transport in the network); Lyon (CLEOPATRA - information strategy for TFIS in automatic mode using data obtained from measurements carried out on the road network); Munich (TABASCO - TFIS for Park and Ride); Piraeus (COSMOS - strategy to change the direction of traffic flows in the seaport area); Southampton (EUROSCOPE - integrated crash site identification and parking management); Toulouse (CLEOPATRA - a general strategy for changing the direction of traffic flows); Turin (CLEOPATRA - the TFIS strategy together with the city's traffic management strategy) [9].

Considering the European Union's expertise in the development of transport systems, we must take into account the course of Germany called "Industry 4.0", which is a course of industrial deployment with extensive use of cyber-physical systems. The method of revolutionary development "Industry 4.0", popularized in the European Union, transfers the standardization of transport systems through digitization and the creation of innovative environmentally friendly technologies. There are now two major innovative transformations of EU transport systems:

1. Smart transport through digitalization. This is done with the help of artificial intelligence, namely digital vision and Big Data technologies because it allows you to track and monitor each vehicle that affects the unloading of traffic flows and affects safety and reduces the number of accidents. The digitalization of smart transport is closely linked to logistics IT systems. Because, using modern "cloud" logistics IT-systems, you can not only quickly find a customer, calculate the most cost-effective route, but also choose the associated cargo on the way back.

2. Implementation of ITS (intelligent transport systems) and ITM (intelligent transport networks). The focus of both European and global automotive markets are intelligent transport systems. Already today, many smart solutions are being created, such as even "smart" highways, wherewith the help of transponders, you can quickly adjust the density of traffic flows and make contactless payments for travel on roads. The most famous car manufacturers globally (Audi, BMW, General Motors, Cadillac, Toyota, Google, Continental, Mercedes-Benz, Volvo, Tesla Motors) have been working intensively unmanned vehicle control technologies in recent years [10].

However, the trend of intellectualization and digitalization of transport systems causes specific problems (Table 1).

Table 1 - Advantages and disadvantages of intellectualization and digitalization of EU transport systems

Advantages	Disadvantages
Overall road safety is increased through better control and monitoring	The cost of electric cars is higher than usual
A single integrated system with other control and monitoring services is being created	Payments for violations are reduced and revenues to the state treasury are reduced
Reducing the cost of transportation	Loss of jobs for drivers, controllers, cashiers
Save time due to absence need to drive a car	The issue of cybersecurity is exacerbated
Reducing emissions of harmful substances and improving the welfare of the population	The problem of disposal of electric batteries and their service

All over the world, intelligent transport systems have long been used to solve a wide range of problems, namely:

Transmission of real-time information for travelers, namely the schedule of traffic, information about delays. Objective: To help travelers make a choice in favor of intelligent transport and make public transport more attractive. Examples: Hong Kong, Brisbane, London, and Berlin.

Entrance fee to the city area. Objective: To reduce the demand for vehicle travel and reduce traffic jams throughout the territory, a toll is applied. Public transport is given priority; it uses tax-free lanes. Examples: Stockholm, London, Singapore. Similar technologies are used in different cities in Italy and Norway.

Accident management. Objective: To ensure the central point's operation to reduce the consequences of emergencies on the road and in the public transport system. Examples: Beijing, London, Madrid, Sydney, Singapore.

Freight transport management. Objective: To improve the efficiency of the fleet. Examples: the United Kingdom, the

United States, Japan, Austria, Germany, Switzerland, and Australia.

Electronic payment collection. Objective: Smart cards are used as a form of e-wallet. These cards can be topped up at payment stations (banks, small shops) or online, and then they can be used to pay for goods and services. Examples: London, Bangkok, Kuala Lumpur, Bogota, Hong Kong, Singapore, Madrid. The use of such a volume and input-based access system is planned in Mumbai and Bangalore, India.

Electronic toll collection. Objective: Electronic toll collection (ETC) helps make payment more convenient, requires fewer stops, reduces toll collection costs, and minimizes revenue gains due to corruption compared to manual toll collection systems. Examples: CityLink, Melbourne; highways in Malaysia and toll roads, Brazil.

Security control systems. Objective: Safety control systems are designed to reduce the number of accidents by increasing drivers' attention in unusual road conditions—for example, Europe, China, and the USA [2].

The development of intelligent transport systems in the transport infrastructure of Ukraine has not become widespread. It is more limited to the use of satellite navigation and obsolete traffic control equipment.

Examples of Ukrainian ITS testing began in 2008, in Kyiv, a system such as "Smart Traffic Light" was introduced. In Kyiv, 478 traffic lights were connected to the mobile Internet. They are equipped with an automated control system that can respond to the situation on the road. The essence of the course is to create a "green wave." The use of green waves to control traffic is considered a promising way to reduce delays and emissions.

Kharkiv has progressed further along the path of introducing an intelligent urban transport system in Ukraine. Before the 2012 European Championships, Kharkivpastrans developed several computerization programs: a single road, a GPS navigation system, and a single urban transport system.

In 2011, Kharkiv set a course for a comprehensive GPS navigation system on all public vehicles. From the middle of the year on all mobile phones, Miskelektrotrans the GPS-navigator works. Besides, the transport infrastructure is gradually approaching the creation of a simple transport system in the city, which allows you to efficiently and effectively regulate passenger traffic and respond to any situation on the roads [11].

Today, Ukraine has already developed a National Strategy for the Development of the Transport System in Ukraine until 2030. This document covers the following tasks:

- introduction of new technologies and intelligent transport systems (ITS) to improve the quality of transport services, information systems on services provided, the introduction of electronic and integrated automatic fare payment system;

- creation of a network of multimodal transport and logistics clusters and primary logistics centers, "dry ports," terminals, specialized transshipment complexes, etc. [12].

Also, one of the latest achievements in the field of ITS development in Ukraine is that the Ministry of Infrastructure of Ukraine is initiating a project to digitize the local highway network to collect geo-coordinates of roads, as well as create a separate database and service for local network certification, which will be available to all regional administrations.

Besides, together with TAPAS, the Ministry of Infrastructure works on the project "Transparent Infrastructure." This project will allow for effective on-site monitoring and the formation of automatic reports and visualizations on maps of road repair facilities [13].

In conclusion, we note that the intensive implementation and use of intelligent transport systems for Ukraine should be only with the support of the government and taking into account the following conditions:

1. The real direction of improving the efficiency of the transport system of Ukraine is to ensure greater openness for new transport companies, attract private capital, develop competition in all sectors of transport

(including railway rolling stock), leaving state market regulation only for elements that cannot be eliminated. structures) and which are necessary to ensure an adequate level of transport safety. To do this, it is worth using the experience of other countries to open markets for transport systems for private capital.

2. The state should monitor the efficiency of all modes of transport and prevent asymmetries in competition between them.

3. Analyze the legal system that regulates transport and transport-related construction, environmental and other issues regarding their compliance with international standards.

4. Transport policy should form the basis for local authorities' action on the establishment of integrated public transport systems for the use of intelligent transport systems [14].

5. Intelligent transport systems can be effectively used in a network of multimodal transport and logistics clusters [15, c. 347-350].

Conclusions. The domestic transport system is of international importance, as the transport routes passing through Ukraine connect Asia, Western and Central Europe. Ukraine has the prerequisites for building a transport and logistics system similar to the European one.

Today, the approved National Transport Strategy of Ukraine for the period up to 2030 sets the task of introducing new technologies and intelligent transport systems for unhindered mobility, interregional integration, and improving the quality of transport services. Implementing the provisions of the strategy will make it possible to create an effectively functioning transport complex of Ukraine, taking into account the progressive world experience of development and implementation of intelligent transport systems.

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