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INTELLIGENT TRANSPORT SYSTEMS AS TRAFFIC FLOW MANAGEMENT TOOL (THE CASE OF KYIV)

Abstract. *The low quality of public transport services, the inconvenience of routes, the long duration of trips and several other problems encourage Kyiv residents to increasingly choose a car for everyday correspondence, which, in turn, increases delays, travel time and leads to environmental pollution of territories. These problems are especially acute in large cities, where numerous industrial, labour, and cultural and household connections are within the city. There is a need to create a single efficient transport system that serves as a city and implement effective traffic flow management approaches.*

First of all, the article defines the concepts of "traffic flow management", "urban mobility" and "urban mobility regime". Four groups of problems of urban transport systems were identified and two ways of solving them were formed: extensive and intensive. Using the instrumental case of Kyiv, the level of implementation of systems for monitoring and managing traffic flows in Ukrainian cities was evaluated. The levels of the legal framework regulating the urban mobility of the population in Ukraine are described. The characteristics of intelligent transport systems and their key subject areas have been studied. Commonly accepted services for users of intelligent transport systems (ITS) are distinguished and segmented according to the needs of these system users. Features, methods of application and technologies of intelligent transport systems are presented. Services that are a priority for potential users of intelligent transport systems in Ukrainian cities are highlighted. The world experience of the formation and development of intelligent transport systems, as well as European programs for their implementation, is characterized. A SWOT analysis of the implementation of intelligent transport systems in Kyiv was carried out and recommendations were made for the creation of an ITS implementation program in Kyiv.

The information base of the article consists of publications by prominent Ukrainian and foreign researchers, data from the Tom Tom transport analytics service, the current legal framework of Ukraine, which regulates urban transport systems, and *urban development strategies. The following methods of scientific research are used in the research process: dialectical method; method of scientific abstraction, analysis and synthesis; method of induction and deduction; comparative method; method of systematization and graphic method.*

Keywords: *traffic flow management tool; urban mobility; intelligent transport systems; case study analysis.*

INTRODUCTION

In Ukraine, there are contradictions regarding the harmonization of terminology in regulatory and legislative, urban planning and scientific literature. That is why, to avoid contradictions, this study proposes to define "traffic flow management" as a set of solutions for optimizing traffic flows based on technical, organizational and programmatic measures. To manage traffic flows, intelligent transport systems are used, which allow real-time data collection and processing of information on the road network, including speed of movement, number of vehicles in a certain period, the density of flows, employment of the road network, schedule of public transport, etc.

In 2021, four Ukrainian cities entered the top 25 cities in the world with the most congested traffic. In this rating, Kyiv with transport delays of 56% is in 3rd place, Odesa with 51% is in 6th place, Kharkiv with 46% is in 12th place, and Dnipro is in 25th place with 40% [1]. This indicates shows the necessity for constant research of the problem and finding a scientifically based solution to this issue and the development of further appropriate methodological approaches for the further implementation of a systemic approach to the solution of this problem in the aspect of territory management and urban planning. **The relevance of the research** lies in the search for management and monitoring tools for these processes in cities. Corresponding to evolving but not yet sufficient scientific literature focusing on how dynamism in intelligent transport systems affects urban innovation and how the traffic flow management tool can be activated for the optimum results, it is relevant to analyze urban transport systems as dynamic whole, taking into account four perspectives of urban transport systems problem groups.

Formulation of the scientific problem. The necessity to regulate urban traffic flows in Ukrainian cities is evidenced by several reasons: increasing urbanization levels, increasing delays on the street and road network, low quality public transport services, inconvenient routes, long journey times, etc. These issues are especially acute in the largest cities and encourage citizens to increasingly choose a car for everyday correspondence, which, in turn, increases delays, travel time and leads to environmental pollution of territories.

The concept of urban mobility management encompasses a variety of services, organizational and consulting activities that allow users to change their travel choices.

Analysing the foreign experience of cities, we can conclude that to regulate traffic flows, they use the only effective method of management - intelligent transport systems (ITS). The development of ITS becomes one of the most important tools for increasing the competitiveness of the transport complex and the economy of the city as a whole. In connection with this, there is a need to define the elements and features of the ITS functioning.

General research question: How to enable intelligent transportation systems as traffic flow management tool for urban transport innovation process?

Research methodology. The philosophical orientation of this study is positivism, which leads to a research strategy focused on evidence that supports the solution of a scientific problem, which is developed on the grounds of the existing theory and systemic and comparative scientific literature analysis thus resulting in the deductive research approach and the empirical research based on the qualitative methodological choice (Case Study analysis).

Actual scientific researches and issues analysis. The theoretical basis for this publication was the works of prominent Ukrainian and foreign scientists, such as Balsys K., Eidukas D., Marma A., Valinevičius S, A., Žilys M. (2007), Bespalov D. (2015), Ignatenko O. (2017), Daunoras J., Bagdonas V., & Gargasas V. (2008), Arthur D. (2014), Semenov V., Linnyk I. (2018)

To describe transport delays in Ukrainian cities, data from the Tom Tom transport analytics service [1] were used. The work also uses the current normative and legal framework of Ukraine, which regulates issues of the transport industry [4; 6; 9] and Module 4e – Intelligent Transport Systems, created by the Sustainable urban transport project [10]. However, despite numerous studies, the issue of intelligent transport systems has not been fully investigated in Ukraine.

The aim of this study is to discuss the methods of managing traffic flows using intelligent systems. To achieve this goal, the following **research objectives** were formed:

- to define the concept of "traffic flow management";
- to assess the level of implementation of urban mobility monitoring and management systems in Kyiv;
- to investigate the characteristics of intelligent transport systems, subject areas, methods of application, technologies and services;
- to describe the world experience of the formation and development of intelligent transport systems; and define its influence on the innovation outcomes;
- to develop a SWOT analysis for the implementation of intelligent transport systems in Kyiv,

Research methods. To achieve the objectives, the following methods of scientific research are used in the work: the dialectical method (to identify contradictions in terminology), the method of scientific abstraction (to study the features of social relations that arise during the functioning of intelligent transport systems), the method of analysis and synthesis (for the conditional division of urban transport system into subsystems and determining their interrelationships), induction and deduction method (to study the transport system based on the properties of its subsystems by analysing Case Study), comparative method (to compare the regulatory and legislative framework of different countries), systematization method (to systematize knowledge about object and subject of research), graphic method (for displaying and visualizing the obtained results).

The object of research: traffic flow.

The subject of research: intelligent transport system.

Deriving from the comprehensive analysis of the scientific literature with regard to various theoretical perspectives and empirical findings, some points of analysis were indicated and discussed in this paper.

1. Problems of urban mobility in the largest cities (and Case Study of Kyiv).

Urban mobility is a tool for meeting the citizen's needs between its functional zones for the implementation of connections formed as a result of life activities, with the help of transport service systems or on foot. Key connections can be divided into labour, recreational and cultural and household ones. The system of transport services for the city population is divided into subsystems of public and individual transport.

Depending on the mode of mobility - the way (on foot or by transport) a person gets from the starting point to the final point of movement, mobility can be general or transport. The main modes of mobility are currently: on foot, public transport, bicycle, individual transport and micro-mobility means, but this is a non-exhaustive list. General mobility is called when all these modes are used, and transport is the one that is implemented using the modes "public transport", "bicycle", "individual transport" and "means of micro-mobility".

Modern cities are characterized by the intensity of economic connections, and the need for transport movements of the population is so great that it can potentially be realized only under the condition of comprehensive development of various types of transport and transport communications. For urban planners and designers, this creates a task, the solution of which will affect both the characteristics of the city transport and the development of the city as a whole.

Four groups of problems with urban transport systems can be distinguished:

- the satisfaction of transportation needs;
- increase in economic efficiency;
- improvement of traffic safety;

- reducing the harmful impact on the environment. [3]

Two problems that are most characteristic of the largest Ukrainian cities deserve special attention:

- high dependence of the population on the car (the coefficient of car use is 0.88 [2], in European cities with developed transport infrastructure – 0.3);
- congestion of cities, especially the centers, from private cars (Kyiv ranks 3rd in the ranking of cities with the largest traffic delays [1]).

Analysing the experience of many countries of the world, it is possible to form two ways of solving the problems of urban transport systems:

- extensive (increase in the % of streets and roads about the total area of the city, expansion of the existing street and road network, construction of intersections at different levels, etc.);
- intensive (change of priorities in the urban mobility pyramid (see Fig. 1), creation of new public transport routes and optimization of existing ones, modelling of traffic flows, etc.).

Cities with developed transport infrastructure give priority to pedestrians and people with reduced mobility when planning transport infrastructure. The second priority is public transport, which can move a much larger population than private cars, which does not require parking and has a much lower environmental impact. Bicycle transport, which requires special infrastructure and parking spaces, is also a second priority.

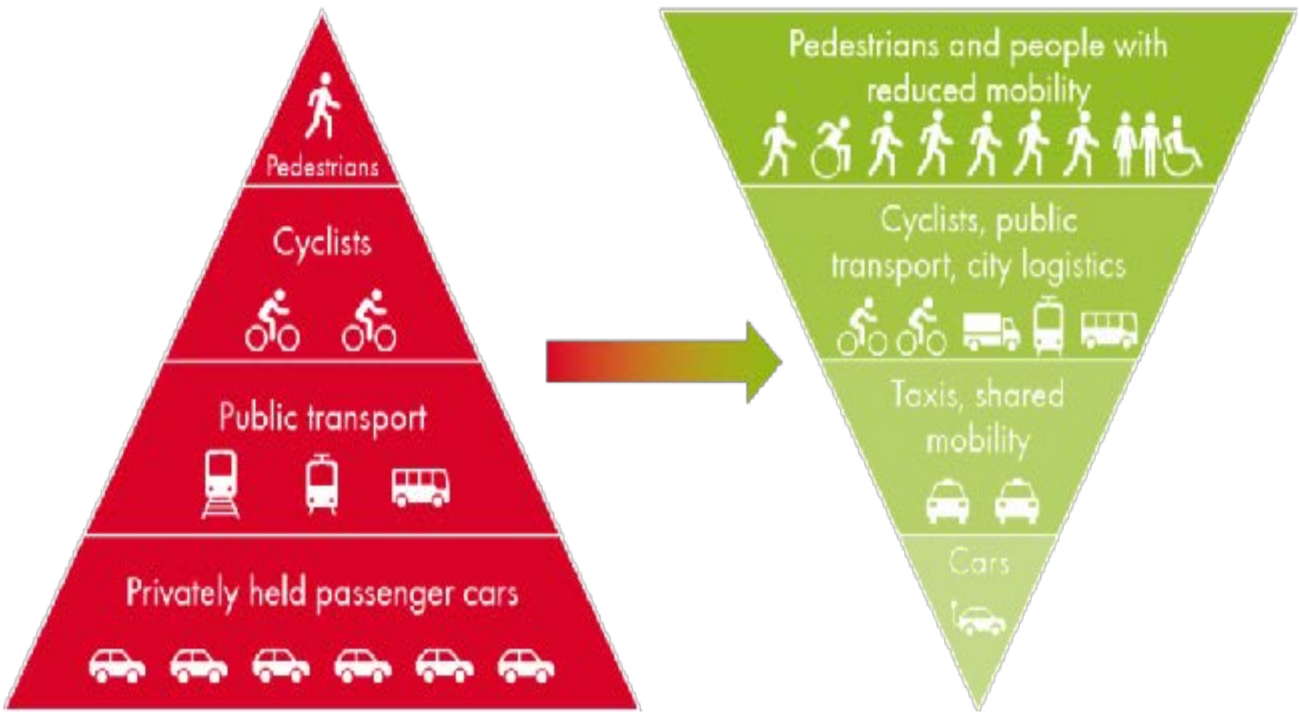

Fig. 1. Changing priorities of urban mobility in cities with intensive development of transport systems (created by Q-park)

It is worth noting that medium-sized (50-250 thousand citizens) and small (up to 50 thousand citizens) cities can pay more attention to the development of the bicycle network than to the public transport network. This is due to the small size of the cities and the compact location of many facilities, which in turn facilitates and encourages cycling. The third priority belongs to taxis, shared mobility and commercial transport, which is a stimulating factor for business. The last position belongs to private and parked cars. They require large areas for storage and maintenance, cause environmental pollution and, despite their greater mobility and comfort, are less efficient.

2. Assessment of the level of implementation of traffic flow monitoring and management systems in Kyiv.

The European Union proposes to solve the problems of urban mobility [11], focusing on the following six directions:

1. Development of an integrated policy, which means rapid implementation of urban mobility measures by the principles of sustainable development.
2. Transport accessibility for all residents (especially for groups with reduced mobility). This also means the availability of information related to transport systems, the implementation of energy conservation campaigns, sustainable development, etc.
3. Increasing the level of environmental friendliness of urban transport, supporting various research and projects that will guarantee the development of sustainable urban mobility.
4. Improvement of the financing process: optimization of existing methods of financing and attraction of new investments.
5. Improving the quality of both the process of obtaining data and the data itself, the creation of monitoring centers with the possibility of accumulating statistical data.
6. Management of urban mobility, coordination of traffic flows.

In many European cities, intelligent transport systems (ITS) are used to monitor and manage urban mobility. ITS is a combination of innovations in the computer field, information technologies and telecommunications together with knowledge in the automotive and transport fields. It is based on the main developments in these areas that key ITS technologies appear. The German Association for International Cooperation (GIZ) defines ITS as "the application of computer, information and communication technologies for the management of vehicles and networks in real-time, including the movement of goods and people." [10]

In Ukraine, there is almost no regulatory framework in the field of urban mobility monitoring and management. Important changes took place in 2018 in the state building regulations of Ukraine, after which concepts such as "transport modelling", "transport calculations", "number of population movements" and "simulated transport models" appeared in the regulatory base. It was these changes that made it possible to simulate the situation on all elements of the city's street and road network with the help of modern software. At the same time, it is worth noting that Ukrainian legislation does not yet have requirements for the performance of transport modelling itself, and therefore there is a risk of poor performance, and during use - of making decisions that will worsen the transport situation in cities.

Also, there are no mentions of the need for monitoring and further management of traffic flows in real-time. And this issue is broad and covers navigation maps, implementation of a single digital cartographic basis, transport monitoring system, etc.

The regulatory framework regulating the issue of urban mobility of the population can be divided into:

- local: master plans of the city, detailed plan of territories, comprehensive scheme of traffic organization, concepts, strategies and programs;
- regional: programs and strategies of regional development;
- national: strategies (Sustainable Development Strategy "Ukraine - 2030", National Transport Strategy of Ukraine for the period until 2030, State Strategy for Regional Development for the period until 2030), urban planning documents (General Scheme of Planning the Territory of Ukraine), state programs (State Program for the level of road traffic safety in Ukraine) and state regulatory acts (laws, SBR, NSU);
- international: the Agreement on the Association of Ukraine with the EU, the Leipzig Charter "European Cities on the Path to Sustainable Development", the UN Framework Convention on Climate Change, the New Urban Development Program and the resolution "Transforming our world: Agenda for sustainable development until 2030. [12]

Another important aspect of the implementation of intelligent transport systems is the training of experts in this field, who need to be able to solve the problems of optimizing the distribution of traffic flows on the street and road network and dynamically direct routes. It is also necessary to evaluate strategies for the organization of road traffic, taking into account the requirements of traffic safety, environmental indicators and the existing state of the street and road network.

From the experience of the leading countries of the world, we can conclude that the implementation of ITS requires systematic coordination, in which all executive authorities and leading scientific organizations participate. In the countries of Western Europe, the USA and Japan, ITS development programs are accepted for a period of 5-10 years.

In Ukraine, intelligent transport systems began to be used on a point-by-point basis only in Kyiv.

Today, the busiest intersections of Kyiv are already analysed by 31 cameras with ITS. This is the intersection of st. Baseinoi, str. Mechnikova, Lesya Ukrainka Boulevard and St. Leo Tolstoy; European Square and Victory Square.

With the help of ITS in Kyiv, it is planned to reduce traffic delays and improve the efficiency of public transport. The intelligent transport system analyses data from cameras and adjusts traffic flows for the most effective unloading of the street and road network and high-quality organization of public transport. It is planned that this system will be able to send notifications to communal services or the Patrol Police of the city of Kyiv to reduce the response time to traffic accidents and road obstacles.

In total, more than a thousand cameras are connected to the traffic load forecasting analytical module.

The analysis of the complex traffic scheme in Kyiv is carried out together with foreign experts. One of the key goals is to optimize the management of traffic light objects.

3. Research of the characteristics of intelligent transport systems.

Traffic flows have been regulated by ITS for more than 80 years. There have been attempts to control traffic signals at intersections and railroad crossings in Europe and the United States. Currently, advanced technologies are used for large transport systems, as well as for informing passengers about the arrival of certain types of transport.

The operational goal of ITS is to perform and support the function of automatic and automated interaction of all transport entities in real time on flexible principles.

Road transport, transport service, transport technology and information infrastructure are the basis for the construction of ITS. This complex is represented by a set of subsystems, which are entrusted with the functions of dispatching, situational and operational coordination of interactions between services, departments and other subjects. Dispatch centers should be created to organize this interaction.

The creation of ITS is impossible without the development and implementation of several solutions for creating a communication environment. This environment should be designed for both cable (high-speed fibre optic networks) and wireless (radio and trunking, Internet, cellular) types of communication.

The decision to design, build or expand ITS should be based on the scientific principles of determining and monitoring performance indicators of ITS subsystems in the system of needs of the region, as well as consumers of information and other services provided through ITS. Also, with the help of these data, the costs of maintenance and reconstruction of the existing street and road network, as well as the construction of new areas, can be substantiated.

Table 1 lists the largest European IT programs.

Table 1

European ITS implementation programs

(created by the authors of the paper by adapting [10])

ERTICO	The European Association of ITS Market Participants, which brings together leading manufacturers interested in the development of the ITS market, ministries and agencies, a number of public organizations, infrastructure communication operators, and users. ERTICO is a non-profit organization created with the participation of the European Commission and the Ministries of Transport of the EU member states. The main goal of the creation of ERTICO is the implementation of political decisions for the development of ITS in the domestic and foreign markets.
ADASIS (Advanced Driver Assistant Systems Interface Specification)	The use of accurate map data in navigation tools for the driver to obtain a forecast of the situation on the road.
E-Call (Emergency Call)	System of emergency response to traffic accidents. Since 2010, in the EU countries, it is mandatory to equip all cars with telematics units with an alarm button
IP PReVENT	The program for the implementationof special electronic devices (ADAS - Advanced Driver Assistance Systems), which allow the driver to receive preventive information about possible dangers in advance and avoid emergency situations.
AIDE (Adaptive Integrated Driver-Vehicle Interface)	The use of special software and electronic equipment that allows you to concentrate the driver's attention at the moment of overtaking and disable the functions of devices in the car interior that distract attention during a difficult maneuver.
ERTRAC (The European Road Transport Research Advisory Council)	The program for coordinating the interaction of European research institutes in the road and transport complex with the aim of structuring and optimizing research works for the benefit of the countries of the European Union.
GST (Global System for Telematics)	Creation of a technological platform for the development of cooperation necessary for the development of a mass market of telematics services that provide collection, transmission and processing

	of information for users - participants in road traffic, ambulance and rescue services.
FeedMAP	Ensuring constant updating of electronic maps for navigation.
SpeedAlert Forum	Informing drivers about compliance with the established speed regime.
ESP21 (European Security Partnership for the 21st Century)	The program of forming a comprehensive approach to ensure a fair, legal, free and safe life in Europe.
ENITE (European Network on ITS Training & Education)	Program for training specialists in intelligent transport systems.
RCI (Road Charging Interoperability)	Toll road development program.
Road Traffic Information Group	Program for the development of information support for road users.
eSafety Forum	The European program for the mass implementation of active and passive safety systems, which includes work on the eCall ("emergency call") project, the creation of electronic maps for use by emergency services, the study of the effectiveness of various information transmission channels from the car to the operator's dispatch center, cooperation with the participants of the American, Japanese and other markets of telematics services, in order to develop priority tasks and international standards for providing emergency assistance to victims of road accidents, harmonization of technical solutions regarding the transmission of information from car to car or from car to road infrastructure, organization of informing road users in real time time about the situation on the roads through a special radio channel.
FRAME Forum	Program to build an infrastructure for the EU ITS.
HeavyRoute	Quick and safe support program cargo transportation.
EuroRoadS	The program for creating a database on European road infrastructure.
AGILE (Application of Galileo in the LocationBased Service Environment) SISTER (Promoting the integration of satellite and terrestrial communication with	Software for commercial use of the Galileo satellite system.

GALILEO for road transport)	
euroFOT (European Large-Scale Field Operational Tests on In-Vehicle Systems), FOT-NET (Networking for Field Operational Tests)	Programs for testing and evaluating applied IT solutions.
Network of National ITS Associations	Development program of the international network of Associations of Intelligent Transport Systems.
TMC Forum (Traffic Message Channel)	The program for informing road users about the real road situation on a special dedicated radio channel.
CONNECT, SIMBA	National and international programs for the development of the market of intelligent transport systems. They include programs in the countries of Central and Eastern Europe, Brazil, India, China, and South Africa.
MODIBEC (Building Cooperation on digital broadcasting convergence with mobile communications between Europe and China)	Cooperation between EU countries and China in the field of digital data transmission technologies.
MAPS&ADAS (IP PReVENT)	Use of electronic maps to improve road safety.
SAFESPOT	A program to support the appearance of more "smart" cars on "smart" roads.
CVIS (Cooperative vehicle-infrastructure systems)	Program of interaction of cars and road infrastructure.

Three standardization systems have the greatest influence in the field of technical regulation of ITS:

- ISO – International Organization of Standardization, where the field of ITS is regulated by technical committee 204 (ITS);
- CEN – European Committee for Standardization, where the field of ITS is regulated by a technical committee 278 (Road Transport and Traffic Telematics);
- ITS Standards of Japan – Japanese standardization system.

The working groups created in these organizations specialize in the areas of: architecture, public transport, systems for returning stolen vehicles, parking lot management, human/machine interface, automatic identification of vehicles; cargo transport and rolling stock management systems, etc.

Currently, there is no definition of "intelligent transport system" (or other tools for managing traffic flows), description of its components, functions and characteristics in Ukrainian legal acts. As a result, there are no requirements for the design, implementation, use and improvement of these systems.

Table 2 defines the key subject areas of ITS.

Table 2

Key subject areas of IT

(created by the authors of the paper by adapting [10])

Term	Definition	Explanation
ITS subsystem	A set of technological solutions completed within the framework of one applied task, which is implemented on the basis of the use of technical means of telematics - a combination of communications and informatics.	The ITS subsystem should include a complex of obtaining target data (based on its own monitoring system or from an adjacent subsystem), a hardware and software complex of analysis and decision-making in accordance with the functional task of the subsystem. Additionally, it may include a complex and widely distributed set of peripheral devices.
Intelligent transport system - ITS	A system that uses modern information, telematics and communication technologies, management technologies. Its main purpose is the automated search and acceptance for implementation of the most effective scenarios for managing the regional transport system (cities, streets, roads), a specific vehicle or a group of vehicles, with the aim of ensuring the given mobility of the population, maximizing indicators of the use of the road network, increasing safety and efficiency transport process, comfort for drivers and transport users.	The ITS function is provided at an expense: - the maximum possible automation of street and road network management processes and transport systems; - development of predictive management solutions based on modern mathematical data and highly efficient hardware and software implementations. At the technical level, ITS has a distributed architecture of elements located: on vehicles and in infrastructure.

External information systems	Information systems of various types of transport, provide for operational and other interaction based on combined dispatching, as well as information systems of various ministries and departments, which provide for functional communication with IT within the framework of the task of operational interaction.	
ITS infrastructure	A complex of technical means, peripheral devices and communication channels that perform certain functions in ITS and are not located on vehicles	ITS infrastructure should include: - the road complex of all subsystems, including: technical means of monitoring, analysis and decision-making in accordance with the functional tasks of the subsystems, means of implementing management decisions; - situational, dispatching and operational centers.
On-board tools of ITS	A complex of hardware and software resources, standard or those that are installed additionally on vehicles, which provide solutions to the tasks of information interaction of the vehicle with the ITS infrastructure, or with other vehicles within the framework of the functional tasks of various ITS subsystems, in order to implement the functions of monitoring, management and optimization of traffic, the state of the vehicle, the driver and cargo, as well as providing informational support for the driver's actions.	With their help, the following functions are implemented: - assistance is provided to the driver in forecasting the road conditions; - encourage him to take action to prevent a dangerous situation; - reducing the fatigue of the driver, taking part of the load of driving the car on himself; - automatically taking over control if the driver was unable to take the necessary actions to prevent an accident or reduce the severity of its consequences; - identification of vehicles and parameters of its operation.

4. Segmentation of services for intelligent transport systems users

There are three main subjects of intelligent transport systems:

- both surface and underground infrastructure (road signs, communications, turnstiles, computers, sensors, etc.);
- vehicles classified by types of vehicles, their safety characteristics, degree of use of modern technologies);
- people: their behaviour and priorities (especially regarding the use of certain types of transport)

Table 3 shows generally accepted ways of using ITS or services for ITS users. This list of 44 services within 11 groups of services is defined by the International Organization for Standardization (ISO). The vast majority of these services are used in synergy with others.

Table 3

Generally accepted services for ITS users

(created by the authors of the paper by adapting [10])

Service center for users	Services
Traveller information service	- information received before the trip; - information obtained during the trip; - information about services during the trip; - determining the route and navigation - before the trip; - determining the route and navigation - during the trip; - travel planning support.
Management of transport operations and operational services	- management of transport operations and traffic regulation; - management of emergencies related to transport; - demand management; - management of transport infrastructure support; - police supervision/enforcement.
Maintenance of vehicles	- improvement of visibility; - automatic control of the vehicle; - collision avoidance; - readiness of the safety system; - restrictions to avoid accidents.
Service of cargo transport	- customs clearance of commercial vehicles; - the process of administration of commercial vehicles; - automatic road safety inspection; - control over the safety of commercial vehicles on board; - management of the freight transport fleet; - information management between different types of transport; - management and control of centers of various types of transport; - management of dangerous goods.

Public transport service	- management of public transport; - demand-responsive transport and shared transport.
Service in emergency situations	- notification of emergency situations related to transport and personal; - safety; - searching for the vehicle after the theft; - management of vehicles in emergency situations; - hazardous materials and emergency notifications.
Electronic payment services related to transport	- electronic financial transactions related to transport; - integration of electronic payment services related to their transport.
Road transport related personal safety	- safety of public trips; - improving safety for vulnerable road users; - improvement of safety for disabled road users; - provisions on safety for pedestrians who use intelligent; - nodes and connections.
Weather and environmental monitoring services	- weather control; - monitoring of environmental conditions.
Disaster response management and coordination services	- disaster data management; - disaster response management; - coordination with emergency authorities.
National safety services	- national safety services; - monitoring and control of suspicious vehicles; - monitoring of structures and pipes.

The structure of ITS can be presented in the form of boundaries for the development, planning, operation and use of ITS. Figure 2 shows 9 functional groups that reflect the types of functions and activities required to provide services to IT users. This scheme, the US National ITS Logical Architecture, covers all functional parts, namely: transit management, emergency services, vehicle monitoring and control, passenger services, electronic payment of services, management of traffic on the street and road network, accumulation and storage of data, as well as management of technical maintenance and construction.

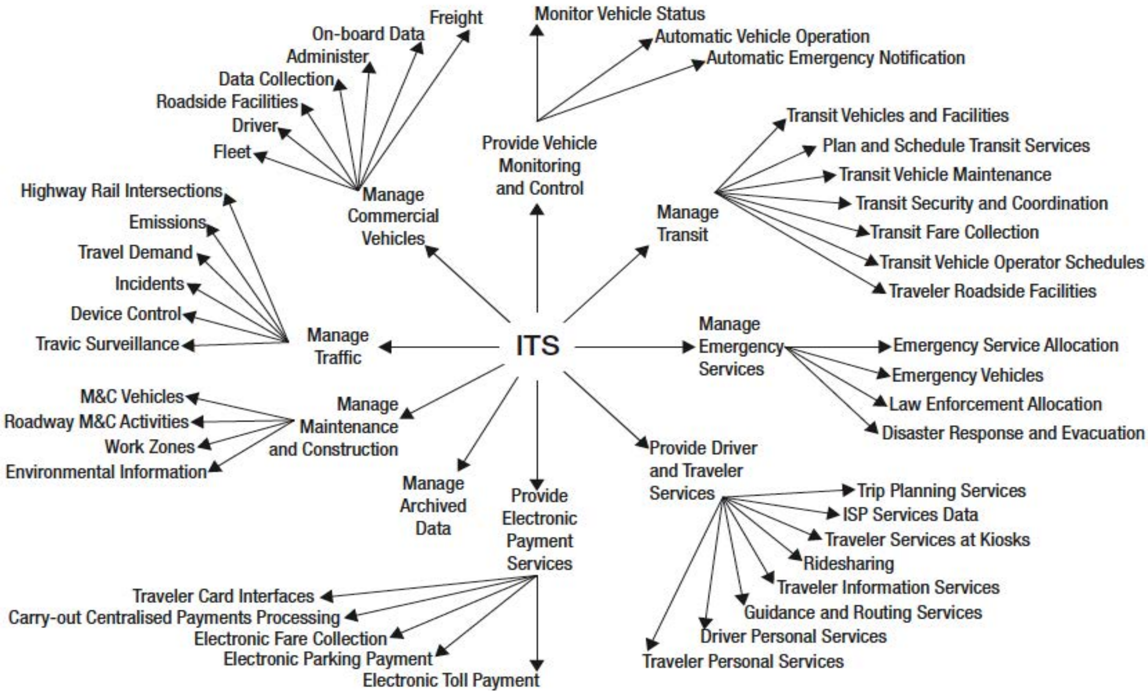

Fig. 2 Functions of intelligent transport systems (developed by the authors of the of the paper [10])

5. Application methods and technologies of intelligent transport systems

One of the tasks that are solved with the help of ITS is the development of public transport. This direction is key for the formation of sustainable urban mobility and the reduction of transport costs. For the largest cities, the following series of priority services and opportunities for their application can be defined:

- information for citizens performing urban movements. These data are needed so that citizens can choose the most convenient routes, receive information about the expected arrival time of public transport, the time and reasons for their delays;
- transport and traffic management, which aims to reduce the demand for individual vehicles and give preference to the public, as well as pedestrian or bicycle traffic;
- management of freight transport, to simultaneously reduce the impact of freight transport on settlements and increase its efficiency;
- management of various types of public transport to comply with traffic schedules, reduce delays and effectively distribute labour and other resources;
- electronic payment for tickets of various types of public transport (for example, smart cards), bicycle and car rental, as well as for paid entry to certain areas of the city;
- reliability and safety, including emergencies.

Table 4 provides examples of the use of each of the above priority services with defined nodes, and also briefly describes the purpose and principle of operation.

Table 5 describes all examples and technologies of ITS application for each service, which is a priority for the largest cities.

Table 4

Priority services for IT users

(created by the authors of the paper by adapting [10])

Service	The goal of the service	Principle of application
Information for citizens performing urban movements.		
Information received online for various types of transport with schedules of their movement	Help travellers choose in favour of public transport, and make it more attractive.	Information from different public transport systems is transferred between these systems. Common routes and schedules are used to plan trips by different modes of transport. Information is transmitted in real time to bus stops and passengers. Each system may collect information in different ways, using different sources and technologies, but this information is distributed through a single source.
Real-time information about public transport	This information is aimed at increasing the level of use of public transport by increasing the reliability of services and eliminating doubts about the arrival of the next vehicle.	Buses use GPS and odometers to determine their location along the route. Location information is transmitted back to the CPU using a wireless connection such as GPRS. The central system compares the actual location with the expected location and calculates how late the bus is. The time by which the bus is late (or early) is used to update data about its arrival time at other stops along the route. The time of arrival is shown on variable information signs at stops and can be sent directly to passengers via SMS or the Internet. To help buses that are running late, traffic sign timing can be modified in real-time and this allows the green light to be on for that bus for longer.
Advanced Passenger Information System (APIS)	APIS aims to influence driver behavior by providing real-time travel time information along different route options. Using this information, drivers can avoid areas with heavy traffic congestion,	Traffic flow on different road segments is measured using inductive loops used in traffic sign control systems and GPS-enabled vehicles (such as buses, taxis, and other vehicles). The journey is profiled in real-time and drivers are advised of the level of delays before they even start a particular route. Information is displayed in many forms,

	reducing congestion and improving the capacity efficiency of the rest of the road.	including variable information signs along the road, it is transmitted directly to the driver in the car using wireless technology or to the public transport driver via SMS or the Internet.
Regulation of traffic and management of transport operations		
Entrance fees to certain areas of the city	In order to reduce the demand for trips by individual vehicles and reduce traffic jams throughout the territory of this zone, a road toll is applied. Public transport is given priority and uses tax-free traffic lanes.	Drivers who want to drive to/through a certain area of the city make a prepayment from their account by phone, internet, mobile phone or SMS messages. When a vehicle enters or approaches the zone, one or more cameras read the license plates. If the user account linked to the given vehicle shows that the vehicle has funds, the funds are withdrawn from the account upon entry. If there are no funds, the funds are withdrawn on credit.
Centers for traffic regulation and traffic control of city transport	Ensure the operation of the central coordination point to reduce the consequences of emergency situations on the road and in the public transport system.	A central coordination center functions to control traffic signs, which collects data on vehicle traffic and trips. Centers can consist of many bodies. All road, transport services, public transport services, police and emergency services use a single centre, or there may be several specialist centers which have links to transmit data to all the other centres. The integrated control center will distribute data and control many ITS systems, including a computerized traffic control system that operates using a closed-circuit television broadcast camera, human-sourced emergency information, RTPI, public transport control systems and operators, cameras APIS and CCTV that the police, transport, toll roads and others have. Control room personnel coordinate the necessary emergency services and road services to manage emergencies, traffic flow and safety. Signs with variable information can also be used in the form of radio messages

		and messages in other mass media for the purpose of informing the public.
Management of freight transport	Improve the efficiency of the transport fleet.	Vehicles determine their location using GPS signals. These signals are sent back to the fleet manager, indicating the location of the vehicles on the map. Route planning software enables the truck to perform additional tasks with electronic instructions sent back to the driver. A detailed history of the stay can be kept on board for further analysis. With the help of on-board systems, it is also possible to monitor the condition of the vehicle and notify the depot if any problems arise.
Electronic payment of services		
Electronic payment collection	Smart cards are used as a form of electronic wallet. These cards can be topped up at payment stations or via the Internet, and then they can be used to pay for services.	By combining the smart card with other functions, in particular the purchase and sale of public transport tickets, better acceptance of the cards is ensured. Contactless cards can be used to implement ticket sales and purchases or with full contact and pin-based access for other payments. Transactions are conducted only between the card and the merchant. Alternative electronic payment systems can be made using mobile phones. The amount of the sale is charged to the telephone account. Sellers get paid from phone company bills.
Electronic toll collection	ETC helps achieve greater convenience in payment, requires fewer stops, reduces the cost of the toll system and minimizes revenue leakage due to corruption compared to manual toll payment systems.	Drivers make prepayment from the account, it is fixed either on a smart card or in the central system. When driving on the road, special stickers are read using built-in signaling devices. The sticker is activated and the system debits the user's account for the distance he has driven. There are systems that use Automatic Number Plate Recognition (APNR). The vehicle number is matched against a central database and a certain amount is deducted from the user's account. Tariffs may vary

		depending on the period of the day. If there is no money in the account, no sticker is attached to the car and the number plate is not registered, then the cameras identify and read the number plates of the vehicle and issue a fine notice about the violation.
Reliability and safety		
Safety control systems	Safety control systems are designed to reduce the number of accidents by increasing the attention of drivers in unusual road conditions.	These systems use an array of roadside sensors to determine environmental conditions. Data from the sensors is transmitted to a central data processing facility, often via wireless communication. Decisions about warning messages, opening lanes or setting speed limits are made by a central system according to the rules, and signs with variable speed information are used to convey this information to road users. CCTV cameras are used to monitor variable speed limits and enable operators to confirm environmental and traffic conditions. The devices record wind, ice, fog and the movement of vehicles. The central system then sets the speed along the road, adapting it to the conditions. Variable speed signs show the current speed, and speed cameras automatically adjust to the current speed change.
Surveillance using closed-circuit television (CCTV) transmission cameras at bus and railway stations	Carry out centralized monitoring of bus and railway stations (and other public areas) in order to provide assistance and respond to emergency situations, if necessary.	Central control center staff use CCTV and advanced communications technology to monitor public areas. Control center employees are connected by advanced means of communication with the police and emergency services. Control center staff can make announcements and ask if passengers need help. Traditionally, an emergency telephone is provided so that passengers can request assistance.

Table 5

ITS application technologies

(created by the authors of the paper by adapting [10])

User service bandle	A separate service	Service technology	Description of application technology
Information for citizens moving	Information before the trip, information for drivers during the trip, information about public transport during the trip	A variety of technologies, systems	Systems that can provide information about scheduled public transport, or travel times, or real-time conditions, via the Internet, SMS, VMS and other means of communication. Can be served by multiple technologies, including GPS, wireless, etc.
	Services of providing personal information	A variety of technologies, systems	May consist of simple Internet access to travel information or location-based services (LBS) that are sensitive to the user's profile, location, and preferences. LBS can use several technologies, using GSM/GPS or other similar mobile communication systems, etc.
	Route guidance and navigation	Navigation systems in vehicles	In-vehicle navigation systems enable drivers of cars and trucks to receive information about the best route choices, as well as information about traffic conditions, such as emergency situations
Traffic control	Transport planning support	City transport demand models, intersection simulation models,	There are a number of models for simulating entire transport networks or individual

		GIS systems for geographic data management, etc.	intersections. GIS is used to aid in data storage and analysis
	Traffic regulation	CCTV - closed circuit television camera transmitters	CCTVs are used to verify events by operators in transport operations control centres.
		VMS – Variable Information Signs – provide information to travelers	Infrastructure is required, often using low-cost LED or other variable sign technologies, but also more expensive technologies such as Plasma or modern LCD displays to display public transport information. Portable VMS variable information signs are also used to display information about temporary roadworks.
		SL – signs with variable speed limit and accompanying legislation	Speed limits are set to manage prevailing traffic conditions (eg more or less congested traffic flow) and weather conditions. Legislation is needed that would make it possible to apply speed limits and provide appropriate evidence of violations if necessary.
		Inductive loops (on the pavement), infrared (above) or optical with intelligent cameras (top) for vehicle tracking	Inductive loops are the most common due to their low cost, but they are less effective if the road maintenance condition is unsatisfactory. Infrared

			systems do not depend on road conditions.
		LED traffic signals and regulatory signs	Higher cost than traditional lamps inserted in traffic signals and signs, but lower running costs due to lower energy consumption, longer and stronger service life.
	Management of emergency situations	Definition of emergency situations and traffic jams, as well as their verification using CCTV and monitoring by the Control Center	Intelligent digital cameras installed in appropriate, advantageous places for monitoring traffic jams and traffic speed and its characteristics
	Demand management	AVI - automatic vehicles identification	AVI systems identify the vehicle and the registered owner by reading the vehicle's license plate or its electronic (ID) card, which may also be known as a sticker or transponder
		Electronic payment/collection	Technologies similar to those used in electronic toll collection (ETC) can be used - for permanent users with the help of OBUs, and for those who use them from time to time - without the use of OBUs.
		Communications	Optical/video systems that scan a vehicle's license plate and check whether the vehicle has the right to access the controlled area or

			whether it should be charged. With their help, the problem of a separate communication system with the vehicle and OBU disappears.
	Police supervision/ enforcement of traffic rules	A variety of technologies, systems	Speed cameras, red light cameras, access control cameras.
	Infrastructure maintenance management	A variety of technologies, systems	Portable VMS and other technologies for managing temporary maintenance work and supporting special events.
Freight transport	Preliminary customs clearance of cars for commercial transport and procedures for the administration of cars for commercial transport	Electronic Data Interchange	EDI or electronic commerce in general is a vital part of managing the paperless flow of information required to secure, transport, upload, transmit, receive, pay and comply with any relevant legal requirements. For efficiency, the physical process and electronic transactions should be synchronized,regardless of the goods involved in the international or domestic transaction. For many information flows in the trade and transport industry there are structured documents that are transmitted in a conventional way, so EDI offers potential advantages.
	Management of the transport fleet of cars for	Fleet management systems (FMS)	FMS can manage and control the operations of its fleet. With the

	commercial transportation		involvement of other systems, it can be used to monitor vehicle fuel consumption, emissions, and provide diagnostics to verify and identify problems and offer solutions.
Public transport	Management of public transport	Fleet management systems (FMS)	Using real-time vehicle location information, FMS can monitor and control the activities of its fleet and use the data to communicate information to passengers. With the involvement of other systems, it can monitor the vehicle's fuel consumption, emissions, and provide data to check and diagnose problems and propose solutions.
Management in emergency situations	Notification of emergency situations and personal safety	CCTV cameras	CCTVs are used to identify and verify events by operators in emergency control centres.
	Management of vehicles in emergency situations	Fleet management systems (FMS)	From real-time vehicle location information, often using GPS, FMS can monitor and control emergency vehicle operations, advise on the best route choices and prioritize traffic signals.
	Hazardous materials and emergency notifications	Fleet management systems (FMS)	With real-time vehicle location information, the FMS can monitor hazardous loads on the network.

Electronic payment	Electronic financial transactions	A variety of technologies, systems	Includes ETC and electronic ticketing and ticketing. Using a magnetic strip and tickets in the form of smart cards.
Safety	Improving safety for vulnerable road users	Intelligent pedestrian crossings	Automatic tracking of pedestrians at crosswalks using microwave and infrared technologies.

6. The international experience in the formation and development of intelligent transport systems

Intelligent transport systems are used to monitor and manage traffic flows in many countries around the world. Also, for the implementation of this tool in Ukrainian cities, it is necessary to first get acquainted with foreign experience.

One of the largest European projects is the Munich COMFORT project, which was started in 1991. This is the first project that took into account streets and roads on the outskirts of the city when coordinating transport in the center. Navigation and information system tools on the outskirts of the city worked depending on city traffic flows. Algorithms evaluate the level of traffic, optimize the operation of traffic lights, predict the development of the traffic load on the street and road network and direct vehicles to bypass areas where traffic jams may occur.

The initial capital investment paid off within 2 years due to the reduction of traffic accidents: the number of collisions decreased by 35%, the number of road accidents with injuries decreased by 30% and the number of fatalities decreased by 31%.

A number of the following projects and measures have also been implemented within the EU:

1. Analysis of the transport network. Data from transport sensors at transport nodes may be sufficient only for general control. ITS requires more detailed data. This is successfully demonstrated in the QUARTET PLUS and EUROSCOPE projects. In practice, new ways of determining travel time, speed on separate lanes and networks, new detector systems based on video detection, as well as algorithms for determining points of departure and destination (OD matrix: Origin-Destination) were tested. The latest data is especially important for ITS. Various prediction algorithms were also tested. This applied to short-term (1-20 min), medium-term (11-12 h) and long-term forecasts (1-2 days). As a result, it became clear what inaccuracies and limitations characterize forecasts of transport system functioning parameters. One of the further

directions of development is the use of data from a mobile laboratory that moves with the traffic flow (CAPITALS project). Within the framework of the VERA project, the complex conditions in the network became clear.

2. The area of establishing the places of traffic accidents is a very important area of using the results of data analysis. After all, the quick detection of problem areas starts the process of taking the necessary measures: informing drivers before the start and/or during the movement, and very quick response of the rescue services. A road accident prediction model was also developed within the IN-RESPONSE project.

3. Information and navigation. Driver information systems through car on-board computers or controlled traffic signs and displays (TFIS) located along streets and roads are of particular importance in the management of traffic flows on highways. Thanks to this information, traffic jams are significantly reduced, because the driver has to choose other traffic options, places for parking or parking. EU countries are increasingly turning to TFIS systems because not all cars are equipped with special onboard computers. Several projects (CAPITALS, CONCERT, CLEOPATRA, COSMOS, EUROSCOPE, TABASCO) in this field are aimed at studying the behaviour of transport and determining the best management strategies. Information and navigation systems can be considered in the example of the following cities:

- Bristol (CONCERT): TFIS for better use of the Park and Ride system (parking in intercity parking lots and onward movement by public transport);
- Brussels (CAPITALS): TFIS as a component of the higher traffic flow management system in the tunnels on the inner ring of the city;
- London (CLEOPATRA): determination of the impact of TFIS during the detection of road accident sites on the choice of the road network by drivers and the efficiency of transport in this network;
- Munich (TABASCO): TFIS for Park and Ride;
- Piraeus (COSMOS): a strategy for changing the direction of traffic flows in the seaport area;
- Southampton (EUROSCOPE): integrated detection of road accident sites and management of parking spaces;
- Toulouse (CLEOPATRA): a general strategy for changing the direction of traffic flows;
- Turin (CLEOPATRA): the TFIS strategy together with the traffic management strategy in the city.

Informing passengers before trips and at public transport stops has a significant impact on passenger behaviour and stimulate an increase in the number of passengers. For example, in Turin, with the help of this tool, the travel time was reduced by 14% in public transport and by 17% in individual vehicles. In the city of Southampton, capital investment in the crash detection subsystem paid for itself within one year.

However, it is worth noting that the payback period depends on the speed and method of accident detection.

4. Traffic jams often occur on streets connecting urban areas. To do this, it is necessary to integrate the management of traffic flows at the entrances to the city with the city-wide management system. The TABASCO project combined traffic management at entrances (Ramp Metering) with information and navigation using TFIS. The Ramp Metering method (adjusting the intensity of traffic flows) increased the capacity of SRS: 5% for highways and 13% for the urban network. The system also improved the behaviour of drivers and led to a decrease in the number of road accidents.

5. Management depends on the load. In the city, this system has a rapidly growing need. It combines the control of entry to the central areas of the city (the CAPITALS project), artificial intelligence technologies, traffic light control, and a system for providing information and assistance to drivers. With the help of this system, you can determine the travel time and information about free parking spaces.

In the USA in the 1990s, the main stages of solving the problems of the development and implementation of Automated traffic management system (ATMS) were described: mathematical modelling of the movement of cars and traffic flows (micro and macro), a single information system; electronic route selection and indication system; driver assistance system.

These stages are implemented through the installation of traffic detectors, information signs and boards with up-to-date information, and traffic lights connected by a single network and controlled by a special Control Center. Currently, all highway networks adjacent to large cities are equipped with ATMS.

Canada and the US pay a lot of attention to the interconnection of the urban system with suburban areas. A good example is the urban network of Montreal, where the urban network includes highways in the suburban area (70-100 km from the city).

Almost the entire road network, both in cities and on highways in Japan, is equipped with ITS of various levels of complexity.

Successful examples of ATMS implementation can be:

- Toronto, Canada: 75 traffic lights are controlled by the SCOOT system. It was possible to reduce travel time by 8%, the number of vehicle stops by 22% and vehicle delays by 17%. As a result, fuel consumption decreased by 5.7%, which in turn has a positive effect on the environment;
- Los Angeles, California: 1,170 traffic light objects and 4,590 detectors are connected to LADOT's new system, used to optimize the control process. A 13% reduction in fuel consumption, a 41% reduction in the number of vehicles stops and a 16% reduction in lost time were achieved;

- Chicago, IL: ATMS-Based OPAC Public Transportation Traffic Optimization Pilot Project. Buses are given priority for passing through the intersection, which increased the speed of buses by 25-50%. It is also planned that urban passenger public transport will be more attractive and at the same time the environmental load will decrease.

Numerous examples of the implementation of specific ITS systems in Europe are given on the website of ERTICO [13] - the European ITS Association.

In practice, it is customary to classify ATMS according to four generations.

Generation 1. Calculation of control parameters and their entry into ATMS are performed manually.

Generation 2. Calculation of parameters is automated, entering them into ATMS is done manually.

Generation 3. Calculation of control parameters and their entry into ATMS are automated. Management (response to changes in traffic flow) is carried out taking into account the dynamics of traffic flows by changing pre-calculated timetables.

Generation 4. Calculation of control parameters and their entry into ATMS are automated. Management is carried out in real-time (with short-term response delay or traffic flow forecasting) taking into account local changes in traffic flows.

Currently, ATMS of the 3rd and 4th generations are installed in several dozen cities: in 53 cities of Great Britain, in Madrid, Tokyo, Toronto, Bordeaux, Bahrain, etc.

The most important component of ATMS is the system of informing the participants of the movement, which has become especially global with the development of Internet networks. Currently, a large part of the territory of the USA or France is covered by information systems that transmit quantitative data on traffic flows to residents in real-time.

In recent years, systems that predict the average speed and travel time for other routes have become increasingly popular. Such systems have a very significant impact on the redistribution of traffic flows.

Japan and several other countries in the Asia-Pacific region are investing heavily in the development of management systems. Transport experts in some Australian cities use the SCATS system in combination with other sub-systems for zonal management

ITS gained wide popularity in Korea. Here, they are implemented in three stages, which correspond to the national transport strategy:

- selection and implementation of a pilot project of this program with the participation of state institutions;
- qualified analysis of the pilot project;
- expansion of the pilot project throughout the country with the coordinating role of the state.

So, here again, the state performs the function of coordinator, while it provides sufficient space for private institutes, especially for the gradual expansion of the pilot project.

The structure of the intelligent transport system in the city of Kwason (South Korea) includes the following main subsystems: speed control, traffic management, weighing vehicles in motion, a navigation system for dynamic route determination, public transport passenger information, parking information, electronic payment for driving, informing drivers.

7. SWOT analysis of the implementation of intelligent transport systems in Kyiv

SWOT analysis is an effective business planning tool used to formulate strategies. This tool helps to analyse the internal factors (strengths and weaknesses) that influence and the external factors (opportunities and threats) that may affect the organization. He has now moved from business to various fields, including public administration. A SWOT analysis can help you analyse your project from a strategic perspective. This will help you determine how to capitalize on your opportunities by leveraging your strengths and how to avoid threats and address weaknesses. [14]

Table 6

SWOT analysis of the use of intelligent transport systems (the Case Stud of Kyiv) created by the authors of the paper

Strength	Weakness
- warning about possible obstacles on the route and its change; - facilitating orientation in the dark period of the day; - intelligent cruise control, lane support systems, obstacle prevention and driver condition monitoring for cars; - reduction of damage to infrastructure from large vehicles; - regulation of city traffic and modes of operation of traffic lights; - vehicle parking management.	- various technological challenges; - stop using outdated technologies and tools; - imperfect response and protection procedures against criminal attacks (including cyber attacks); - security of data that may be subject to cyber attacks; - Internet connection of all system users; - lack of the necessary level of knowledge among experts who are involved in the implementation of this system in cities.
Opportunities	**Threats**
- instant notification of any changes to all stakeholders; - no need for "manual management" of the road situation. - convenient navigation throughout the entire route;	- physical impact and threat of damage to the external elements of the ITS; - potential increase in the level of unemployment in connection with the automation of a number of technologies; - creation of indicators to monitor the effectiveness of system implementation

- improving the comfort (safety) of road traffic; - collection of data on city traffic.	and the possibility of adjusting the chosen course; - groundless expectations of full-fledged autonomy of systems, instead of perceiving them as a supplement to traditional planning methods; - integration of new elements into the already existing intelligent transport system and their potential incompatibility; - development of normative legal acts and guiding principles; - finding and diversifying sources of funding for this program.

Conclusions and discussion. The issue of increasing traffic delays is becoming increasingly acute in Ukrainian cities, which is why there is a need to manage traffic flows. The article defines the management of transport flows as a complex of solutions for the optimization of transport flows based on technical, organizational and programmatic measures. Cities with developed transport infrastructure use intelligent transport systems to manage the situation on the city's street and road network. That is why the article defines the concepts of "traffic flow management", "urban mobility", "urban mobility regime"; four groups of problems of urban transport systems were identified and methods of solving them were formed (extensive and intensive); on the example of the city of Kyiv, the level of implementation of systems for monitoring and managing traffic flows in Ukrainian cities was evaluated; the levels of the legal framework regulating the urban mobility of the population in Ukraine are described; the characteristics of intelligent transport systems and their key subject areas were investigated; generally accepted services for users of intelligent transport systems are singled out and segmented according to the needs of these system users; functions, methods of application and technologies of intelligent transport systems are presented; priority services for potential users of intelligent transport systems in Ukrainian cities are highlighted; the world experience of the formation and development of intelligent transport systems is characterized, as well as European programs for their implementation; a SWOT analysis of the implementation of intelligent transport systems in Kyiv was performed.

To reduce weaknesses and threats when implementing intelligent transport systems, the implementation strategy of this project should consist of the following mandatory elements:

- existing and prospective transport problems and needs, their priorities;
- list of available and potential ITS technologies;

- programs for creating a competitive space for technology development;
- tools for stimulating scientific and educational work among the public and in the private sector: dissemination of advanced practices in the use of ITS, promotion of research work, conducting seminars, courses and educational programs on ITS;
- responsible organizations, which are entrusted with the authority to develop ITS, identify priority areas and promote their implementation. Also, these bodies should develop standards, protocols, and strategies.
- improvement of the legislative and regulatory framework. Bills should be developed for the use of new technologies, for example, for the following tools: red light cameras, electronic payment of tolls in certain areas, monitoring of speed limit concessions;
- characteristics of existing and necessary institutional changes;
- determination of stakeholder's interests;
- assessment of the ability to solve transport needs with the help of ITS;
- tools for ensuring the transparency of tenders and facilitating the process of the partnership of different levels of government, research institutions and business;
- international cooperation programs for transfer and exchange of achievements;
- to be connected and coordinated with other areas, because ITS is a connection of transport, information, multimedia, communication and other industries.

The research results indicated that, the ITS implementation strategy is further transformed into the ITS implementation program, which is based on the following elements:

- prioritization of ITS applications and projects, which is formed after the analysis of interested parties, institutional framework and technical requirements.
- organizational measures for the functioning of ITS;
- detailed projects and financial agreements for the near term and proposals for the medium and long term.

Directions for future research: Future research will focus on the empirical implementation of the framework to assess the Intelligent transport systems (ITS) in Ukraine. This will provide new scientific knowledge about the urban mobility and allow to test the mobility traffic flow management benchmarking tool.

REFERENCES

1. Transport analytics service [E-resource] – Resource access mode https://www.tomtom.com/en_gb/traffic-index/kiev-traffic. (Application date: April 22, 2022). {in Ukrainian}.
2. Bespalov D. The coefficient of car use in Kyiv has been established [E-resource] / Dmytro Bespalov. – 2015. – Resource access mode:

https://bespalov.me/2015/10/23/vstanovleno-koeficient-avtomobilekorystuvannya-v-kyevi/. (Application date: April 22, 2022). {in Ukrainian}.

3. Designing urban areas: Textbook: in 2 parts. P.1/ [red. by V. T. Semenov, I. E. Linnyk]; O.M. Beketov National University of Urban Economy in Kharkiv. – Kharkiv: O.M. Beketov NUUEKh, 2018. – 449 p. (Series "Urban Construction and Economy"). {in Ukrainian}.

4. State building standards B.2.2-12:2019 Planning and development of territories. K.: MDCT of Ukraine, 2019. 185 p. {in Ukrainian}.

5. Balsys K., Eidukas D., Marma A., Valinevičius S, A., Žilys M. Systems of transport route development, Electronics and Electrical Engineering. 2007. 3(75). P. 17–22. {in English}.

6. State building standards V.2.3-4:2015 Roads Part I. Planning Part II. Construction Database "Legislation of Ukraine" / Verkhovna Rada of Ukraine. {in Ukrainian}.

7. Daunoras J., Bagdonas V., & Gargasas V. City transport monitoring and routes optimal management system. Transport. 2008. 23(2). P. 144-149. {in English}.

8. Development strategy of Kyiv until 2025 [E-resource]. 2017. URL: https://dei.kyivcity.gov.ua/files/2017/7/28/Strategy2025new.pdf. (Application date: April 28, 2022). {in Ukrainian}.

9. State building standards B.2.3.-5:2018 Streets and roads of settlements. K.: MinRegion of Ukraine, 2018. 61 c. {in Ukrainian}.

10. Intelligent transport systems. Module 4e: Sustainable development of the transport system. Collection of materials for urban policy [E-resource]. - Access Mode: https://www.sutp.org/files/contents/documents/ resources / A_Sourcebook / SB4_Vehicles- and-Fuels / GIZ_SUTP_SB4e_Intelligent-Transport-Systems_UA.pdf (Application date: April 11, 2022). {in English}.

11. Official page of the European Commission, section "Transport and Mobility" [E-resource] – Resource access mode https://europa.eu/capacity4dev/waqsp/topics/transport (Application date: April 23, 2022). {in English}.

12. Cherednichenko O. (2022) Management of city transport systems. Current Problems of Architecture and Urban Planning, (63), 164-180. https://doi.org/10.32347/2077-3455.2022.63.164-180. {in Ukrainian}.

13. ERTICO – ITS Europe [E-resource] – Resource access mode: https://ertico.com. (Application date: April 23, 2022). {in English}.

14.What is a SWOT analysis? [E-resource] // Dia. Business. – 2020. – Resource access mode: https://business.diia.gov.ua/en/handbook/marketing/so-take-swot-analiz. (Application date: April 23, 2022). {in Ukrainian}.

15. Ignatenko O. (2017) Passenger transportation — К.: НТУ, 2017. —265 р. {in Ukrainian}.

16. Arthur D. Little Future lab (2014). Future of urban mobility 2.0. Imperatives to shape extended mobility ecosystems of tomorrow. – [E-resource] – Resource access mode:http://www.adlittle.com/downloads/tx_adlreports/Arthur_D._Little_UITP_Future_of_Urban_Mobility_2_0.pdf. (Application date: April 23, 2022). {in English}.

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ІНТЕЛЕКТУАЛЬНІ ТРАНСПОРТНІ СИСТЕМИ ЯК ІНСТРУМЕНТИ УПРАВЛІННЯ ТРАНСПОРТНИМИ ПОТОКАМИ (НА ПРИКЛАДІ М. КИЄВА)

Низька якість послуг громадського транспорту, незручність маршрутів, велика тривалість поїздок та ще ряд інших проблем спонукають мешканців Києва все частіше обирати автомобіль для повсякденних кореспонденцій, що, в свою чергу, збільшує затримки, час переміщення та призводить до екологічного забруднення територій. Особливо гостро ці проблеми стоять у великих містах, де існують численні виробничі, трудові та культурно-побутові зв'язки всередині міста. Виникає потреба у створенні єдиної ефективної транспортної системи, яка обслуговує як місто, та впровадженні дієвих підходів до управління транспортними потоками.

Першочергово у статті визначено поняття «управління транспортними потоками», «міська мобільність», «режим міської мобільності». Виділено чотири групи проблем міських транспортних систем та сформовано два способи їх вирішення: екстенсивний та інтенсивний. На прикладі м. Києва оцінено рівень впровадження систем моніторингу та управління транспортними потоками в українських містах. Описано рівні нормативно-правової бази, що регламентує питання міської мобільності населення в Україні. Досліджено характеристики інтелектуальних транспортних систем та їх ключові предметні області. Виокремлено загальноприйняті послуги для користувачів інтелектуальних транспортних систем та сегментовано відповідно до потреб даних користувачів систем. Представлено функції, способи застосування та технології інтелектуальних транспортних систем. Виділено послуги, які є пріоритетними для потенційних користувачів інтелектуальних транспортних систем в українських містах. Охарактеризовано світовий досвід становлення і розвитку інтелектуальних

транспортних систем, а також, європейські програми їх впровадження. Виконано SWOT-аналіз впровадження інтелектуальних транспортних систем в Києві та надано рекомендації щодо створення програми впровадження ІТС в Києві.

Інформаційну базу статті склали публікації видатних українських та закордонних науковців, дані сервісу транспортної аналітики Tom Tom, чинна нормативно-правова база України, якою регулюються міські транспортні системи, та міські стратегії розвитку. У процесі дослідження використовуються наступні методи наукового дослідження: діалектичний метод, метод наукової абстракції, метод аналізу та синтезу, метод індукції та дедукції, порівняльний метод, метод систематизації, графічний метод.

Ключові слова: інструменти управління транспортними потоками; міська мобільність; інтелектуальні транспортні системи; міські транспортні системи; аналіз кейсів.