



## Conceptual framework for the formation of the integrated intelligent transport system in Ukraine

**Abstract.** *Introduction.* The research is dedicated to the conceptual framework of the integrated intelligent transport system (ITS) formation in Ukraine. The author presents different approaches and technologies in the field of the functional structure of the integrated intelligent transport system optimisation and describes the influence of the integrated ITS creation on political, economic and social situation in Ukraine. *Purpose.* To develop a conceptual framework of the integrated intelligent transport system as a balanced synergetic factor of the transport sector development in Ukraine. *Methods.* In order to achieve the goal set in the article, the appropriate methods have been used based on the systemic approach, artificial intelligence, management theory and decision-making theory. The system analysis was used to define the scientific task. *Results.* The study related to the development of the conceptual framework for the formation of the integrated intelligent transport system has made it possible to introduce approaches and technologies in the field of ITS functional structure optimisation and determine its principal components. The functional structure of the proposed integrated intelligent transport system includes implementation of a modern methodology of mathematical transport modelling, which provides an objective, comprehensive and advanced approach to planning and solving problems of the transport industry of Ukraine. *Conclusions.* The global experience and the results of the implementation of ITS are invaluable. The creation of the integrated ITS in Ukraine should provide not only solutions to specific problems, but also improve the efficiency of the transport system in general. The proposed conceptual framework for the formation of the integrated intelligent transport system in Ukraine may be useful for government authorities, transport enterprises and consumers of transport services.

**Keywords:** Country's Competitiveness; Intelligent Transport System; Transport Infrastructure; Transport Flows; Management Structure

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#### Концептуальні засади формування інтегрованої інтелектуальної транспортної системи в Україні

**Анотація.** У статті розглянуто концептуальні засади формування інтегрованої інтелектуальної транспортної системи в Україні. Представлено підходи і технології в області оптимізації ряду транспортних завдань. Запропоновано функціональну структуру інтегрованої інтелектуальної транспортної системи. Також досліджено вплив створення інтегрованої ІТС на політичне, економічне та соціальне становище України.

**Ключові слова:** конкурентоспроможність країни; інтегрована інтелектуальна транспортна система; транспортна інфраструктура; транспортні потоки; структура управління.

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#### Концептуальные основы формирования интегрированной интеллектуальной транспортной системы в Украине

**Аннотация.** В статье рассмотрены концептуальные основы формирования интегрированной интеллектуальной транспортной системы в Украине. Представлены подходы и технологии в области оптимизации ряда транспортных задач, предложена функциональная структура интегрированной интеллектуальной транспортной системы. Также исследовано влияние создания интегрированной ИТС на политическую, экономическую и социальную ситуацию в Украине.

**Ключевые слова:** конкурентоспособность страны; интегрированная интеллектуальная транспортная система; транспортная инфраструктура; транспортные потоки; структура управления.

### 1. Introduction

The objective growth of traffic intensity, its load on the infrastructure, its impact on the environment, as well as the implementation of modern information systems in transport and infrastructure facilities, require proper management of the transport processes. The current use of intelligent transport systems is an effective innovative approach that can ensure an increase in the competitiveness of Ukraine both in the domestic and international markets. The creation of the integrated intelligent transport system requires the application of a comprehensive approach which should include the mechanism of state management, the relevant road infrastructure and an intelligent information system to manage the transport system.

ITS should be created as a unified centralised system of the Ukrainian transport system management, rather than the complex of local management systems. Its creation, development and integration into the existing local transport systems, as well as the standard design solutions based on the use of advanced foreign technologies, should be viewed as an important stage of the implementation of the integrated ITS. This approach will allow avoiding mistakes in the design of the intelligent system, optimizing terms and expenditures for its creation, change the existing principle of local informatization for each mode of transport.

### 2. Brief Literature Review

The approaches to the use of intelligent transport systems worldwide and their efficiency are presented in the works of foreign scientists, such as J. Russell (2012) [4], J. S. Sussman (2005) [5], M. A. Chowdhury, A. W. Sadek (2003) [6], R. Mogre (2010) [7], R. P. Roess, E. S. Prassas and W. R. McShane (2010) [8], S. Ghosh, T. S. Lee (2010) [9] and others. Also, the given problem has been described in the scientific works of the following Ukrainian scientists: A. R. Haikov, O. P. Yevsieieva, O. V. Baranov, V. Y. Baranov (2014) [1], R. M. Tsyhan, A. A. Kravchenko (2013) [2].

The approaches to the design and use of the intelligent transport system are the basic ideas of the presented researches. Nevertheless, the issues dedicated to the conceptual framework for the creation of the integrated intelligent transport system in Ukraine are still understudied. The current existence of certain business applications related to both the transport itself and infrastructure facilities requires their general unification by means of the integrated intelligent transport system.

### 3. Purpose

To form a conceptual framework of the intelligent transport system as a balanced synergetic factor for development of the transport sector of Ukraine.

4. Results

Informatization of industrial, economic and social processes is evolving rapidly, which allows for asserting the information revolution. The transport sector, where one of the principal innovative directions is creation and implementation of intelligent transport systems, does not stay aside from it.

Today, modern technologies are used to improve the transport network based on intelligent transport systems (ITS). The rapid developments of computer devices and related applications have significantly influenced the price of such commodities making them more accessible.

The kinds of intelligent transport systems can be divided into applications for online travel planning, vehicle navigation systems, digital road maps, automatic traffic information. Essentially, any combination of technology and transport can be considered as «smart», hence the possibilities of ITS applications are practically unlimited.

ITS represents the largest and most diverse group. It covers a wide range of information, traffic, navigation, automotive systems, as well as insurance and monitoring systems of vehicle / driver (telematics) and thousands of other systems which use data to create «smart» solutions in the field of transport. This category includes the majority of transport «applications», which are available in modern smartphones. ITS ensure great economic benefits. ITS users have many advantages: time savings in route design (including congestion), fuel economy, operative interference during the transportation, etc.

An important feature of intelligent transport systems, whereby they can be attributed to a particular area of research is the existence of logical and mathematical tools based on the system approach to transport management.

By using ITS, the following tasks can be solved:

- implementation of electronic payment systems for transport services (toll roads);
- remote control and supervision during the transportation of hazardous and valuable cargos;
- driving control and rest periods of drivers and restraints of violations of the set mode;
- transport safety of transport means (TM) on a voyage;
- systems (groups) management of TM, e. g. vehicles for operative services, road maintenance and public utilities, freight and passenger transport companies, taxi companies, etc;
- formation of optimal (rational) routes of TM determining their destination points and travelling time;
- optimal traffic management;
- provision of information related to users of transport services (drivers and passengers);
- response to emergencies;
- ability to track the location of stolen vehicles;
- use of ITS data to solve tasks related to law enforcement.

It should be noted that the creation of individual systems to solve each of the stated problems leads to irrational consumption of time and costs because of the duplication of similar elements of such systems. In the modern context, the main problem of efficient organisation of transport process in major cities of Ukraine and suburban areas of the road network with intensive traffic lies in the optimisation of use of limited public resources, i. e. the transport network capacity.

In order to solve this problem, it is expedient to create an integrated intelligent transport system (IITS). IITS presents the system of integration of modern information and communication technologies and automation facilities into the transport infrastructure, transport vehicles and users, which is relevant to the enhancement of safety and efficiency of the transport process in the country and the improvement of comfort for drivers and transport users. In other words, this is an information system which combines the existing systems in the transport sector.

In Ukraine, for example, there is a number of projects implemented with regard to the intel-

lectualisation of transport, introduced within the UARoads project which monitors the status of national roads [1].

Using GPS location data and the gyroscopic sensor of a smartphone which responds to vibrations, the UARoads application evaluates the quality of road surface. Unfortunately, this information is purely informative, but it can be transferred to competent authorities for further planning of the quality improvement of road surface.

The following example is the State Border Guard Service of Ukraine, which uses the interactive map of checkpoints on Ukraine's border. At present, it is possible to get information on the border checkpoints loading level online and view the state of accumulation of vehicles through surveillance cameras in real time.

Ukraine has joined the development of the concept for transport system management known as «Mobility-as-a-Service» (MaaS) [10]. The basic idea of MaaS is to provide mobility to services due to which users will be able to choose the transport services of various service providers by using one interface to compare the fees charged while using taxis, buses, airplanes, as well as the cost of car rental services, etc.

It should be noted that a synergistic effect can be obtained by attracting investments both in the transport infrastructure and the information systems of traffic flows management. This approach is the cornerstone of IITS.

Electronic traffic control systems with interactive road signs have already been introduced in the EU member states. Currently, the EU is also working on the implementation of eCall, a comprehensive electronic emergency call system, by which information on a traffic accident is automatically transferred to the emergency service centre via a special device in a vehicle [10].

Intelligent transport is an essential element of the «smart city». The development of the «smart city» can be applicable to many sectors of city management: its transport, «electronic government», energy, health care, construction and public life. Innovations that save and optimise resources can be introduced in each of these areas. Table 1 presents approaches and technologies in the field of optimisation of a number of transport tasks.

In order to solve traffic problems in Ukraine the aforementioned measures should be introduced and improved by using the global experience on travelling demand management, reducing the load on the transport infrastructure where it is needed.

Tab. 1: Methods and technologies for demand management in transport

No.	Demand management measures	Examples of use
<b>1. Reduced demand for personal transport travels / Increased operating costs when using a personal transport for travels in the city</b>		
1.1	Organisation of paid parking spaces in the downtown	Helsinki, Stockholm, Moscow, St. Petersburg (pilot project 08/2015)
1.2	Entry fee into the downtown	Stockholm (2008); London (2003)
1.3	System of short-term car renting / system of shared use of personal vehicles	Cities of Germany (2014); Moscow (2015)
1.4	Additional taxes for vehicle owners / registration fee	Singapore
1.5	Organisation of the streets system with a quiet traffic / consistent spaces with pedestrian priority	Cities of Germany
<b>2. Increased demand for non-motorised travels and travels in public transport</b>		
2.1	Development of the public transport system based on the principle of the public transport priority over the private transport in the traffic organisation	European cities, Bogota (2000)
2.2	Development of the main public rail transport	Cities of Germany (S-Bahn; tram lines); Helsinki
2.3	Intelligent transport systems; elements of the «smart city»	Barcelona; Australia; Canada
2.4	The system of public bike rent	Copenhagen (1995); Paris (2007); Moscow (2013); St. Petersburg (2014)
2.5	Development of the system of transport interchange hubs	Cities of Germany
2.6	Creation of a comfortable pedestrian communication system in the downtown	Copenhagen; Paris (La Défense downtown)
2.7	Introduction of a united hourly payment system for travel by all modes of transport	Berlin; Copenhagen, Prague
2.8	Increasing of public transport accessibility and quality of passenger servicing	European cities

Source: Based at data from <http://ertico.com>

Therefore, the above studies on the implementation of certain activities and information systems in the transport sector activity of different countries allow us to form the Functional management structure of Integrated Intelligent Transport Systems shown in Figure 1.

The proposed functional structure of the integrated intelligent transport system provides an introduction of the elements of transport imitation modelling. In this case, a transport model is a mathematical computer model of transport, which is a combination of databases on the transport infrastructure and the geo-platform.

The expected results of the creation of the integrated ITS in Ukraine may be:

- the development of the procedures to improve the efficiency and operation of the transport system, as well as a regulatory framework for the regulation of transport;
- the creation of inquiry and communication of the transport sector management;
- the creation of a mechanism of information delivery to government authorities and other interested persons about the operation of the transport sector;
- the improvement of the transport network and reduction of the negative impact of vehicles on the environment.

Further on, we will examine the impact of goals of the integrated ITS creation on the needs of the society and the

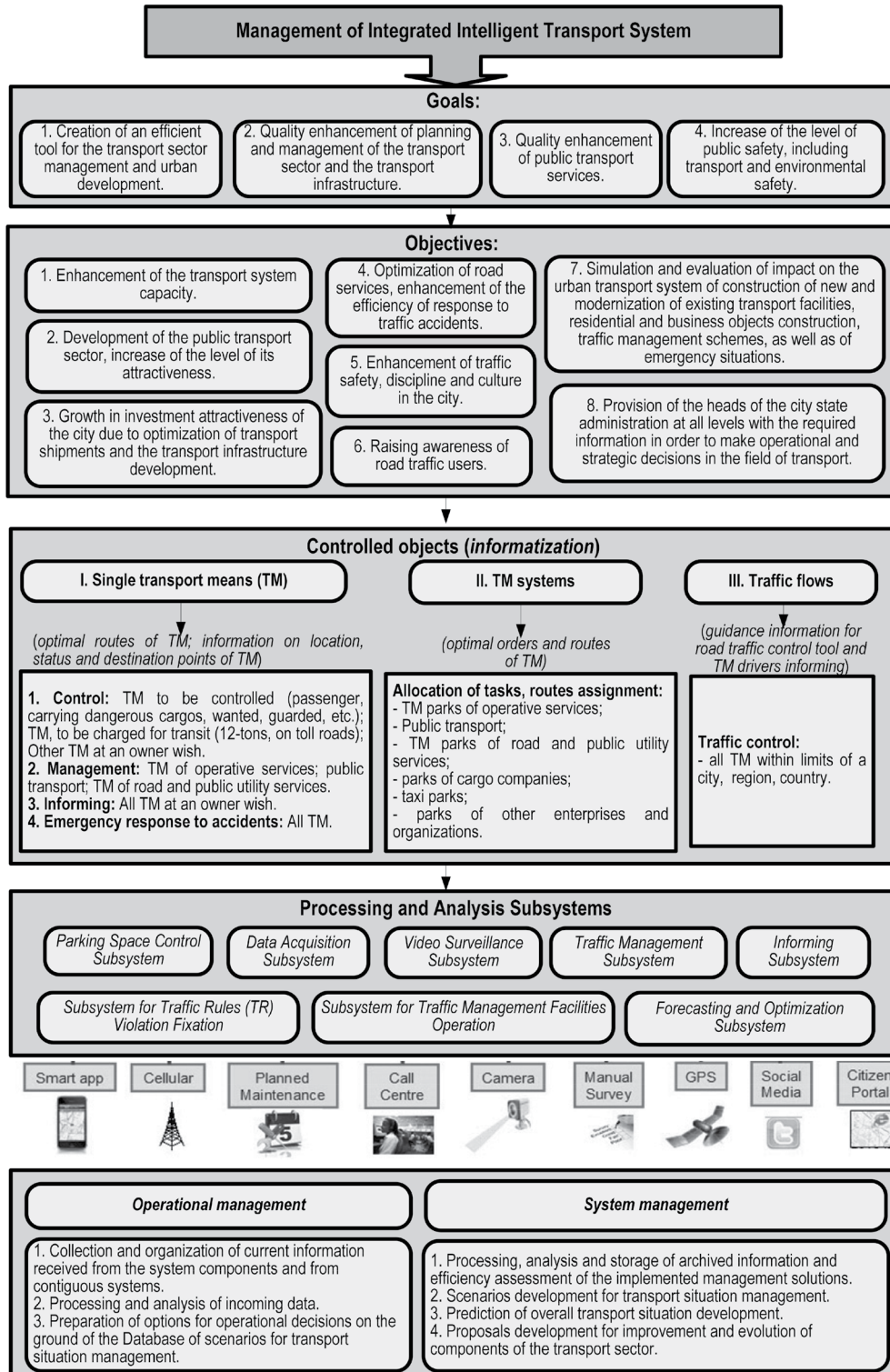


Fig. 1: Functional management structure of the Integrated Intelligent Transport Systems  
Source: Compiled by the author

Tab. 2: Impact of the integrated ITS creation on the political, economic and social situation in Ukraine

Goal	Impact on political situation	Impact on economic situation	Impact on social situation
<b>Enhancement of efficiency of the transport sector of the country</b>	Improvement of international economic relations, increase in transit flows, improvement of the investment climate of the country	Enhancement of efficiency of the economy in general	Growth in prosperity of people due to the enhancement of efficiency of the economy
<b>Enhancement of Safety</b>	Improvement of the country image, operational control of violations of law	Reduction of loss of labour forces, treatment expenses of injured and elimination of consequences of traffic accidents, reduction of losses which occur because of violations of law, traffic delays	Decrease in the number of victims and people injured in road accidents, decrease in the number of violations of law relevant to the road transport, traffic delays due to traffic accidents
<b>Improvement of the environmental factor</b>	Sustainable development and protection of the environment, rational exploitation of natural resources in the country	Reduction of loss of labour forces, decrease in treatment expenses	Improvement of living conditions, reduction of disease incidence
<b>Ease of use</b>	Improvement of foreign economic relations, comprehensive control of all processes in the transport sector	Growth in demand for vehicles, travels and transportation, decrease in time consumption required for transport processes	Reduction of loss of time and energy of road transport users for journeys and transportation, growth in satisfaction with transport services

Source: Compiled by the author

economy of Ukraine. Considering the fact that the intelligent transport systems are information systems, they are subject to general theoretical and applied results obtained in the course of a wide range of researches and developments related to the problem of systems analysis and synthesis within the framework of such interdisciplinary scientific areas as systems theory, system analysis, systemology, etc.

As previously stated, the discrepancy in the quality indicators (efficiency, environmental safety, user convenience) is a major drawback of the transport sector of Ukraine. Therefore, the goal of the creation of the integrated ITS is to improve the quality indicators of the transport sector by using modern informational and navigational means.

Each of the presented indicators has a different impact on the economy, policy and social situation of Ukraine. Table 2 shows the impact of the creation of the integrated ITS on political, economic and social situation in Ukraine

Therefore, it may be rational to develop the concept of a universal multifunctional integrated ITS that provides solution of the full range of problems.

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