



### Results of International Research

## HIGH CAPACITY ROBOTIC URBAN traffic system

The increase in motorization and transport mobility of the population has led to increase of the city streets transport flow, causing reevaluation of principles of traffic management, as well as an incentive to develop new forms of public transport. Statistical data of traffic on the main streets of the United States and Europe show that people spend (on average) from 1 to 2.5 hours a day to move around the city. That causes significant interest in improving traffic management and public transport in the city roads and main streets. The annual increase in the traffic load on the main highway is leading to a steady decrease of transport speed and the creation of traffic jams.

Private transport is not able to provide a high capacity as each car moves with an average of 1.2-1.5 person[1]. Therefore in order to avoid traffic jams it is necessary to unload the transport lines by expanding the performance of ground public transport approaching the performance of the metro. The costs of metro construction are too high (1km. of metro costs 40-60 mln. dollars) [2].

Transport with high performance should not interfere with other traffic participants or with the road network infrastructure, for example traffic lights. Achieving such an effect may be done by the diversification of different traffic flows through the levels. Hence, accordingly we have an underground, ground and elevated transport. The last one moves using overpasses. Construction of overpasses is about 4-8 times less expensive than construction of underground transport (metro). And from the standpoint of the safety of passengers such trucks are much safer than the subway. But elevated transport lines badly fit in urban infrastructure and

distort the appearance of the city.

Thus, ground public transport with mass transportation of passengers is the best alternative urban transport of the future. Is it possible under conditions of intense ground transport flow? Oddly enough, but the answer is yes.

In this work we propose a new type of urban public transport - based on robots and information. It is capable of operating in an intensive environment of the streets and roads without interference from the other vehicles and also of transportation of the large numbers of passengers comparable to the subway. In contrast to the metro this type of transport is more energy efficient, as there are no escalators to move passengers to a station and to lift them from it.

The proposed type of transport is a system in which information processes (information gathering, information processing, decision-making) are carried out continuously and form the basis of the information transport systems. Violation of any of these processes, making the system unworkable. The vehicle in such a system is an electric car (without driver) called infobus with ability to carry up to 50 people. In contrast to the known means of passenger transport (bus, trolleybus, tram, etc.) that operate autonomously INFOBUS can only function as part of an information transport system.

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## Road Safety Statistics

## A Brief Analysis of Accidents in the Republic of Belarus and Abroad

Road traffic accidents (RTA) are a major global threat to the people's health and lives. The damage from the accident exceeds the damage from all other transport accidents (aircraft, ships, trains, etc.) combined. According to the WHO Global status report on road safety 2015, every year 1.2 million people are killed in road accidents worldwide and about 50 million are injured of varying severity. In the study of road safety it is necessary to identify the factors affecting the frequency and severity of accidents.

In the Republic of Belarus, the accident rate is also the most difficult and tragic loss in traffic. If economic and environmental losses are evenly distributed among all the members of society, then safety losses focus on all individual members of the movement.

In order to improve traffic safety and reduce accident rates on the roads within the Republic the Concept of ensuring road safety is applied, which mainly aims to reduce the number of deaths and injuries in road traffic accidents. A similar strategy was developed in all developed and developing countries. To obtain a general idea about the level of accidents in Belarus and the countries of the European Union and North America (USA and Canada), based on data obtained from public sources [1] was a comparative analysis of injury accidents. Criteria for comparison considered in the study are the population density and the number of inhabitants in the countries under consideration (Figure 1).

Country	Number of inhabitants, million (2015)	Population density, pers./sq.km
Belarus	9,48	45,7
Austria*	8,58	100,2
Denmark	5,67	126,4
Portugal*	10,43	114,0
Belgium	11,24	365,0
Lithuania**	2,91	49,0
Poland*	38,48	123,0
France	64,20	116,0
Italy**	60,78	201,1
Spain	46,51	91,5
Germany	80,78	229,0
Finland	5,47	16,0
Sweden*	9,77	21,9
Greece*	10,99	85,3
Great Britain	64,31	246,0
USA**	318,62	32,0

Based on the selected criteria analysis can be noted that the closest population densities correspond Italy, Lithuania and the USA, and the number of inhabitants of Austria, Portugal, Poland, Sweden and Greece (highlighted in light blue on Figure 1). One important relative incident rate can be called the number of accidents per 1000 vehicles (Figure 2).

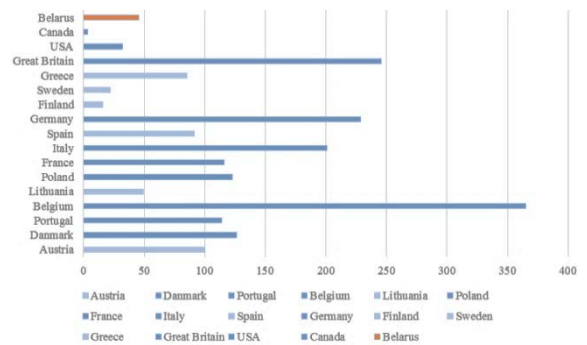


Figure 1 – Distribution on population density in the countries of Europe, North America and Belarus

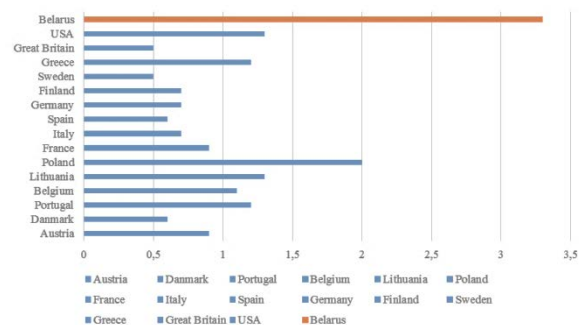


Figure 2 – Distribution of the proportion of road accident victims in the countries of Europe, North America and Belarus per 10,000 vehicles (data for 2012)

Unfortunately, in this comparison, our country takes the leading position in the number of accidents. That probably indicates oversaturation of cars, particularly in cities (according to the source [2] the highest number of accidents with victims occurs in settlements).

As for the comparison for killed in road accidents, the distribution of accidents is comparable with countries close to the Republic of Belarus on the criterion of population density, such as Lithuania and the USA, although it is worth noting that in Italy the rate was much lower (Figure 3).

According to the analysis in our country you can mark the highest level of severity of the consequences of accidents with victims, more than 1.5 times higher than that in Lithuania (the nearest rate among examined).

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## International Best Practices

# Establishment and development of intelligent transport systems based on automated traffic control systems

Due to the constant growth in demand for transportations which is due to the development of the economy, there is an increase in the fleet of vehicles, as three quarters of the total scope of transport services are accounted for highway transportation.

Highway transportation helps people in all fields of their activity, while creating a lot of problems, which resolution requires more and more attention. That is why more attention should be paid to the integration of systems and creation of unified intelligent traffic control systems of various levels of hierarchical subordination.

## Current Systems

Since 1981, the city of Minsk has been operating an automated traffic control system "CITY-M1" which at present includes about 400 traffic lights.

ASMD-A (Automated System of Bus Management Dispatching) carries out traffic logging and optimization on public transport.

Automation of control over the rest of the urban transport, taxis and car-parking is not carried out. Thus, the situation with the integration of automated systems in the field of transport is relevant.

Especially since there are attempts to combine the Automated Traffic Control System which modernization started in 2002, with route orientation systems, specialized public transport pass, including trams, travelling across railway crossings and regulatory systems.

## Establishment of Intelligent Systems

In the nineties of the last century many countries of the world (US, Japan, Western Europe) started to implement the projects of intelligent transport systems – "*Intelligent Transport System*". Many European countries use the term "*Telematic Systems*".

The establishment of such systems is based namely on the integration of information and control systems which were established separately but are associated with road transport and are subject to the same goal - to improve the efficiency of the road transport.

As part of these systems, nowadays issues of improving road safety, reducing the environmental impact on the environment, improving the quality of transport services, improving the road quality in general, and so forth are separately resolved.

## Development Prospects

The developed intelligent transport system is advisable to create on the basis of the automated traffic control system (traffic ACS).

The automated traffic control systems are constantly being improved in various ways, developed in the territorial and functional terms and upgraded (due to technical and mathematical services).

Today we can say that:

- new computing resources and data communication equipment are introduced;
- advanced communication lines are used (for example, cellular and satellite channels);
- detectors of different types of transport are actively set (according to the operation principle and sensitive elements);
- there is build-up of intelligent capabilities of the used traffic controllers;
- multistage remote-controlled road signs, variable speed signs, warning boards are introduced;
- more appropriate models to describe the traffic flow are applied and software and algorithmic support are improved.

In some areas the Automated Traffic Control System provides adaptive control of traffic light signaling online. However, unfortunately, this is not referred to the entire road network (not all the traffic lights are included in the system or equipped with detectors). Also, only the Minsk ring highway has an automatic drivers informing about traffic conditions, as well as, in part, about long-distance routes.

As it can be seen, a clear disadvantage of the system is the lack of public transport control (especially control over the trams, as in 70% of the cases the passengers get in and get off the public transport from the sidewalk) and parking lots and public transport stops. Control over them will relieve the city center and increase the carrying capacity of individual major highways.

The traffic control system being perfected should also provide an automatic identification of traffic accidents (their fixation) for the emergency call of rescue services and the arrangement of bypass routes by informing drivers about road and traffic conditions.

The development of detection systems will allow monitoring the compliance of the road users with the existing restrictions (for example, video detection), providing timely information to drivers about traffic conditions, and monitoring the speed of traffic flow (use methods of traffic calming).

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## International Best Practices

# A classification of driver assistance systems

Driver assistance systems seem to have a considerable potential for road safety and traffic efficiency improvement. At present the use of driver assistance systems presents a rapidly growing industry as these systems are expected to improve road safety, increase road capacity and attenuate the environmental impacts of traffic. The advent of new technologies supporting vehicle intelligence (e.g. sensors, transmitters, communications and computers) makes the use of driver assistance systems less unapproachable to the wide public, allowing for safer and more efficient driver experiences. Driver assistance systems support the modification of the driving task by providing information, advice, and assistance, they influence directly and indirectly the behaviour of users of both equipped and non-equipped vehicles and alleviate accident consequences by in-vehicle intelligent injury reducing systems (Naniopoulos, 2000). According to the literature, the classification of such systems follows either a system oriented approach or a user oriented approach, fully responding to the increasing complexity of driver assistance functions. Based on the road safety features examination, the distinct phases in the accident process are often used for the classification of the driver assistance systems (Heijer et al 2000).

On the other hand when functional analysis of the driver assistance systems characteristics is attempted, these systems are initially classified according to the type of user (individual driver, professional driver, fleet owner, elderly drivers, etc.). Inevitably these systems are classified according to the levels of driver tasks they are supporting.

Although these kinds of classification fail to provide answers on the usefulness of driver assistance systems, as the impact to traffic efficiency and road safety is not taken into consideration, the present paper aims to outline these two different approaches on driver assistance systems where priorities for future developments can better be identified.

## Classification of driver assistance systems based on the distinct phases in the accident process

Driver assistance systems have the potential to improve road safety by influencing traffic exposure, by reducing the probability of

crashes and by reducing injury consequences. Towards this direction, a fundamental classification of these systems consists of certain advances during the following accident phases:

- pre-crash
- crash
- post-crash

### 1. Pre-crash phase

During the pre-crash phase, the driver assistance systems are mainly focused in the support provided to the driver in terms of information, perception, convenience, and (driver – vehicle) monitoring.

The classic systems for driver information are those related to navigation routing, which provide location and route guidance input to the driver (Srinivasan and Jovanis 1997). A number of integrated navigation systems have emerged in the past years, supporting the driver through a variety of additional services, such as signing, warning or even intervening in the driving process (e.g. by temporarily taking control of the vehicle), in the event of unsafe driving conditions, such as unsafe travel speed for the geometry ahead. No significant traffic efficiency impact is anticipated from these systems as speed and headway benefits are not expected to be considerable. **Real time traffic and traveler information** systems combine the information available to users of traditional navigation systems with real time travel-related information, which they receive from the infrastructure (e.g. through dedicated radio channels, roadside beacons or wide-area transmissions).

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Published by: Research Centre for Transport and Logistics - "Sapienza" University of Rome.

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