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Assessment and Development Problems of Smart City Transport and Logistics System

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ABSTRACT
Today in the world there is a pronounced trend towards the development of smart cities, the movement of economic resources in which is hampered by the growth of urbanization, population, and motorization. At the same time, within the framework of sustainable development, a trend of development of intelligent transport systems that increase mobility in the city was noted. Huge resources are allocated for these purposes, R&D is carried out and the corresponding transport and logistics, digital and intelligent infrastructure is being formed. The most important indicator that allows you to assess the efficiency of stream processes in the city is congestion, which, with the development of these systems, can be controlled and predicted. But, even these efforts are not fully effective because the congestion index remains in rather high ranges, and affects additional time costs for all participants in sweat processes. The development of an intelligent transport system as part of a transport and logistics system has a positive effect on the formation of a mobility map in the city but requires coordination with the logistics complex, as well as a transition to a new technological level. This transition is possible when building a streaming model of the smart city transport and logistics system, which will assess the feasibility and efficiency of using the current infrastructure and building a new one with the development of cooperative and autonomous transport systems as the next stage in the formation of smart cities.
Keywords: *smart city, transport and logistics system, mobility card, congestion, intelligent transport system, logistics*

1. INTRODUCTION

Current processes and trends taking place in the modern economy allow us to conclude that there is an accelerating change in the usual relations of 'producer-consumer', 'employer-employee', 'human-computer', and 'state-person'.
As part of sustainable development and the formation of smart cities [1-5], modernization programs are being implemented everywhere: information and communication technologies [6-9] are being introduced into all spheres of human life, improving the quality of life in the city [5;11-12]. There is a concentration of efforts and the development of methodologies related to the technical systematization and formalization of information for the organization of stream processes in the city. At the same time, the concept of technological improvement of algorithms and methods of collecting information for automated decision-making on managing processes in the city is being implemented [8-9]. These technologies [6-9], combined with the development of appropriate infrastructure [11-14], will form a modern smart city transport and logistics system, but the trends in their formation today lag behind the necessary needs of modern cities.
It is impossible to correct the bank by ensuring structural changes in the economy, in particular in the transport and logistics system [3; 5-6; 14-16], without introducing new methodological approaches, developing a unified system for assessing sweat processes, and developing radically new solutions for their optimization.

2. METHODOLOGY

For a smart city, the most important are the smart economy [17-18], smart environment, smart management, smart mobility, smart residents, and smart life in the development of infrastructure, including network, and information and communication technologies (Figure 1). Moreover, each of the criteria in the given category in the form of a structural [16; 19] indirect connection affects the development and functioning of the smart city transport and logistics system. At the same time, the rating approach acts as the main consolidated system composed of indicators that are ranked by development categories, in particular, in the field of assessing flow processes.
Existing assessment indices (IESE Cities in Motion Index, Global Power City Index, Juniper Research, EasyPark Smart City Index, etc.) reflect many indicators that are similar, they can also be attributed to any modern city and reflect the dynamics of its development in the field of economics, social and human capital, governance, environment, technology and other areas.

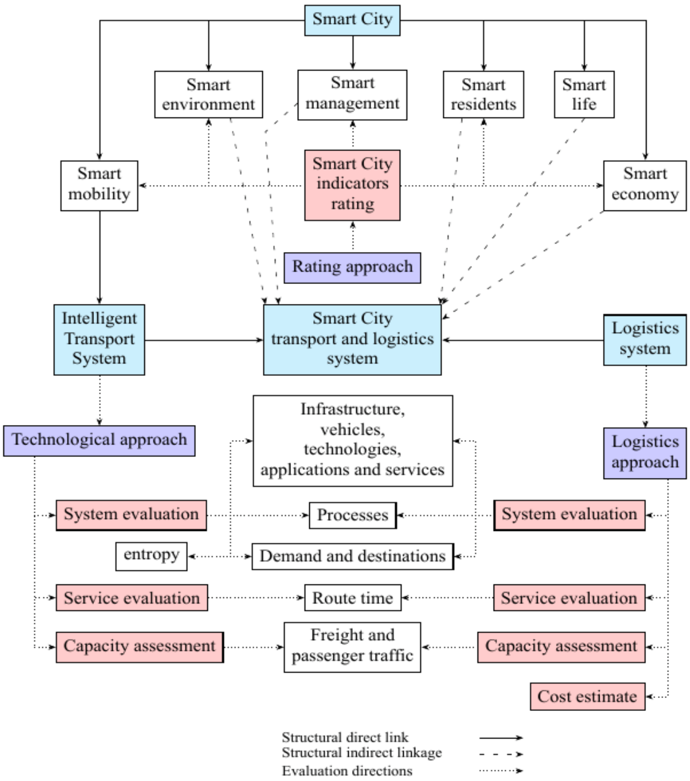

Figure 1 Directions of methodological approaches of evaluation of smart city transport and logistics system

They also allow you to classify a city as 'smart' in the direction of 'mobility' (or 'accessibility'). At the same time, each index differs in research directions, calculation methods and cities under study (Table 1).

Table 1 Main systems for evaluating the smart city transport and logistics system

Index (number of evaluation cities)	Assessment direction
IESE Cities in Motion Index (174)	Mobility and transportation this is the tracking time spent on traffic, traffic inefficiencies, travel time to work, etc.
Global Power City Index (48)	Accessibility is international cargo flows, the number of air passengers, the use of public transport, congestion, etc.
Juniper Research (20)	Mobility is the average vehicle speed, private vehicles per capita, congestion charges, injuries per capita, air quality, public transport per capita, etc.
EasyPark Smart City Index (EPSI) (100)	Transport and mobility is the availability of parking applications and places in the city, the number of car sharing services, levels of congestion, the percentage of people satisfied with public transport services, etc.)

At the same time, the 'mobility' direction of the technological approach [4; 5-9; 13-17], which is similar in content and has a direct structural connection, is characterized by the following conditional functional areas and assessment indicators:

– airport (number of arrivals per year, cities with direct connections, runways, the total annual number of arriving / departing passengers, average travel time from a major airport);

– individual transport (personal vehicles per capita), public (percentage of people satisfied with the services), commercial (the number of registered vehicles, cars belonging to shared use, the number of car-sharing services);

– cycling (the development of the rental system, percentage of bicycles per family);

– metro, rail transport and tram (the number of stations, length, and density of lines);

– high-speed movement (presence or absence);

– parking (the availability of parking applications and user penetration, number of parking spaces in the city center per km^2);

– electrification of transport (the number of electronic charging points);

– smart transport initiatives (smart phasing of traffic lights, strategies to reduce vehicle use, increase public transport use, interagency cooperation, road safety, open transport data);

– traffic (tracking the time spent in traffic jams, the average travel time from home to work, the cost of a taxi).

In general, the city's TLS as an integral part of the transport and logistics system of the country (region) is assessed in the following areas: physical availability of infrastructure, financial availability of services, convenience and safety for participants in flow processes, the efficiency of the entire management system, as well as the degree of implementation of elements of intelligent transport a system in which the logistic approach is applied from movement control (transportation), but does not take into account all flow processes in a single smart city transport and logistics system.

The use of a logistic approach will make it possible to determine the necessary components, prospects for use and development, and ensure the most efficient operation of the existing intellectual infrastructure.

The key direction of assessment in the field of organizing streaming processes today is the congestion indicator of the smart city TLS, and in this situation, intelligent transport systems can reduce this indicator, as well as:

– reduce the high mortality rate in transport;

– to ensure the growth of consumption of non-renewable resources;

– solve environmental problems;

– reduce delays in the transportation of people and goods;

– ensure the efficient use of the current infrastructure and the construction of a new one;

– improve the quality of management of sweat processes.

3. RESULTS

Today, many cities in the world in the context of the scientific paradigm of sustainable development today are gradually introducing some elements of intelligent transport systems [19-23]:

– automatic monitoring and traffic management on roads, which involves the use of sensors, cameras, ‘smart’ traffic lights and road signs (Automated Traffic Management System or ATMs);

– emergency management;

– public transport management;

– informing passengers and drivers on the best travel routes and parking places;

– freight transport management;

– an automatic collection of payments and a unified payment system;

– traffic control in difficult weather conditions (anti-icing system, etc.)

According to the IESE Cities in Motion Index rating in 2020, the leading cities (Table 2) have a video surveillance system (Closed Circuit TV cameras or CCTV), special signs with variable messages (Variable message signs or VMS) and speed limits (Variable Speed Limit Signs or VSL), Advanced Passenger Information City System (APIS), which is designed to influence driver behavior by providing information about travel times for different route options, Electronic Toll Collection or ETC, Resident Information System public transport movement through information boards at stops, transport and through special services and applications, as well as a fleet management system (Fleet management systems or FMS), which allows you to control the location, route, vehicle fuel consumption, emissions and carry out diagnostics to check and diagnose problems and offer solutions, information collection system public transport occupancy rate (PIT). It should be noted that the most famous traffic and traffic light control systems Urban Traffic Control (UTC) or Area Traffic Control (ATC) are Sydney Coordinated Adaptive Traffic System (SCATS), SCRAM, GLIDE, Vehicle Information and Communication Systems (VICS), etc.

I-Transport as a project allowed Singapore [16] to integrate all management functions into an Integrated Transportation Management System (ITMS), as well as collect information in real time using J-Eye cameras (Junction Electronic Eyes) and sounding vehicles (mainly taxis) to collect information about road traffic real-time conditions (TrafficScan) and expressway monitoring system (EMAS), etc.

Many cities [13-14; 16-17; 23-26] have developed public transport management systems or Public Transport Information and Priority System (PIPT) and emergency response. Freight transport [27] is not allowed in the central part of the city during the daytime, the congestion management and weighing system in motion Weigh in Motion System or WMS is used. Congestion charging (CC) payment for freight transport has been introduced.

Table 2 Elements of an intelligent transport system for leading cities

City	Automated Traffic Management System	Payments	Environment
1. London	SCOOT, CCTV, VMS, VSL, APIS, FMS, PIT, PIPT, WMS	P, ETC, CC	LEZ
2. New York	S. I. College, CMAQ, CCTV, VMS, VSL, APIS, FMS, PIT, PIPT, WMS	P, ETC, CC	
3. Paris	PC Lutèce, CCTV, VMS, VSL, APIS, FMS, PIT, PIPT, WMS	ETC, CC	B
4. Tokyo	VICS, CCTV, VMS, VSL, APIS, FMS, PIT, PIPT, WMS	ETC, CC	B
5. Reykjavík	CATS, CCTV, VMS, VSL, APIS, FMS, PIT, PIPT, WMS	ETC, CC	
6. Copenhagen	CITS, CCTV, VMS, VSL, APIS, FMS, PIT, PIPT, WMS	ETC, CC	
7. Berlin	Balance, CCTV, VMS, VSL, FMS, PIT, PIPT, WMS	ETC, CC	LEZ, B
8. Amsterdam	KCC, CCTV, VMS, VSL, APIS, FMS, PIT, PIPT, WMS	ETC, CC	LEZ, B
9. Singapore	GLIDE, J-Eye, I-Transport, TrafficScan, EMAS, CCTV, VMS, VSL, APIS, FMS, PIT, PIPT, WMS, EMAS	P, ETC, CC	
10. Hong Kong	SCATS, CCTV, VMS, VSL, APIS, FMS, PIT, PIPT, WM	Octopus, CC	
87. Moscow	COOT, CCTV, VMS, VSL, APIS, FMS, PIT, PIPT, WMS	Strelka, Troika, CC	

Many cities are introducing a system of administrative restrictions (ban on entry, or car tolls - P) for the environmental situation and problems of congestion in cities, for example, the Congestion Management and Air Quality (CMAQ) system or analogues. Ultra-Low Emission Zones (LEZ) are created. Cycling is encouraged (B).

The unified payment cards Octopus, T-Money, Bus Rapid Transit, Strelka, Troika and other products are also being introduced. Systems for detecting fog, icing and road moisture, etc. are also being implemented.

Installed systems automatically detect the presence of pedestrians crossing the road, and, if necessary, allocate additional time for the walking phase (depending on age). For example, Pedestrian User Friendly Intelligent (PUFFINS), etc.

All cities form a transport and logistics system by population growth: public transport is developing, electronic payment for city services, a system for collecting and informing participants in streaming processes, city platforms and services.

The leaders in the development of intelligent transport systems can be called Japan, Singapore, South Korea, where intelligent transport systems were formed [16].

The coordinated and detailed work of the United States [23] in the development of intelligent transport systems today can be attributed to developing, which is supported by appropriations for their development. Noteworthy is the experience of the European Union [13-14; 17; 24; 26], which is developing in each country separately and fragmentarily, characterized by uncoordinated work in the development of the European Framework Architecture.

But congestion continues to grow due to continued urbanization, population growth worldwide, and the development of intelligent transport systems. The consequences of vehicle traffic are widespread, including air pollution, lost time and loss of life on the roads.

However, the emergence of new technologies, such as general micromobility and an increase in the number of people choosing to walk, cycle, and use public transport, has led to a rapid change in the mobility landscape, but not in all smart cities (Table 3). As a result, the congestion rate becomes more predictable and predictable, but during the peak time intervals from 6:00 AM to 6:00 PM, they still reach critical values (Table 4) in any city.

Table 3 Preferred ways to travel in the city,%

City	Homework	Walk	Auto	Bike	Motorcycle	Bus (Trolleybus)	Tram	Metro (Train)
London	5,96	19,27	11,01	9,17	1,83	9,17		43,58
New York	6,62	21,32	18,38	4,41		5,15		44,12
Paris	5,31	13,27	19,47	10,62	2,65	6,19	1,17	40,71
Tokyo	3,75	20,00	8,75	5,00		3,75		58,75
Reykjavík	1,61	14,52	72,58	3,23		8,06		
Copenhagen	2,54	16,95	12,71	38,98		11,02		17,80
Berlin	4,55	19,70	10,61	26,52		4,55	3,03	31,06
Amsterdam	4,94	17,28	16,05	40,74	1,23	2,47	2,47	14,81
Singapore	2,59	11,64	19,40	1,29	3,88	26,72	0,86	33,62
Hong Kong	3,57	18,57	12,86	0,71	0,71	30,71	2,14	30,71
Moscow	5,57	17,30	28,23	2,39	0,99	5,69	0,60	38,97

Table 4 Congestion of world cities, 2019

City	Congestia, max/year	Extra time daily, min		Extra time driving at rush hour, per year, hour
		In the morning	In the evening	
London	57/38	19	20	149
New York	59/37	16	21	142
Paris	78/39	22	21	163
Tokyo	71/42	20	19	139
Reykjavík	48/18	12	14	98
Copenhagen	48/22	14	14	105
Berlin	54/32	15	18	124
Amsterdam	61/26	13	17	112
Singapore	47/32	17	18	135
Hong Kong	54/31	17	17	131
Moscow	97/59	26	32	225

Congestion as a characteristic of streaming processes reflects the delay when moving around the city, the calculation of which is based on a time interval of 30 minutes. In other words, how much a traffic participant spends more time due to ineffective traffic organization. For all cities, the growth of time predominantly prevails on average up to 48% (14.4 minutes).

At the same time, the level of congestion for Smart Cities TLS is significant, and each participant in streaming processes additionally spends 98 to 163 hours a year in traffic jams.

The development of an intelligent transport system in a city is a necessary attribute of the formation of a smart city, and modern cities are following the path of creating the most favorable environment, introducing advanced digital technologies, changing the mobility map, speed, developing intelligent infrastructure, etc. But temporary losses in the city grow.

Let's agree with the statement that ‘a person is imperfect, but the transport and logistics system is not’. The basis for the development of Smart Cities TLS today should be their design based on a new technological approach, and an important aspect of the implementation of an intelligent transport system is government support, which should be expressed not only in financing, but in the development and implementation of standards, and in helping to organize procurement. installation, commissioning using systems engineering methods, training of specialists, etc.

4. DISCUSSION

In transport and logistics systems, the introduction of intelligent information systems can achieve the following results:

– growth of transport throughput - at least 25%;
– increase in cargo turnover - by 50-100%;
– optimization of the use of public transport - by 50%;
– increase in passenger traffic - by 20%;
– reduction of road traffic accidents - up to 60% on certain road sections.

According to the existing assessment of the transport and logistics system, the logistics system is not considered as an element of development, but is developing as an element of providing a ‘smart’ city. Foreign experience of the functioning of transport and logistics centers (or TLC) as elements of the city's TLS confirms their economic efficiency, which is reflected in the reduction of transportation costs by an average of 7-20%, for loading and unloading operations and storage of material resources and finished products - by 15-30%, total logistics costs - by 12-35%, as well as in accelerating the turnover of material resources by 20-40%, and reducing inventories by an average of more than 50%.

The results reflect only the minimum threshold of possible positive dividends for all participants in logistics flow processes. Scientists have not calculated the cumulative effect of organizing a modern Smart City TLS.

Continuing this idea, we note that the current trend in the creation and development of intelligent transport systems is one of the stages in the creation of a Smart City TLS. Providing integration with the logistics complex of the region, this approach will allow forming a unified streaming model, the optimization of which is possible during the transition to cooperative and autonomous intelligent systems using artificial intelligence technologies, neural networks, etc.

Let’s highlight the main directions in which the construction of a smart city TLS streaming model is developing:

– permanent change, development, and improvement of transport and logistics, digital and intellectual infrastructure;
– development of cyber-physical and intelligent systems;
– automation and robotization;
– improvement and creation of new approaches to the organization of movement (transportation);
– development of a technology accumulation mechanism that ensures production and creates new high-tech enterprises, sectors (industries) and training the necessary personnel;
– improving cooperation and coordination.

All of these large-scale areas are very costly and require a logistic approach to flesh out the bank of promising research for TLS many cities.

5. CONCLUSION

The development of a smart city presupposes the formation of a modern intellectual system, respect for the environment, as well as improving the quality of education and the level of human life. The ‘smartness’ of the city does not depend on the population in the city, and the set of services and technologies provided is determined by the problems that prevail in the city. At the same time, the problem of congestion in cities is common.

At the same time, the logistics approach is not fully reflected in the unified transport and logistics system of the city in the digital economy. At the same time, the development of a digital society imposes new principles, forms of future interactions, and relationships, which allows us to assert that a cardinal transformation of the smart city TLS will take place.

In this situation, intelligent transport systems, as an element of the smart city TLS, should also be transformed into cooperative and autonomous intelligent transport systems with deep integration with the logistics complex.

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