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IMPROVEMENT OF LOGISTICS SYSTEM
OF MUNICIPAL TRANSPORT MANAGEMENT

It is established that the use of the transport logistics theory in passenger transportation makes it possible to eliminate complex contradictions that arise, on the one hand, between passenger and transport enterprises, and on the other – between transport enterprises and society. It is theoretically proved that the use of logistical approaches in the organization of municipal passenger transportation gives a transport company advantages in the fight for the market and passengers, leads to lower costs and cost of services, improves the quality of service.

On the basis of the analysis of logistical approaches in municipal transport management, the improvement of logistics transport system is carried out, which, unlike the existing ones, characterizes branched multithreaded urban transport processes and systems and is built on the basis of modern information and computer technologies.

Keywords: logistics system, information and computer technologies, municipal transport, passenger transportation.

Relevance of scientific research. From a logistical point of view, municipal transport enterprises specializing in passenger transportation are quite specific entities that are characterized by the following features [1-4]:

- the process of passenger transportation takes place outside the territory of transport enterprise, which increases the requirements for control over the operation of the vehicle;

- the process of passenger transportation has high socio-economic importance;

- the need for passenger transportation depends on a number of stochastic external factors, which increases the influence of the control room;

- passenger vehicles are sources of increased danger, therefore the need to ensure the safety of passenger transportation is indisputable and has a priority over economic interests of carriers.

The external environment of the management system of passenger transportation is formed by the following factors: the area of the city, the number of places and guests of the city, their mobility, urban planning, the list and orientation of production enterprises, seasonality, etc.

All these factors are divided into [5]:

- controlled or uncontrolled by the passenger traffic management system;

- long-term or seasonal action;

- daily or hourly oscillation of the frequency of oscillation of passenger flows.

Such factors should necessarily be taken into account by the administration of the municipal transport enterprise in order to improve passenger transportation.

The municipal passenger transport market is characterized by high profitability and dynamism, which can be characterized as highly competitive, especially in small cities where the low standard of living of the population does not allow the use of taxis or private cars.

The increase in the number of carriers (including private carriers) requires the transport companies to attract additional reserves to account for the extensive multi-stream transport processes and systems within cities, which are built on the basis of modern information and computer technologies; improving transportation quality, safety and cost savings. Logistics and its principles, which underlie the activities of each organization, give the latter significant competitive advantages, and its introduction in the process of organization of passenger transportation gives the municipal transport enterprise significant advantages: reducing costs and cost of services, improving the quality of service, etc. [6-8].

The improvement of logistics system of an enterprise consists in reduced costs. However, if an enterprise does this on its own and in one of the subsystems, then there is a risk of worsening of the overall situation, which will eventually

lead to a reduction in costs in one subsystem and an increase in them in another.

Therefore, it is important to improve the logistics system of transport management for passenger transportation within the city.

The purpose of the study is to improve the logistics transport system, which, unlike the existing ones, characterizes the extensive multi-stream urban transport systems and is built on the basis of modern information and computer technologies.

Analysis of recent research sources. The use of logistics information systems as a tool in the passenger transport chain is quite widespread in various modes of transport, but insufficient attention is paid to their implementation on municipal transport.

On the other hand, increasing the number of trips of citizens of Ukraine in municipal passenger transport requires high quality and efficiency of passenger transportation through the development and practical implementation of appropriate organizational, technical and logistical-methodological measures (introduction of modern means of traffic, optimization of routes of transportation, dispatching control system computer technology, optimal coordination of different modes of transport, tariff optimization, etc.) [9].

Therefore, information support is proposed to be implemented at the level of logistics development [10-12]: for a motor transport enterprise (MTE) with a high level of logistical attractiveness – creation of an information logistics center (ILC); for medium-sized MTEs with logistical attractiveness – providing computerized control of dispatching services; for MTE with low level of logistical attractiveness –

providing dispatching services to the program management for optimization of decisions in separate functional areas. O. Bakaev, M. Bilyk, M. Grigorak, A. Kalchenko, E. Krykavskii, G. Kucheruk, O. Novikov, D. Novikova, L. Mirotin, M. Auckland, Yu. Nerush, V. Pidgornyi, V. Sergeev, A. Chukhray et al. [13-16] have researched topical issues of information logistics in transport: automation of workflow and EDI technology and have established the following. The streamlined information flows provided with the appropriate information and technical means together with the trained personnel make up the information infrastructure of the transport enterprise, the use of which will allow to streamline the movement of passenger flows, to optimize the loading of routes, to reduce material costs along the entire logistical movement of the vehicle.

At the same time, rational interaction of different modes of transport should ensure high-efficiency passenger transportation.

Improvement of logistics management system. Improvement of the logistics system of municipal transport management in this scientific research is complex and characterized in that the first stage audits the logistics of municipal motor transport enterprise and identifies zones and areas of efficiency gains, determines the indicators and sets the proportion of those improvements.

In the second stage, a set of organizational, technical, technological, methodological and information solutions is developed and implemented. In practice, this gives businesses a 10 % reduction in logistics costs.

Thus, the general scheme of improvement of logistics system of municipal transport management can be represented thus (Figure 1).
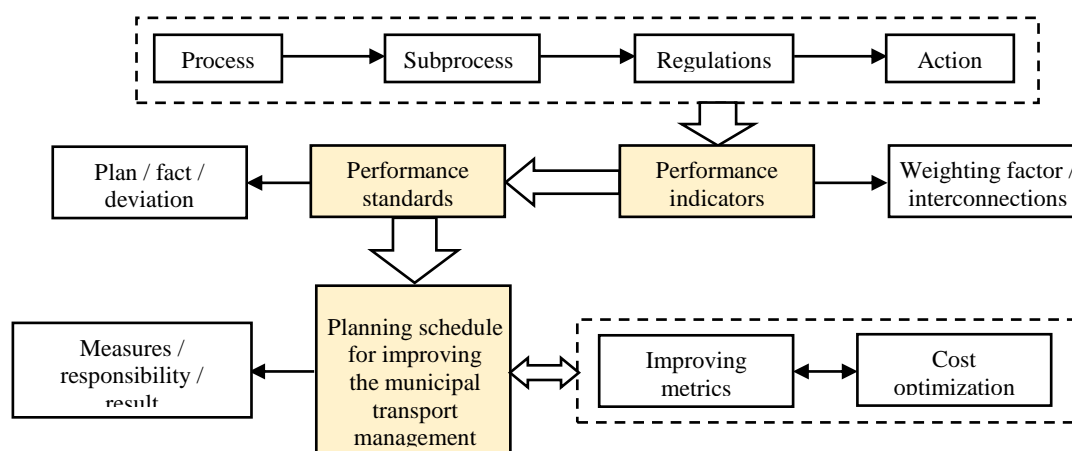

Figure 1 – General scheme of improvements of logistics system of municipal transport management

Based on the results of the evaluation of logistical approach at municipal transport enterprise, we will consider ways to improve these processes and evaluate their economic efficiency.

Development of measures to improve the work of an enterprise on passenger transportation is considered. In order to improve the municipal transport management and the organization of passenger transportation management, we will consider measures aimed at eliminating these problems by applying a logistical approach and drawing up a scheme of logistics system.

The scheme (Figure 2) should pay attention to such competence as "logistical information", which determines the most important strategic resource of logistics. Logistical information costs are reduced through more efficient management of information flows, increasing their speed and improving coordination, with the use of modern information and computer technologies.
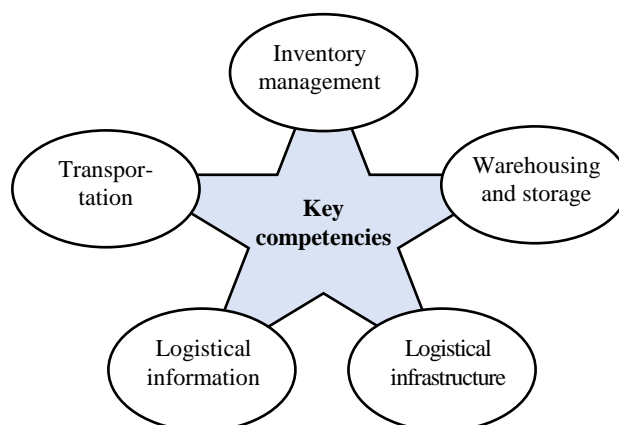

Figure 2 – Key competences of the integrated logistics system

Information resources of integrated logistics are represented as a kind of "tree" consisting of 12 basic elements (Figure 3).
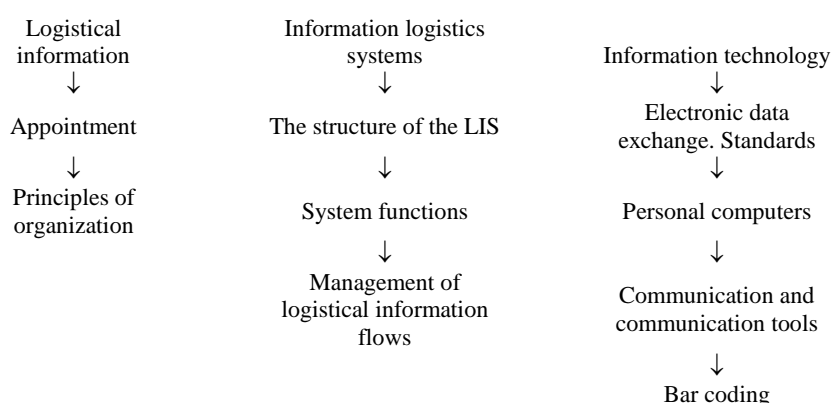

Figure 3 – Integrated logistical information resources

It is recommended to implement modern telematics solutions for managing both individual vehicles and transport parks as an information base in order to improve logistical approach of managing a transport enterprise.

So, the transport location and the status of its key parameters is determined by NASA's Global Positioning System (GPS). The information is transmitted to the dispatcher via various GSM digital communication channels – via the Internet or via SMS and displayed on an electronic map in real time.

The main possibilities of implementation of telematics solutions for the management of transport enterprises are shown in Figure 4 [17].

Dispatching. The dispatch service is a department that provides information services and acts as a coordinator of the passenger and carrier actions.

The main task of the dispatcher is to inform the carriers about the status of the route and the need to change it at different points in the service area. The greater the flow of information transmitted by the dispatcher is, the more convenient it is for the carrier to work with him, as the probability of timely adjustment of the route and the timetable is increased. This is especially evident in the dilution of extensive multi-stream transport processes and systems within the city. There is an optimization of the

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carrier's working time by reducing the vehicle's "empty" mileage. The complexity of the work of the dispatcher is the necessity to meet the needs of passengers in the fast, safe and accurate submission of transport and driver in the maximum occupancy.
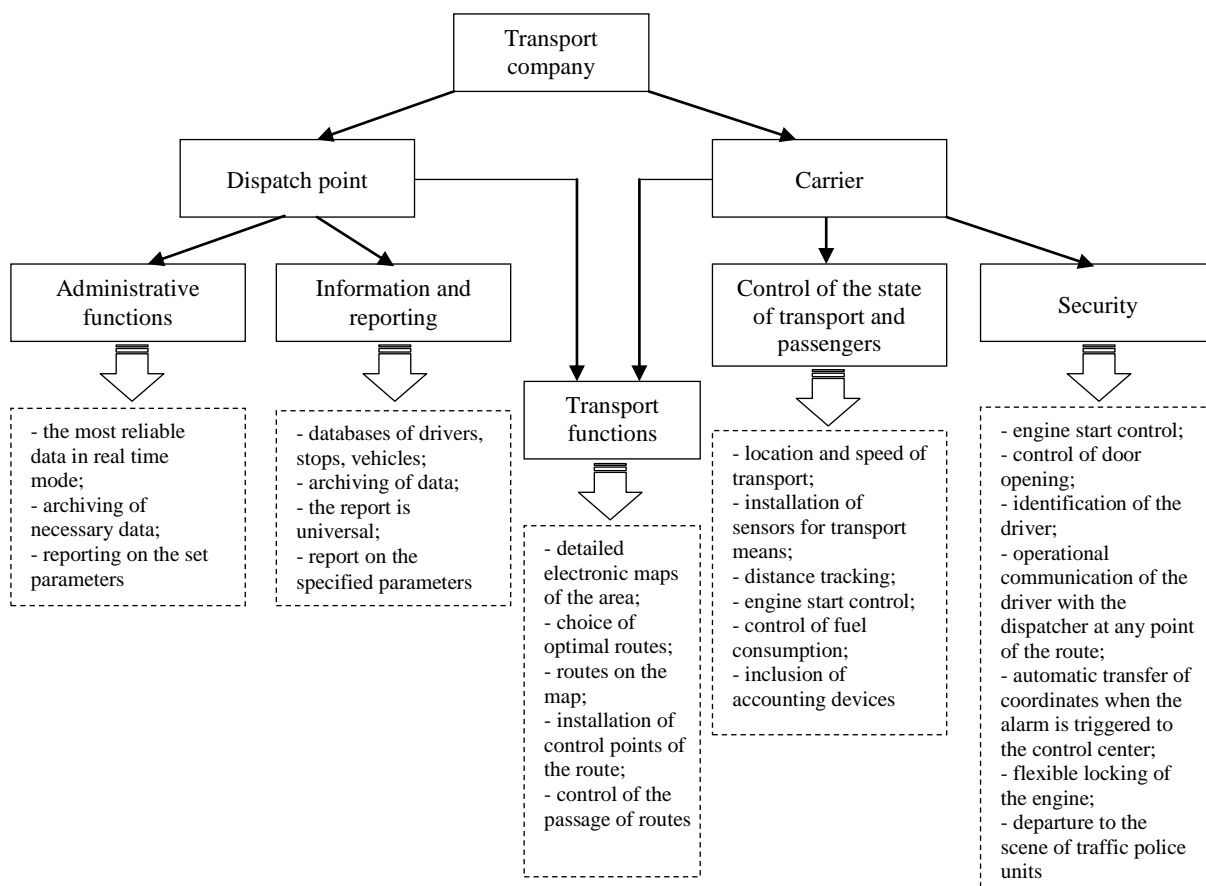
Figure 4 – Logistic scheme of the basic possibilities of application of telematics solutions for the management of transport enterprises

The automated system of dispatching management of passenger transportation by application of modern information and computer technologies allows to receive the following advantages [18]:

- control and implementation of transport companies plan of transport release on the line;
- automated distribution of transport on high demand routes;
- compilation of reports on the performance of drivers, dispatchers and transport companies.

Research of logistics management system. The construction of a transport service model is based on rational transportation routes and timetables, i.e. transportation routing. Routing is the most sophisticated way of organizing a flow that has a significant impact on the efficient use of passenger transport.

As a rule, there is no separate, dedicated logistics service for most municipal transport companies. Creating your own logistics service requires the enterprise and its management a whole complex of solutions in parallel related tasks. Thus, it is possible to distinguish the following general recommendations in the framework of creating a logistics service and its effective functioning in the transport enterprise.

There are following ways of improving the logistics system for managing municipal passenger transportation as strategic measures:

- further improvement of the dispatching management of the transport system;
- release of rolling stock of different capacity and class;
- change in the number of rolling stock depending on the forecast demand;
- operative change of the duration and interval of movement on the basis of constant

monitoring of the state of passenger transportation.

The optimal timing of vehicles is determined on the example of municipal bus route No. 25 at the section of the Second Microdistrict stop – the Trade House stop, Cherkasy.

For this purpose, a network graph is drawn up, showing the technological connection and the sequence of works (Figure 5).
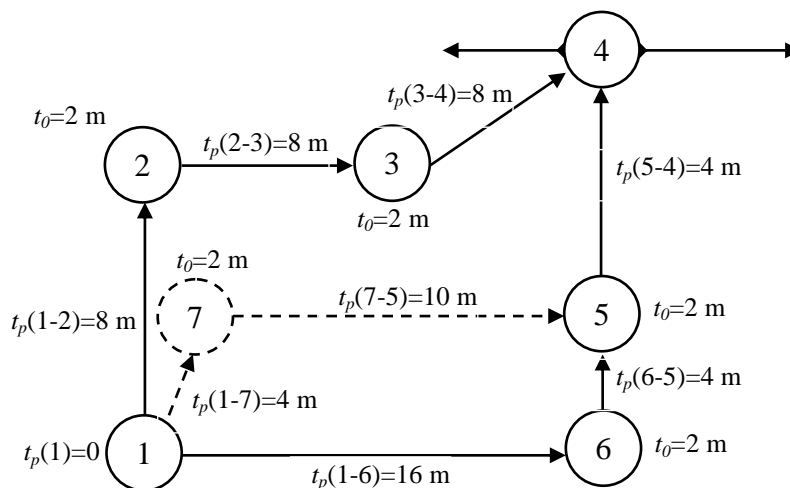

Figure 5 – Network schedule of the logistics system of municipal transport management on route No. 25 at the section of the Second Microdistrict stop – the Trade House stop, Cherkasy

Each node corresponds to a specific event, which is the completion of each stage of work. Each "edge" corresponds to a certain action, understood as a process, not the end result.

For example, the edge 0-1 defines the base route and its area of operation, this action ends at node 1. For each area of action, the duration is indicated, which is indicated on the "edges" of the graph in minutes.

The meaning of the schedule is to display all transport links along the route of transportation. In the case of finding an alternative route (which does not exist at the time of calculation) we use the "dummy route" (in Figure 5 they are indicated by a dotted line).

Let us calculate for our example the duration of possible and alternative municipal passenger routes at the section of the Second Microdistrict stop – the Trade House stop, that is, of the entire cycle of the agreed passenger transportation schedule.

To do this, enter the following notation: i, j are event numbers (event i is preceded by event j); $t(i - j)$ – duration of action; $t_p(i)$, $t_p(j)$ is the earliest term of event completion i or j; $t_n(i)$, $t_n(j)$ is the latest term of event i or j.

The term of completion of any j event can be determined by the maximum value of the earliest amount of completion of the previous event and its duration:

$$t_p(j) = \max \{t_p(i) = t(i-j)\}. \qquad (1)$$

Two directions will be obvious: 1-2-3-4 and 1-6-5-4. Both routes converge at point 4.

In calculations in the direction 1-2-3-4 assume that the earliest completion date of the initial event is zero, i.e. $t_p(1) = 0$. Then:

$$t_{\mathrm{p}}(1\text{-}2) = t_{\mathrm{p}}(1) + t(1\text{-}2) = 0 + 8 = 8 \text{ min.}$$

For the second event, the previous event is event $t_p(1\text{-}2)$. Its completion date is defined as follows:

$$t_{\mathrm{p}}(1\text{-}3) = \max(t_{\mathrm{p}}(1) + t(1\text{-}2) + t_0 + t(2\text{-}3)) = \\ = 0 + 8 + 2 + 8 = 18 \text{ min.}$$

Similarly, for the third event:

$$t_{\mathrm{p}}(1\text{-}4) = \max(t_{\mathrm{p}}(1) + t(1\text{-}2) + t_0 + t(2\text{-}3) + t_0 + \\ + t(3\text{-}4)) = 8 + 2 + 8 + 2 + 8 = 28 \text{ min.}$$

Here, t_0 is the idle time of the vehicle at intermediate stops.

The calculation for the direction 1-6-5-4 is carried out in the same way:

$$t'_{\mathrm{p}}(1\text{-}4) = \max(t_{\mathrm{p}}(1) + t(1\text{-}6) + t_0 + t(6\text{-}5) + t_0 + \\ + t(5\text{-}4)) = 16 + 2 + 4 + 2 + 4 = 28 \text{ min.}$$

As you can see from the previous calculations, the time spent in both directions (1-2-3-4 and 1-6-5-4) is the same – 28 minutes.

Considering the time spent on the alternative route 1-7-5-4, we get the most rational route equal to:

$$t''_p(1\text{-}4) = \max(t_p(1) + t(1\text{-}7) + t_0 + t(7\text{-}5) + t_0 + t(5\text{-}4)) = 4 + 2 + 10 + 2 + 4 = 22 \text{ min.}$$

The implementation of all the measures described earlier requires a large financial investment from the transport company, which requires an assessment of their effectiveness and return. Therefore, let us further determine economic effectiveness of these measures.

Cost effectiveness of the proposed measures. Let's consider changes in technical and operational performance of enterprises under the implementation of measures, i.e. the use of alternative route 1-7-5-4 (Table 1).

Table 1 – **Changes in technical and operational indicators as an example of the use of an alternative route in the direction 1-7-5-4**

Characteristics	Normative value	Route in the direction of the Second Microdistrict stop – the Trade House stop	
		Prior to implementation (direction 1-2-3-4)	After implementation (direction 1-7-5-4)
Number of passenger transport in municipal transport per 1000 inhabitants	1,28 – 1,52	3,7	2,24
Stop density for 1 km	0,87	0,45	0,48
Flight time, min	27 – 34	53	27,6
Route range, km	6,7 – 8,0	12,06	7,3
Coefficient of passenger service culture	0,75 – 0,85	0,04	0,20

When evaluating cost-effectiveness, a culture of passenger service is a must:

$$K = 1/Pg, \quad (2)$$

where Pg is the number of complaints received from passengers.

The value of this indicator according to 2018 assessment is 0.04. The indicator for 2019 at the initial stage of implementation of measures – 0.20.

To further evaluate the proposed measures, we will estimate the costs of their implementation and their effectiveness using the project profitability index.

Finding the Profitability Index – PI. The profitability index of a route characterizes the efficiency of investments – the more its value is, the higher is the return of each invested hryvnia.

PI is calculated as follows:

$$PI = \frac{PV}{I_0} ; \quad PI = \sum_t \frac{CF_t}{(1+r)^t} \Big/ IC . \quad (3)$$

There are three possible values for this metric:

- $PI > 1$ – the rate of return exceeds the investment: the route should be taken;
- $PI < 1$ – route does not provide the proper level of profitability: route should be discarded;
- $PI = 1$ – investments are not profitable: the route is neither profitable nor unprofitable.

In this case:

$$PI = P \cdot C \cdot H \cdot a \cdot k / 1{,}25 c I = 7{,}91,$$

where P is the annual passenger flow, $P = 2\,150\,000$ people; H – average occupancy, $H = 0{,}75$; $C = 5$ UAH – fare; $k = 15$ hours – working shift; a – number of passenger seats per 1000 inhabitants (see Table 1, $a = 2{,}24$); C – time spent on the flight, (see Table 1, $c = 27{,}6$ min); I – the amount of investment invested (the cost of a new Bogdan A069 bus), $I = 1\,588\,000$ UAH [19].

Since the $PI = 7.91 > 1$, so the 1-7-5-4 route is cost effective. Moreover, even if the size of the investment is multiple of the cost of the seven new buses ($PI = 1{,}13 > 1$) – the project will still remain cost-effective.

Conclusions. Thus, the involvement of the theory of transport logistics in the process of passenger transportation can eliminate the contradictions between passengers, transport companies and society.

Increasing the number of carriers requires motor transport companies to use a variety of methods to further improve the quality of transport, reduce their cost and more. In general, the principles of logistics that are put into the organization of the organization's activities give it sig-

nificant advantages over its competitors. There-fore, the use of logistical approaches in the activities of a municipal transport enterprise gives the latter significant advantages in the fight for the market and passengers, and also reduces costs and cost of services, improves the quality of service, etc.

The logistics system of municipal transport management in Cherkasy, which is characterized by the ability to characterize the extensive multithreaded transport processes and systems within the city, has been improved and is based on modern information and computer technologies. The network schedule of the logistics system was developed at the site of the Second Microdistrict stop – the Trade House stop, which calculated the duration of traffic on two main and one alternative routes. It also calculates a profitability index that demonstrates the feasibility of using an improved municipal logistics management system to find alternative routes that are more efficient than actual ones.

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УДОСКОНАЛЕННЯ ЛОГІСТИЧНОЇ СИСТЕМИ УПРАВЛІННЯ МУНІЦИПАЛЬНИМ ТРАНСПОРТОМ

Встановлено, що застосування теорії транспортної логістики в пасажирських перевезеннях дає можливість усунути складні протиріччя, які виникають, з одного боку, між пасажирськими і транспортними підприємствами, а з другого – між транспортними підприємствами і суспільством. Збільшення кількості перевізників вимагає від автотранспортних компаній використовувати різноманітні методи для подальшого поліпшення якості транспорту, зниження його собівартості тощо. Теоретично доведено, що застосування логістичних підходів в організації муніципальних пасажирських перевезень дає транспортному підприємству переваги в боротьбі за ринок і пасажирів, веде до зниження витрат і вартості послуг, поліпшує якість обслуговування.

Метою дослідження є удосконалення логістичної транспортної системи, яка, на відміну від існуючих, характеризує розгалужені багатопотокові міські транспортні системи та побудована на базі сучасних інформаційно-комп'ютерних технологій.

На основі аналізу логістичних підходів в управлінні муніципальним транспортом проведено удосконалення такої логістичної транспортної системи. Так, удосконалено логістичну систему управління муніципальним транспортом на прикладі м.Черкаси, яка відрізняється можливістю характеризувати розгалужені багатопотокові транспортні процеси і системи в межах міста та побудована на базі сучасних інформаційно-комп'ютерних технологій. Проведено розробку мережевого графіка логістичної системи на ділянці зупинка «Другий мікрорайон» – зупинка «Будинок торгівлі», за яким розраховано тривалість руху за двома основними та одним альтернативним маршрутами.

Також розраховано індекс рентабельності, за яким доведено доцільність використання удосконаленої логістичної системи управління муніципальним транспортом для пошуку альтернативних маршрутів, що є більш ефективними порівняно з дійсними.

Ключові слова: логістична система, інформаційно-комп'ютерні технології, муніципальний транспорт, пасажирські перевезення.