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PROBLEMS AND PROSPECTS FOR THE IMPLEMENTATION AND DEVELOPMENT OF SMART ACCOUNTING SYSTEM AT MUNICIPAL TRANSPORT

The aim of the article is to research of problems and prospects of implementation and development of smart accounting system in urban passenger transport. Today's conditions there is an urgent need to create and implement a unified automated payment system in all cities of Ukraine without exception. The automated payment system for payment in the city public transport vehicle is intended to simplify the payment control and registration of travel on the basis of advanced information technologies. The main tasks of implementing such a system are: creation of a single transport space with the standardization of the means of fares; possibility of flexible tariff policy; maximum increase of transparency and accuracy of the accounting of actually provided services for the carriage of passengers, in particular, privileged ones; providing complete, reliable and detailed information on the performed transport work to solve the tasks of analysis and planning of passenger transportation, etc. Automated fare system is the most effective way to increase income collection and reduce the number of non-billable passengers at the expense of complete automation of sales processes for travel documents, collection and accounting of proceeds, and also control of passenger's passage. The introduction of the system implies that stops and rolling stock of public transport are equipped with turnstiles and read-out devices for travel documents. Data on the transportation of passengers electronically through a centralized control system comes directly to the server processing of transport transactions. The automated payment system covers not only privileged categories of citizens and users of season tickets, but also buyers of one-time ticket tickets for cash. Replenishment of the transport card account (e-purse) and the purchase of a one-time ticket is carried out both in ordinary cash desks, as well as in payment terminals or vending machines for selling tickets, as well as via the Internet or mobile applications. This system, in combination with organizational and technical measures, enables to organize a complete automated accounting of each passenger in a single system, regardless of the types of ticket carriers and transport cards, as well as from forms of payment of travel, including payment for cash, cashless payments and all types of contactless payments. Passengers, the introduction of an automated payment control system will have the following benefits: the system of transport of passengers is established; comfort and convenience in payment of travel; socially fair tariffs; availability of travel documents that satisfy the needs of passengers as much as possible; the possibility of using one card in different modes of transport;

improving the quality of service through the information provided by the system. In further research, it would be worth paying attention to the information component of the implementation and development of the smart metering system in urban transport, since this area of research is still developing in Ukraine. Recent attempts to introduce technologies such as an e-ticket or a citizen's map did not make much progress in terms of information support and technical devices. That is why researching technological opportunities in modern economic conditions is very relevant.

Keywords: smart accounting system, municipal passenger transport, automated fare-payment system, modern intelligent systems.

Introduction. Optimization of municipal passenger transport (MPT) and transport infrastructure functioning, transport enterprises efficiency and the provision of high-quality transport services to the population embody a complex social and economic task, which solution requires fundamentally new theoretical and practical approaches.

In Ukraine, these recent decades both destruction and demolition of municipal passenger transport infrastructure, machinery and equipment took place; stated is insufficiently rapid rate of new technical means and technological solutions introduction. The transport policy in MPT field does not stimulate the efficient work of this domain's enterprises. The amount of gain from the passenger transportation services rendered does not correspond to those services prime cost for the transport company services, and the volume of transport products does not depend entirely on its quality.

One of the main reasons causing such a situation refers to the lack of efficient systems for fares payment controlling and accounting of passenger traffic in all residential areas and settlements.

That control and accounting can be provided with the introduction of technological solutions, including those increasing both the accuracy of passenger transportation planning and that traffic profitability with the use of continuous automated accounting of passengers flow.

In worldwide scale the trend is such that public transport operators apply efforts to introduce and improve travel management and charging systems that usually is due to strong external and internal pressures. Numerous advantages of these new systems are well known. With a very high annual return on investment, such systems generate profits quickly nearly as early as implemented. Therefore, natural is that they use such a high demand.

Currently, in MPT enterprises operation, still unregulated remains the issue of the possible cashless municipal fare payment, in particular with the use of modern intelligence systems.

Analysis of main research and publications. Implementation of the municipal passenger transport functioning model has been sought in the many scientists' researches. Mainly such economic studies are devoted to problems of transport operation and to the search for solutions as to those shortcomings identified while such study running. A significant contribution to the development of transport activities organization and management has been made by such scientists as: A. M. Gadzynsky, M. M. Tretyakov, O. A. Novikov, V. V. Shcherbakov, M. A. Chernyshev and others. I. O. Khomenko, V. P. Ilchuk, A. V. Bazylyuk in their monograph emphasize that improving the quality of transport services involves the automation of fares payment and represents one of the passengers transport services level progressive development stages embodying a new approach to the passenger transportation organization. Fare payment automation allows transferring this payment category in cashless form, which, according to researchers will minimize the corruption component at transport services [3].

The problem of public municipal transport travel cashless payment has been investigated in the works of leading Ukrainian and foreign scholars. Provisions of state legislative acts [2], [4] and publications in the field of municipal passenger transportation [1], [7], [6], the prospects for the development of passenger transport and fare automated control systems [5], [8], all aforementioned allows to emphasize again this problem relevance and the need for its solution.

Focusing the previously unresolved issues. Unfortunately, at the given moment in Ukraine still

missing is an stable and regulated mechanism, that would allow calculating the exact number of passengers transported by each transport means type. In addition, at geometric progression rate grows the number of population dissatisfied with the sharp increase in public transportation services cost. The task of developing and integrating automated fare-payment systems for municipal public transport is very relevant, as these systems shall allow fundamental changes with the situation we observe now.

This article purpose relates to studying the problems and prospects of smart accounting system for municipal passenger transport implementation and development

Main material exposition. The modern life standards determine the growing needs of population not only in faster, but also in more convenient and safer transportation. Even more requiring become conditions the transport sector faces to regarding reliability, convenience, regularity and other, not less important issues of passenger transportation quality, with respect to the EU Association Agreement signed in 2014 and further implementation of the European integration policy

The positive efficiency of municipal transportation can be considered as one of the most important preconditions for functioning of public, industrial and economic sectors of any city whichever country seeking. A rapid and intensive development of the city causes an intensive consumption of public transportation services, i.e. its high load that does necessarily involve several difficulties with the provision of skilled transport services to the population.

Unfortunately, recently, the functionality of municipal transport companies in many Ukrainian cities is characterized by several unfavorable factors, which ultimately lead to a decrease in their work efficiency and decrease in the population needs satisfaction level. The danger threshold, people and luggage transportation quality conditions and efficiency, energy efficient use indicators and the degree of human factors influence on the environment are not at the desirable level adequate to contemporary requirements.

The transport strategy of Ukraine, approved by the Cabinet of Ministers of Ukraine in 2010 for the period up to 2020, emphasizes that the transport sector in the economy of our country can provide only basic needs in transportation services [10].

The worst sadly is the fact that, despite of intensive and rapid development of information technologies and incredible opportunities offered by the century we are living, the transport situation in Ukraine still remains unchanged. First, it concerns the passenger transportation quality and safety, as well as the environmental ecology, the threat to which is largely contributed by wheel transport.

From Table 1, we see that most people in Ukraine use this kind of transport [9].

Table 1 – Passenger traffic and the number of passengers carried by various transport categories in 2017¹ (according to [9])¹

Transport type	Passenger traffic		Number of passengers transported	
	mln. pas. km.	% to 2016 traffic	Mln	% to 2016
Railway ^{2,3}	28043,4	103,6	165,0	98,0
Automobile	35412,4	102,5	2018,7	99,7
Tramway	3922,6	98,2	675,6	97,4
Trolleybus	6016,0	102,0	1057,8	101,8
Metro	5507,3	102,9	718,9	102,9
All	78901,7	107,4	4636,0	100,3

¹ Not including the temporarily occupied territory of the Autonomous Republic of Crimea, the city of Sevastopol and anti-terrorist operations zone areas; ² According to the operational data of PJSC "Ukrzaliznytsya"; ³ Taking into account transportation by city electric train.

Among the important reasons for municipal transport passengers' dissatisfaction are the following:

- reduced comfort (lack of Wi-Fi, air conditioning systems, etc.);

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- impossibility of planning the travel time due to lack of relevant transport scheduling;
 - high probability of injuries when travel (driver's distraction from driving process when monetary transactions with fare payment; possible "competition" among drivers of route taxis, as a consequence, resulting in violation of traffic rules);
 - unjustifiably overestimated fare, according to numerous passengers' opinion;
 - an uncomfortable route taxis operation schedule in the winter period (after ten o'clock most taxi routes stop their traffic, and the rest are running very rarely).

Many years of research show that the municipal transport network still remains inefficient and does not ensure the absolute satisfaction of all the needs of transport services consumers in the conditions of today's rapid growth of the quality requirements to the offered transport services.

The system of public municipal passenger transport functioning and development (Fig.1) should be oriented on target and resource criteria, take into account complex dynamic changes and established regulatory requirements.

As we see, in today's conditions there exists an urgent need to create and implement an unified automated payment system in all cities of Ukraine without exception.

The automated municipal fare payment system for public transport is intended to simplify the payment control and travel registration on the basis of advanced information technologies.

The main tasks of implementing such a system are following:

- creation of a single transport space with the standardization of fare collection means ;
- possibility to implement a flexible tariff policy;
- maximally increased transparency and accuracy in accounting of actually provided services for the passengers carriage, in particular, privileged categories;
- providing complete, reliable and detailed information on the performed transportation operations to solve the tasks of passenger transportation analysis and planning, etc.

The system of fare payment using special tools, which can be entered as fare payment to carrier agencies will solve the following tasks:

- ensuring control over payment and / or registration of travel by transport;
- provision of targeted social assistance to the population, in particular, privileged passengers' categories, in terms of transport costs;
- implementation of effective and reliable control over the number of transportations carried out at the expense of local budgets, in order to protect the interests of both the carrier and the local self-government body as such services customer;
- possibility of using a multifunctional card as a tool for paying the transport services and the carrier with other social, banking, financial applications;
- travel documents increased security from illegal use or reproduction when needed;
- possibility to obtaining real data on passenger traffic distribution by the carrier that will optimize the route network planning and the number of required rolling stock

The system of passenger traffic and fares payment automated control is designed to provide the transport company with the opportunity to carry out transportation as efficiently as possible. Taking into account the urgent need for the city authorities and for municipal transport enterprises to create a citywide automated payment system, first of all, necessary is to solve the problem of choosing the basic technology for the latest socially oriented payment technology development, which can be further improved.

The Automated fares payment system (hereinafter AFPS) is a system for passenger registration and restriction of unlicensed access to public transport.

The bus operating within that system shall be equipped with a turnstile and ticket validator. Passengers can enter the bus only through a turnstile in the front of the cabin, and to leave the bus through any door,

except for the frontal one. The turnstile prevents the passage into a salon without a ticket and excludes the need in ticket controllers staff. In addition, the system allows an accurate passenger traffic accounting.

In the event of AFPS introduction at the municipal enterprises in Ukraine there will be a real opportunity to effectively combat the flow of free travel and travel documents forgery. Instead of a variety of privileged travel documents (with forgeries difficult to recognize on the spot), a single electronic ticket is introduced. All e-ticket data are found in a centralized database, therefore, handmade forgery is excluded, and after the expiration, such ticket function automatically ceases. The privileged ticket getting when needed becomes the passenger's own responsibility.

Implementation of the AFPS will allow accurate accounting of the privileged trips number. This information is used to bill organizations that provide travel privileges.

In order to fully assess the feasibility of AFPS implementation we must also consider the disadvantages of using these systems. The main disadvantage of AFPS is the slowdown of passengers getting aboard (especially at high-load stops). This is due to entrance restricted with only front door, the need to pass turnstile and buy tickets from the driver. The small space in front of the turnstile does not allow the driver starting movement without waiting for all passengers' passage through the turnstile. Long queues at such situation, especially in bad weather and peak hours, annoy passengers. Increased bus entering time leads to a general increase in travel time. At the same time, at some stops, buses block the roadway, delaying other traffic participants' movement.

Disabled people, wheel chaired and passengers with huge luggage can not cross the turnstile and still enter through the middle door (there is usually a ramp for passing into). Thus, the logic of "front doors" is under breach.

Most drivers do not monitor the use of the turnstile by passengers (they are responsible only for the validator and monitor it), still people can jump over the bars of a turnstile or dive under them.

In addition, the AFPS maintenance requires significant additional costs.

Despite the shortcomings listed, the AFPS has in practice proved itself as a system that contributes to a significant increase in the economic efficiency of urban passenger transport. Thus, the need for AFPS implementation at transport services rendering enterprises is not in doubt. We can identify the main tasks that can be solved using AFPS systems:

- the transported passengers' registration and accounting immediately in the transport means when fare, including by various types of travel documents and passengers' categories entitled to privileged travel fare;
- maintaining the passenger traffic data and traffic structure permanent recording with the account of daily hours-schedules in the context of some transport unit, route, current season, with those data further use in planning and management of territorial transportation service orders (scheduling route network, volumes for route orders, transportation plans and train schedules, traffic dispatching management);
- ensuring the completeness of travel fare collection using all types of travel documents by the means of electronic devices and equipment, which excludes the admission for the carriage of passengers who have not registered their fare payment;
- maintaining a permanent data recording on revenues from transportation service rendered, their structure according to types of travel documents, passengers' categories and daily hours-schedules in the context of some transport unit, route, territorial route network, season;
- planning and managing the territorial transportation orders financial support used when payments settling with the operators of passenger transport services.

The passenger flow accounting embodies a key priority task for motor transport companies in assessing their economic efficiency as well as when planning measures to increase the services provided attractiveness and the business profitability.

Many carriers rely on manual counting, believing that it provides a sufficient amount of glossy data to form an informative report. However, in this case the negative role of human factor is very high: people are capable of fraud, there occur several counting mistakes; even the simplest factor that a human counting can become tired thus efficiently works for a limited time. The use of an automated system for travel fare checking and passenger flows registration essentially contributes to solving these problems.

Consequently, the components of a typical fare automated control system are:

- contactless cards;
- turnstiles;
- fare gates;
- driver's terminals;
- devices for refilling contactless cards account;
- mobile transport servers.

A contactless card is a plastic card with a built-in microprocessor and an antenna. The card principle is based on data exchange between the card and the reader over the radio channel. Each card has its own unique serial number that is assigned at cards production process and can never be changed during the entire period of card using. The card memory consists of 16 sectors. This memory structure allows using the card in a variety of non-interconnected applications.

Other features of the card:

- term of data storage in memory: not less than 10 years;
- number of recording cycles: not less than 100 thousand;
- working distance from the card reader antenna: up to 100 mm (depending on the antenna type and size);
- possibility to work with several cards;
- typical transaction time for transport use: about 0.1 seconds, the user can simply carry the card near the reader antenna, and this time shall be enough to complete the transaction.

The turnstile is a device to enter the passenger cabin with a valid contactless electronic card and to register it using the validator.

The validator is a device for reading or registering contactless electronic cards.

The Driver's Mobile Terminal - device for printing one-time tickets, checking contactless electronic cards status and their refilling (located in the driver's cabin).

The card recording device is purposed for AFPS and paid access systems users' self-servicing, namely: account refilling, selling visits or travel access, and so on.

The mobile transport servers are designed for managing the equipment network in the cabin, reporting to the central server and organizing the management interface [7].

Conclusions. The automated payment system embodies the most effective way to increase gain collection and reduce the number of fare evader passengers by fully automating the travel documents sales process, revenue collecting and recording, and passengers travel control. This system introduction implies that both the public transport stops and the rolling stock are equipped with turnstiles and travel documents reader devices. E-data on the passengers' transportation are sent through a centralized control system directly to the server processing the transport transactions. The automated fare payment system covers not only privileged passengers' categories and users of season tickets, but also buyers of one-time tickets for cash. Refilling the transport card account (e-purse) and the purchase of a one-time ticket are carried out both at ordinary cash desks, as well as at payment terminals or tickets selling machines, as well as via the Internet or mobile applications.

This system, in combination with organizational and technical measures, enables to organize a complete automated accounting of each passenger in a single system, irrespectively to ticket carriers and transport cards types, as well as to forms of travel payment, including payment for cash, cashless

payments and all types of contactless payment.

For passengers, the introduction of an automated fare payment control system will have the following benefits:

- adjusted passenger transportation system
- comfort and convenience in travel payment
- socially fair tariffs
- availability of travel documents that meet the passengers' needs as much as possible
- possibility of using one card for different transport types
- improving the service quality through of data provided system processing.

Prospects for further research. In further research, it would be convenient to consider closer the information component of the smart accounting implementation and progress in municipal transport, since this area of research is still under early development in Ukraine. Recent attempts to introduce technologies such as an e-ticket or a municipal passenger's card did not make much progress in terms of information support and technical devices. Therefore, of surely high relevance is researching such projects technological opportunities in modern economic conditions.

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Проблеми та перспективи впровадження та розвитку системи смарт-обліку в міському транспорті

Метою статті є дослідження проблем та перспектив впровадження та розвитку смарт-обліку в міському транспорті. В сучасних умовах функціонування економіки існує нагальна необхідність створення і впровадження єдиної автоматизованої платіжної системи для оплати у міському громадському транспорті у всіх містах України, яка призначена для спрощення контролю за платежами та реєстрацією поїздок на основі передових інформаційних технологій. Основними завданнями реалізації такої системи є: створення єдиного транспортного простору із стандартизацією засобів проїзду; можливість гнучкої тарифної політики; максимальне підвищення прозорості та точності обліку фактично наданих послуг для перевезення пасажирів, зокрема, привілейованих; надання повної, достовірної та детальної інформації про виконану транспортну роботу для вирішення завдань аналізу та планування

пасажирських перевезень тощо. Впровадження цієї системи передбачає необхідність обладнання зупинок та рухомого складу громадського транспорту турнікетами та пристроями для зчитування дорожніх документів. Відповідно до цієї системи, дані про перевезення пасажирів електронним шляхом через централізовану систему управління потрапляють безпосередньо на сервер обробки транспортних операцій. Автоматизована платіжна система охоплюватиме не тільки привілейовані категорії громадян та користувачів сезонних квитків, а й покупців одноразових квитків за готівку. Поповнення транспортного карткового рахунку (електронний гаманець) та придбання одноразового квитка здійснюватиметься як в звичайних касах, так і в платіжних терміналах або торгових автоматах для продажу квитків, а також через Інтернет або мобільний додаток. Ця система, у поєднанні з організаційними та технічними заходами, дозволяє організувати повний автоматизований облік кожного пасажира в єдиній системі незалежно від видів квитків та транспортних карток, а також від форм оплати подорожей, включаючи оплату готівкою, у формі безготівкового платежу та всіх видів безконтактних платежів. Для пасажирів запровадження автоматизованої системи контролю за платежами матиме такі переваги: налагоджена система пасажирських перевезень; комфорт та зручність у оплаті поїздок; соціально справедливі тарифи; наявність проїзних документів, які максимально задовольняють потреби пасажирів; можливість використання однієї картки в різних видах транспорту; поліпшення якості обслуговування. У подальших дослідженнях варто було б звернути увагу на інформаційний компонент впровадження та розвитку системи інтелектуального вимірювання в міському транспорті, оскільки ця проблема все ще залишається не вирішеною остаточно в Україні. Недавні спроби запровадити такі технології як електронний квиток або карта громадянина, не мали позитивного ефекту внаслідок проблем з інформаційним та технічним забезпеченням.

Ключові слова: інтелектуальна система обліку, муніципальний пасажирський транспорт, автоматизована плата за проїзд, сучасні інтелектуальні системи.