Qualitative assessment of passenger service

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Abstract. The developed methodology for assessing the level of quality of passenger service presented below is relied on existing developments in this area, international standards for determining the quality of service and passengers' questionnaire. The main goal of the proposed methodology is to determine the necessary social effect of the urban passenger transport, as well as the costs that must be incurred to ensure it and the income that will be received at a given level of service for the population of the city (region). When determining all these indicators, it is necessary to take into account the interests of all participants in the passenger service market (urbanities, owners of private motor transport enterprises and passengers). According to the methodology, it is proposed to determine the social effect of the urban transport through the level of quality of passenger service. This indicator should include both the qualitative characteristics of passenger service and the level of transport tariffs of different carriers, since for many categories of passengers, the latter indicator will play a decisive role in choosing the type of the vehicle and the carrier.

1. Introduction
A modern metropolis cannot be imagined without a well-developed transport infrastructure, since this indicator largely determines the pace of development of the city’s economy, industry and other areas of activity. Given the limited financing of urban transport from local budgets, it becomes necessary to determine the optimal amount of investment in the development of the transport infrastructure of the city [1]. Modern urban passenger transport is unprofitable. Therefore, even with some budget compensation for the transportation of commissionary passengers and restraining tariffs, urban transport enterprises still do not have enough funds to renew their rolling stock. This causes deterioration of the passenger service. Sometimes such a situation occurs that all losses of motor transport enterprises are compensated at the expense of the budget, regardless of what caused these losses: providing benefits and restraining tariffs or simply inefficient work. Consequently, urbanities are interested in reducing losses. Currently, losses are increasing even more due to the outflow of passenger traffic to commercial motor transport enterprises (MTE), which offer a different (excellent) quality of the transportation process [2]. Therefore, there is a need to determine the optimal level of the passenger service, which will ensure the necessary passenger traffic in order to minimize losses of urban motor transport enterprises and, accordingly, optimize investments in urban transport from local budgets. In each urban MTE, the main task of organizing and planning the production process always becomes the optimal combination and use of all resources to perform maximum transport work and improve the quality of public services [3,4].

Commercial enterprises are interested in maximizing their own profits as a factor in increasing the value of their business. At the same time, they can achieve maximum profit by reducing the cost of
passenger transportation, which may lead to some deterioration in the level of services provided. A decrease in this indicator, in turn, can adversely affect the amount of passenger traffic. Therefore, it is also important for private motor transport enterprises to determine the optimal level of the passenger service, which will ensure their maximum profit [5].

2. Analysis of methods for assessing the efficiency and quality of the passenger service

Before talking about methods for analyzing the efficiency of the passenger transport, it is necessary to determine what efficiency is. The following definition is found in the literature: efficiency is the relative effectiveness of a process or project, defined as the ratio of the effect (result) to the costs (expenses) that determined its receipt.

A number of authors recognize social and economic efficiency, but suggests distinguishing between these two concepts. Some define economic efficiency as cost-effectiveness. They view social efficiency as the one in whose interests the results of production are used. Others define economic efficiency as the effectiveness of economic activity or economic programs, characterized by the ratio of the obtained economic effect, the result to the cost of resources, which determined that result. And social efficiency is understood as a system of indicators reflecting: the level of satisfaction of consumer demand at the consumer market, the time spent by buyers to purchase goods or receive services and the service level.

A number of authors advocate the view that there is a close relationship between the social and economic effect, and it is impossible to determine the boundaries between them. Some scholars believe that economic efficiency cannot be purely economic, since the effect and costs always contain elements aimed at achieving certain social results in both the production and non-production areas. Social efficiency cannot be purely social, since it does not exist regardless of the effect and costs incurred for purely economic activity. This explains the appearance of the term "socio-economic efficiency".

The socio-economic efficiency of the urban urban passenger transport as a category is considered. In this case, it is considered legitimate to talk about the socio-economic efficiency of the passenger service. This category, as if combines the economic and social aspects of efficiency, reflects their interdependence and their unity. Thus, an increase in the social efficiency of passenger services, expressed, in particular, in an increase in the free time of the population, also leads to an increase in economic efficiency, that is an increase in labor productivity by means of an increase in the level of education and skills. And the economic effect gives such a social result as the most complete satisfaction of the needs of the population in passenger services, strengthening material and moral incentives to work. At the same time, they distinguish between qualitative and quantitative assessments of socio-economic efficiency.

It should be noted that there is a problem of assessing the performance of passenger transport in the economic and social aspects and their coordination. This is due to the fact that factors of economic and social efficiency are changing at different rates and sometimes in different directions. Another problem in assessing the effectiveness of the passenger transport is that there are several participants at the market of passenger motor passenger services whose interests do not coincide. Therefore, the effectiveness for each of them will be evaluated differently. It follows that the methodology for assessing the effectiveness of the passenger transport should take into account the interests of all participants at the market.

Assessment of the quality of the passenger service consists of the following indicators:

1. Transport mobility of the population is one of the main indicators characterizing the transport system of the city;
2. The relationship between public and individual modes of transport, which greatly affects the parameters of the road network and the economic characteristics of the system as a whole;
3. Reliability of the urban passenger transport (the level of integrated transport accessibility) representing the weighted-average time spent on passenger transportation [6];
4. The level of transport discrimination of the population, which shows how much of the city's population (%) lives outside the regulatory accessibility zone [7];
5. The comfort of the urban passenger transport viewed as convenience, speed, etc. [8,9];
6. The specific lost free time fund. Total unproductive losses of time for receiving passenger services of a socially guaranteed minimum by each resident of the city per day (hour);
7. The share of the urban passenger transport in total environmental pollution. The main negative consequences of the transport on the urban environment: atmospheric and noise pollution [10];
8. The level of development of not a mechanical mode of transport. The share of bicycles in the total number of movements of the city residents (%);
9. The level of accidents caused by the urban passenger transport;
10. Efficiency of the urban passenger transport. This indicator is calculated as the ratio of results to costs [11].

An analysis of existing methods for assessing the quality of passenger services allows to conclude that there is no one that would fully meet the existing conditions at the market for the passenger service. The disadvantages of existing methods for assessing the quality of the passenger service in the region (each method has one or more of the following disadvantages) are as follows [12-14].

1. They propose to evaluate the quality of passenger services using only one indicator, which is very problematic, if not practically impossible.
2. They are characterized by the subjectivity of the assessment. This is due to the fact that to assess the quality of passenger services, one uses indicators that are not calculated in practice or those that cannot be quantified. In these cases, it is proposed to use expert assessment methods, which are characterized by a certain degree of subjectivity.
3. When determining the integral indicator of the quality of the passenger service, some methods do not take into account the significance of each individual private quality indicator. This leads to the fact that they try to compensate for the unsatisfactory value of some indicators characterizing quality at the expense of other indicators, and this is unacceptable.
4. They do not take into account the real interests and needs of passengers, but these needs have changed significantly lately.
5. Most of the analyzed methods were developed back in the period when the passenger transport market did not have such a large number of private traders. So, many of these methods cannot be used to evaluate the performance of private carriers. This is due to the fact that private carriers, especially those that own one vehicle, do not have much of the data necessary to calculate these coefficients.

Therefore, an improved methodology for assessing the quality of the passenger service is required, which will eliminate all the above disadvantages, take into account all the main indicators characterizing the quality of the passenger service and will allow to get the most objective assessment.

3. Materials and methods
When developing the methodology to assess the quality of the passenger service presented below, the authors relied on existing developments in this field, international standards for determining the quality of the service and passengers’ questionnaire.

The main goal of the proposed methodology is to determine the necessary social effect of the urban passenger transport, as well as the costs that must be incurred to ensure it and the income that will be received at a given level of service for the population of the city (region). When determining all these indicators, it is necessary to take into account the interests of all participants at the passenger service market (municipalities, owners of private motor transport enterprises and passengers).

The offered methodology proposes to determine the social effect of the urban transport through the level of quality of the passenger service. This indicator should include both the quality characteristics of the passenger service and the level of transport tariffs of different carriers, since for many categories of passengers the latter indicator will play a decisive role in choosing the type of the vehicle and the carrier. Given the limited financing of urban passenger transport from local budgets, it becomes necessary to determine the optimal amount of investment in the development of the urban transport.

Based on the economic situation at the market of municipal passenger transportation, one can conclude that it is necessary to find some compromise between its participants. For this, it is necessary
to determine the optimal level of quality of the passenger service and the costs associated with them, which would suit all participants.

For this, the following algorithm is proposed [15]:

1. The development of a methodology that would allow assessing the level of the transport service in the region.

The modern methodology for assessing the socio-economic efficiency of urban public transport should be a comprehensive system of indicators, on the basis of which it would be possible to determine the effectiveness of a separate enterprise, regardless of ownership and the efficiency of transport services in the region as a whole. The system of these indicators should reflect the degree of satisfaction of the needs of passengers and society as a whole, as well as an increase in services per unit of expenditure while improving their quality characteristics and an increase in revenues of motor transport enterprises per unit of services.

To determine the level of the passenger service in modern conditions, it is necessary to use an integral indicator based on a number of private indicators. This is due to the fact that it is rather difficult to assess the level of quality of any service using only one characteristic. It is necessary to take into account the significance of each particular indicator, while remembering that it can vary depending on the population group, goals and travel time.

2. Determining the relationship between the level of the passenger service and the costs that are necessary to ensure it.

3. Determining the relationship between passenger revenue and the passenger service level. In general, the level of service affects the number of passengers using this type of transport (passenger traffic), however, there is a certain percentage of passenger traffic that does not depend on the level of service. Passenger traffic, in turn, has a direct impact on revenues received by transport enterprises. Therefore, all income derived from the passenger service can be divided into income from the sale of passenger services, provided that the passenger requirements for the level of service are not taken into account, and income that is caused by an increase in passenger traffic as a result of an increase in the level of the passenger service.

It is advisable to consider the determination of the dependencies between the costs of providing passenger services and the level of transport services, as well as between the revenues from the sale of services and the level of the service in the city or the region, but in this case the average data will be obtained.

4. Determining the optimal level of the passenger service quality.

Municipal city passenger transport is unprofitable and these losses are covered by subsidies from the regional (local) budget, not in full, as a rule. Underfunding significantly affects the competitiveness of the municipal transport and the quality of services provided. Therefore, the goal of municipalities will be to minimize losses. Then the target function of municipalities can be represented as follows:

\[
\begin{align*}
K \geq K_{\text{min}} \\
E - R & \rightarrow \min
\end{align*}
\]

where: \( K \) is the level of the passenger service by municipal transport;
\( K_{\text{min}} \) is the minimum acceptable level of transport services for the population of the city (region);
\( E \) is expenses for transport services by municipal motor transport enterprises, expressed depending on the level of the passenger service;
\( R \) is revenues received by municipal MTEs from passenger service, expressed depending on the level of the service provided.

Private enterprises engaged in transport services in the region are profitable. Therefore, for them, the objective function will look different:
where: $K$ is the level of the passenger service by private transport; $K_{\text{min}}$ is the minimum acceptable level of transport services for the population of the city (region); $BV$ is business value of a transport enterprise.

In this case, it may turn out that the optimal level of public transport services for municipalities and private enterprises will be different. But in any case, this level of service will correspond to the objective function.

4. The methodology for calculating the integral indicator of the quality of transport services

Defining the most important private indicators characterizing the level of transport services for the population. To determine the most important indicators, the method of interviewing passengers, specialists of the transport and communications department of the city administration and motor transport enterprises was used.

A survey of passengers was carried out according to a questionnaire designed for the study of the passenger flow [16]. It should be noted that people of different ages, social status and engaged in various activities were interviewed. The questionnaire was filled out by 135 people. In the process of questioning, a question was asked about the factors that, according to passengers, determine the quality of the passenger service. The respondents were asked to choose six from the list of factors, which were factors of passenger service quality for them.

In the process of processing the data, the following results were obtained and presented in the form of a histogram (Fig. 1).

![Figure 1](image_url)

**Figure 1.** The results of the passengers' questionnaire on the factors of the quality of the passenger service.

Local indicators and factors that determine the quality of the passenger service for the population of the region are as follows:

1. Total time spent on the trip. This local indicator is influenced by a number of factors:
The density of the route network (77 times) is defined as the ratio of the total length of the streets and roads along which the routes of urban passenger road transport go to the area of the city (region). Based on the density of the route network, it is possible to determine how well the entire population of the studied city (region) or a specific district of the city is provided with transportation [17,18].

The frequency of movement (73 times) is defined as the ratio of the number of vehicle movements along a specific route for a specific time interval.

Having analyzed the three factors described above, one can conclude that certain changes are necessary in the existing route network of urban public transport in order to reduce the travel time, as well as one can create new routes for public transport or, on the contrary, decide to cancel existing ones, if the route network is too dense.

2. Comfort conditions during the trip. The value of this indicator depends on the values of the following factors:

   • The degree of filling the vehicle (64 times) is defined as the number of passengers per 1 m² of the vehicle area.
   • The average number of transfers per trip (68 times).

3. Safety. To assess the degree of traffic safety, two factors were used [19].

   • Environmental safety (57 times) is defined as the share of urban passenger transport in total atmospheric pollutant emissions [20].
   • Traffic emergency safety (75 times) is estimated by the level of traffic accidents caused by transport faults, including fatalities per 1,000,000 passengers.

4. The rhythm of urban public transport. The following factors can be used as evaluation criteria.

   • Frequency of movement (61 times) is calculated as the ratio of the actual number of completed trips to the number of scheduled trips.
   • The frequency of public transport (73 times) is defined as the ratio of the number of transport movements on a specific route for a certain time interval.

5. Cost indicator is defined as the proportion of the level of tariffs on urban public transport (84 times) in relation to the cost of living.

   All the above indicators can be represented in the form of a diagram in Fig. 2.
Figure 2. Indicators and quality factors of the passenger service for the population of the region.

To calculate integral indicator $K$, it is suggested to use the following formulas:

$$K = \sum_{i=1}^{5} \alpha_i \times P_i, \quad \text{(3)}$$

$$P_i = \sum_{j=1}^{m} \beta_{ij} \times k_{ij}, \quad \text{(4)}$$

where: $K$ is the integral indicator of the level of the passenger service; $P_i$ is the $i$-th local indicator characterizing the level of the passenger service; $k_{ij}$ is the indicator characterizing the degree of compliance of factors with their optimal value; $\alpha_i$ and $\beta_{ij}$ are weighted coefficients of indicators $P_i$ and $k_{ij}$, respectively, determined by the method of analysis of hierarchies by constructing matrices for pairwise comparison:

$$\sum_{j=1}^{m} \beta_{ij} = 1.$$  

where: $m$ is the number of quality factors.

Index $k_{ij}$ is proposed to determine:

- for those quality factors whose increase in value has a positive effect on the level of quality of the passenger service.
\[ k_{ij} = \frac{n_{ij}}{n^e_{ij}}, \]  

(5)

where: \( n^e_{ij} \) is the maximum value of the j-th factor for the analyzed period (standard).

- for those quality factors whose increase in value negatively affects the level of quality of the passenger service:

\[ k_{ij} = \frac{n_{ij}}{n^e_{ij}}, \]  

(6)

where: \( n^e_{ij} \) is the minimum value of the j-th factor for the analyzed period (standard).

\( k_{ij} \rightarrow 1 \) in the analyzed period, so \( P_i \rightarrow 1 \). The value of indicators \( k_{ij} = 1 \) and \( P_i = 1 \) is not a limit, since in the future, as a result of effective management of the passenger service system, the values of factors \( n_{ij} \) can improve and exceed the reference values, then \( k_{ij} > 1 \) \( k_{ij} > 1 \) and \( P_i > 1 \).

The higher the value of integral indicator K is, the more the created conditions for the passenger service for the population of the city (region) correspond to ideal [21].

5. Conclusions

The proposed methodology meets the current conditions at the analyzed market, as well as the goals and interests of its participants and includes the main indicators that may affect the passenger’s choice of the vehicle. Therefore, the assessment of these indicators is important for all carriers providing the passenger service, as competition at this market is currently increasing. At the same time, these indicators are important for municipalities because they must provide the necessary level of quality of the passenger service for the population.

The developed methodology increases the objectivity of assessing the level of quality of the passenger service due to the fact that, firstly, all applicable indicators can be quantified, and secondly, weighted coefficients are justified, which makes it possible to determine the degree of influence of each particular indicator on the integral one.

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