Modern issues of forming an assessment of the effectiveness of the functioning of public urban passenger transport systems

Sergey Mochalin1*, Yuliya Koleber1, Anatolij Shonin1, and Andrej Larin2

1Siberian State Automobile and Highway University, 5 Mira pr., Omsk, Russia
2Omsk State Transport University, 35 Markska pr., Omsk, Russia

Abstract. The article is devoted to the formation of an assessment of the effectiveness of the functioning of public urban passenger transport systems. The great potential of urban passenger transportation in maintaining the economic stability of the regions and the important social significance for the population substantiate the relevance of forming reliable estimates of the transportation process in the city. However, at present there are problems in the field of forming an assessment of the effectiveness of the functioning of public urban passenger transport systems. These problems do not allow the formation of sufficient and reliable evaluation indicators that would help to form timely corrective actions and sound management decisions. The article analyzes these problems and based on it, the requirements for evaluating the effectiveness of public urban passenger transport systems are compiled. Based on these requirements, an algorithm for forming a performance assessment model in the field under consideration has been formed. The results of the study can be useful both for specialists in the field of planning transport processes in the city, and as a theoretical basis for the formation of a methodology for assessing the effectiveness of the functioning of public urban passenger transport systems.

1 Introduction

Urban public passenger transport plays an important role in the development of the urban environment and helps millions of people make daily trips to places of employment and leisure. The harmonious development of urban passenger transportation, on the one hand, supports the economic development of the region and the transport industry, on the other hand, plays an important social role in the process of providing transport services to passengers.

However, to date, a number of problems have accumulated in all passenger transport systems of large Russian cities, such as traffic congestion, long intervals of rolling stock movement, low level of passenger comfort, and many others. Indicators of the functioning of public urban passenger transport do not meet modern requirements [1, 2]. The existing problems in the field of urban passenger transportation, as well as their important economic
and social significance determine the relevance of the development of theoretical and practical developments to assess the results of the functioning of public urban passenger transport systems. This task in the field under consideration is, on the one hand, an important, on the other hand, a complex multi-criteria task that requires effective management decisions and sound scientific approaches. However, at present, there are problems in the field of assessing the effectiveness of the functioning of public urban passenger transportation systems that need to be considered further.

2 Methods

The concept of "effectiveness" in assessing the process of urban passenger transportation is often identified or replaced by the concept of "efficiency", which is incorrect and unacceptable [3]. Currently, there is some confusion about the origin of the concepts of "effectiveness" and "efficiency". According to one source [4], the concept of "efficiency" was the first to appear, and only later came the concept of "effectiveness". At the same time, according to another source [5] the concept of "effectiveness" appeared before the concept of "efficiency" - in the XVI century. This kind of confusion in the historical content of the concepts under consideration proves the close relationship that exists between them.

Effectiveness is a derivative of the word "result". The result (fr., from Latin resultare - to be reflected, to be recalled) is the consequence of something, the final conclusion, outcome, end [6]. A great contribution to the development of this concept in relation to the field of organization management was made by domestic scientists A.K. Semenov, V.I. Nabokov, Z.A. Koval, I.V. Bondarenko and foreign scientists Ch. Barnard, J. Oakland, P. Drucker, M. Porter, J. L. Gibson, et al. The concept of "effectiveness" is defined by them as the ratio of the actual results of the activities to the planned ones. According to the GOST R ISO 9000-2015 Quality management systems, effectiveness is the degree of implementation of planned activities and achievement of planned results.

Efficiency is a derivative of the word "effect". Effect is the achieved result in its material, monetary, social (social effect) expression [7].

Such authors as D. Riccardo, P.T. Sabluk, K.R. McConnell, S.L. Bru, Yu.N. Novikov and others were engaged in approaches to the definition of the concept of "efficiency". According to these approaches, efficiency is the ratio of the result and the various resources and funds spent on achieving it. According to the GOST R ISO 9000-2015 Quality management systems, efficiency is the relationship between the achieved result and the resources used.

Comparing the above definitions of the concepts of "effectiveness" and "efficiency", we can conclude that these concepts are completely different in their content. The issues of differentiation of the concepts under consideration are considered in [4, 5]. Based on the analysis of these works, a comparison table of the concepts of "effectiveness" and "efficiency" has been formed.

<table>
<thead>
<tr>
<th>Category</th>
<th>Term</th>
<th>effectiveness (performance)</th>
<th>efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Definition according to the ISO 9000:2000 series standard</td>
<td>the degree of implementation of planned activities and achievement of planned results</td>
<td>the relationship between the achieved result and the resources used</td>
<td></td>
</tr>
<tr>
<td>2 Formula for calculation</td>
<td>the ratio of fact to plan</td>
<td>the ratio of the result to the resources spent on achieving it</td>
<td></td>
</tr>
</tbody>
</table>
The analysis of the above provisions allows us to draw a clear boundary between the concepts under consideration. Next, it is necessary to consider the specifics of the concepts under consideration in relation to the organization of urban passenger transportation. The system of public urban passenger transport has not only an economic orientation, but also a social one. In the system under consideration, not only the process of profit-making is important, but also the orientation to meet the needs of the passenger. In this regard, it should be assumed that the use of the concept of "efficiency" to assess the results of the functioning of the system will be insufficient. This system pursues a specific goal, which is designed to ensure the social order of society. At the same time, carriers that are interested in making a profit operate in this system. In this regard, the overall goal of the system should take into account the diverse interests of its participants. The concept of "efficiency" in this case can be well applied to the assessment of the activities of carriers. The result of the functioning of the entire system should be evaluated by such an indicator as "effectiveness", which will be expressed by some integral indicator reflecting the degree of achievement of the goals of all participants in the system. Efficiency as an assessment of the carrier's activities will thus be a component of evaluating the effectiveness of the system. Such an organization of the assessment of the process of urban passenger transportation once again proves the position that the concepts of "efficiency" and "effectiveness" are closely interrelated, but not interchangeable [8].

The effectiveness of the functioning of the public urban passenger transport system is a comprehensive assessment system that summarizes many parameters of the functioning of the public urban passenger transport system determines the degree of achievement of the goals and results of the activities of the participants of this system and opens up areas of corrective management actions.

To date, there is no comprehensive methodology for assessing the effectiveness of the functioning of public urban passenger transport systems, which would be generally accepted and take into account the entire set of evaluation indicators and the interests of all participants in the transport process [8].

Modern approaches to the assessing the effectiveness of public urban passenger transport systems have the following disadvantages.

1. They do not allow evaluating the effectiveness of the system from the positions of all participants in the transportation process. As a rule, quality indicators are considered only for passengers.

2. In most works, only quality indicators or only the efficiency of the urban passenger transportation process are considered. As already noted above, this does not allow us to reliably assess the degree of achievement of the planned results of the system.

3. For evaluation, as a rule, only some individual indicators are taken, which, from the position of the authors, are the most significant for participants in the transportation process. For example, the comfort of a passenger's trip, travel time [1, 9, 10], carrier costs. As a result, a significant number of other indicators that somehow affect the final effectiveness of the transportation process are not taken into account. Moreover, the values of some obtained indicators increase, while the values of others decrease, which does not correspond to the logic of a single integral assessment.
4. The methodology of the final assessment is poorly formalized, insufficiently reliable and accurate. As a rule, the result of calculating this methodology is a certain set of indicators that are not interconnected into a single component.

5. The performance methodology is poorly applicable to working with absolute indicators, a single scale of their ranking and evaluation is poorly developed.

As a result, the existing approaches to performance assessment are poorly applicable to the system under consideration, have a fragmented, unsystematic nature and are used by the organizers of transport services within the framework of solving individual tasks.

In order to assess the activities of providing services to passengers by public urban passenger transport, a social standard of public transport services (On the approval of the social standard of public transport services when transporting passengers and luggage by road and urban ground electric transport. Order of the Ministry of Transport of the Russian Federation No.NA-19-p. 15 dated January 31, 2017) has been adopted. However, it reflects only an assessment of the quality of passenger transport services, and the standard under consideration is not able to achieve the goal of forming an integral assessment of the effectiveness of the functioning of public urban passenger transport system. Despite the fact that the social standard of transport services for the population was formed as part of the implementation of the decisions of the Transport Strategy of the Russian Federation (Order of the Government of the Russian Federation No. 3363-p dated November 27, 2021 On the Transport Strategy of the Russian Federation until 2030 with a forecast for the period up to 2035), it does not properly comply with all its provisions providing for increasing economic growth, competitiveness of the country's regions, reducing the harmful effects of transport on the environment and climate.

Approaches to evaluating the effectiveness of systems are considered in the works of Russian and foreign scientists [2, 8, 11, 12]. Different authors offer different models for evaluating the effectiveness of systems: expert assessments, performance evaluation index normalization model (MINOR), goal tree and system tree, fuzzy expert systems, neural networks, simulation modeling, balanced scorecard, application of weighting coefficients.

Of great interest in the field of forming an integral assessment of the effectiveness of the functioning of public urban passenger transport system is the work [8], the authors of which made an attempt to collect the interests of all participants in the transport process into a single integral indicator. At the same time, a set of performance indicators has been formed for each participant of the system. The methodology is based on the model of index normalization of performance evaluation (MINOR), which focuses on the magnitude of the increment of the indicator. This work contains a qualitatively new approach to the formation of an assessment of the effectiveness of urban passenger transportation, which takes into account the above provisions. However, the paper does not provide an assessment of the necessity and sufficiency of calculated indicators, there is no qualitative proof of the representativeness of the sample. From a scientific point of view, it seems relevant to form an integrated performance assessment based on various methods of mathematical modeling in order to increase its objectivity.

Weaknesses in assessing the effectiveness of the functioning of public urban passenger transport systems lead to a decrease in the economic effect, an increase in risks, untimely corrective actions to eliminate negative results, to a decrease in the efficiency of the functioning of carriers and the quality of transport services provided to the population.

The participants of the urban passenger transportation system are passengers, carriers and the organizer of transportation represented by the Department of Transport of the City Administration. While any carrier in the system is interested in making a profit, the quality of the services provided is important to the passenger, and the transportation organizer monitors such an important characteristic as the regularity of movement. Thus, the overall
goal of the system itself does not coincide with the goals of each of the participants individually. The contradiction of goals within the system of urban public passenger transport requires the formation of a certain integral indicator that would take into account the interests of all participants in the transportation process. This provision reflects Figure 1.

![Diagram of integrated assessment of the effectiveness of the public urban passenger transport system](image)

**Fig. 1.** Effectiveness (performance) indicators of the transport system.

For a more accurate assessment, a sufficient set of calculated indicators is required for each participant of the system. An analysis of the work in this area [1, 4, 9, 10, 13, 14, 15] allowed us to identify the most currently used indicators, which are reflected in Table 2.

**Table 2.** The most currently used indicators of the transport systems performance (effectiveness).

<table>
<thead>
<tr>
<th>Calculated indicators for passengers</th>
<th>Calculated indicators for the organizer of transportation</th>
<th>Calculated indicators for carriers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability</td>
<td>The coefficient of regularity</td>
<td>Volume of traffic</td>
</tr>
<tr>
<td>Reliability</td>
<td>Grants</td>
<td>Profit</td>
</tr>
<tr>
<td>Comfort</td>
<td>Number of detected violations</td>
<td>Coefficient of technical</td>
</tr>
<tr>
<td>Economy</td>
<td>Volume of traffic</td>
<td>readiness</td>
</tr>
<tr>
<td>Operational maintenance</td>
<td>Number of flights</td>
<td>Operational speed</td>
</tr>
</tbody>
</table>

It is worth noting that each of the calculated indicators for passengers reflected in Table 2 is quite capacious and includes several additional coefficients. Some indicators of individual participants in the transport process coincide, which indicates their close connection in a single key of the functioning of the system. It is worth noting that the formation of a sufficient set of calculated indicators is a direction for individual studies. The broader the set of indicators, the more likely it is to obtain a reliable performance assessment.
3 Results and discussion

Based on the above provisions, the following requirements can be formed for evaluating the effectiveness of the functioning of public urban passenger transport systems (Further on the term «effectiveness» is called «performance»):

1. Performance evaluation should be based on a mathematical model with a meaningful argumentation of the choice of this model.
2. Performance evaluation should be implemented on the basis of a certain algorithm.
3. The performance evaluation algorithm should contain the final stages for identifying and analyzing the causes of deviations of the fact from the plan, as well as for developing corrective actions.
4. Performance evaluation should be based on the necessary and sufficient number of indicators for calculation.
5. The calculated indicators should take into account the goals of all participants in the transportation process.
6. Planned (normative, reference) values should be established for the calculated performance evaluation indicators (this provision once again indicates a clear boundary between the concepts of "effectiveness" and "efficiency").
7. The result of the calculation of the performance assessment should be an integral indicator that takes into account all the selected calculated indicators.

The analysis of the above provisions makes it possible to form an algorithm for forming a model for evaluating the effectiveness of the public urban passenger transport system. This algorithm is shown in Figure 2.

All points of the algorithm take into account the requirements for evaluating the effectiveness of the functioning of public urban passenger transport system.

4 Conclusions

Urban passenger transportation systems in the conditions of their unstable development are particularly in need of timely and sufficient assessment. The effectiveness acts as an evaluation indicator. Evaluation of the effectiveness of the functioning of the public urban passenger transport system is an important mechanism for identifying weaknesses in the system and the formation of timely and correct corrective actions. However, today there are problems in the formation of an assessment of the effectiveness of urban passenger transportation: the concept of "effectiveness" is often identified or replaced by the concept of "efficiency"; modern approaches to evaluating performance do not take into account the specifics of the system, contain an incomplete set of calculated indicators, are not supported by sufficient sampling, are fragmentary, do not take into account the planned indicators of all participants in the system. Based on the results of the analysis of the state of the issue in the field under consideration, the authors have formed requirements for evaluating the effectiveness of the functioning of public urban passenger transport systems, on the basis of which an algorithm for forming a performance assessment model has been compiled. The results of the study are relevant in the field of forming a reasonable and sufficient assessment of the effectiveness of the functioning of public urban passenger transportation systems. The study will be useful in compiling a methodology for evaluating performance in the field under consideration.
Fig. 2. Algorithm for forming a model for evaluating the effectiveness of the public urban passenger transport system.

References

1. A.L. Komilov, IJARSET 7(9), 14818-14825 (2020)
2. E. Bhaduri, Dr. A. K Goswami, Dr. R. Moeckel, How sustainable is the growth of mass transit system in developing countries – an Indian perspective, in Proceedings of the World Conference on Transport Research, 26-31 May 2019, Mumbai, India (2019)

5. A.V. Klyuev, Vestnik UrFU, 16(4), 532-555 (2017)


9. Y. Liao, J. Gil, R.H. Pereira, S. Yeh, V. Verendel, Scientific Reports, 10(1), 1-12 (2020)


