QUALITY INDICES OF PUBLIC TRANSPORTATION SERVICES

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ABSTRACT
The authors’ study was devoted to the methodology that could estimate quality and ranking of transport services provided to townspeople in urban passenger and baggage Transit, particularly using road vehicles and land electric transport vehicles. The experience of the entities of the Russian Federation, of the United States and the European Union in relation to standardization of the quality of transport services is cited. A mathematical model of quality of transport services, and methods of its integral assessment are considered. Basing on the general analysis of the methodology for assessing transport services, the authors suggest conclusions on its adaptability regarding city of Moscow. A systematic approach to obtaining the initial data necessary for calculation of quality indicators is proposed.

Keywords: quality of transport service, urban passenger transport, social standard of transport service, quality indicators.

Background. The quality of life of population and productivity of various sectors of the economy depend to a certain extent on the efficiency of urban passenger public transport system. Improving the quality of transport services requires comprehensive measures, the implementation of which will help optimize route schemes and passenger flows, use of machinery and infrastructure, help improve management and increase the efficiency of the transport network.

Objective. The objective of the authors is to consider indicators of quality of public transport services and to analyze relevant methods.

Methods. The authors use general scientific methods, comparative and economic analysis, evaluation and engineering approach, system and mathematical analysis.

Results.

Methodical approaches
According to the decree of the Ministry of Transport of the Russian Federation [1], a methodology for assessing the quality of public transport services has been approved, which establishes the level and quality indicators for transportation of passengers and baggage by road and urban land electric transport, including municipal regular routes.

The quality of public transport services is expressed through a combination of reliability, accessibility and comfort characteristics and is an integral evaluation (Pic. 1).

Table 1

<table>
<thead>
<tr>
<th>Method for calculating the integral quality indicator</th>
<th>Calculation formula</th>
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</thead>
<tbody>
<tr>
<td>Arithmetic sum of the partial indicators</td>
<td>$K_a = \sum_{i=1}^{n} K_i Z_i$</td>
</tr>
<tr>
<td>Weighted sum of the partial indicators</td>
<td>$K_a = \sum_{i=1}^{n} K_i A_i Z_i$</td>
</tr>
<tr>
<td>Product of the partial indicators</td>
<td>$K_a = \prod_{i=1}^{n} K_i Z_i$</td>
</tr>
<tr>
<td>Weighted product of the partial indicators</td>
<td>$K_a = \prod_{i=1}^{n} K_i A_i Z_i$</td>
</tr>
<tr>
<td>Geometric mean of the partial indicators</td>
<td>$K_a = \sqrt[n]{\prod_{i=1}^{n} K_i Z_i}$</td>
</tr>
<tr>
<td>Value of a vector constructed in the system of coordinates of the partial indicators</td>
<td>$K_a = \frac{1}{n} \sum_{i=1}^{n} K_i Z_i$</td>
</tr>
</tbody>
</table>

The obtained values of the transport service quality indicators of population in comparison with the normative values in [1] can be applied in the sphere of transport and urban planning in development of normative legal acts and in assessing the effectiveness of the measures taken.

Methods for assessing the level of quality of public transport services are successfully applied in foreign countries. The analysis of international experience made it possible to get acquainted with the basic normative legal acts in the field of standardization of the quality of transport services [2, 3].

The analysis of domestic experience in standardizing the quality of transport services of population made it possible to single out regulatory legal acts in Moscow, Kazan, Bratsk, Penza, Omsk, Krasnoyarsk region, and the Republic of Tatarstan.

Mathematically, the quality of transport services is represented by a vector in the n-dimensional coordinate system, where $n$ is the number of quality assessment indicators (Pic. 2). The vector interpretation of quality explains its fundamental difference from quantitative indicators. The quality assessment is a two-stage procedure: primary assessment for each of the indicators is considered, after which the integral indicator is calculated [4].

System analysis of the methods [4–12] of the integral assessment of the quality of Ku transport service is given in Table 1, where $K_i$ is a particular quality indicator, $A_i$ is a weighting coefficient at the exponent, and $Z$ is an operator that reduces the value of $K_i$ to the dimensionless form.

Basic definitions and wording concerning the quality of transport services are set out in GOST [Russian state standard] 30596–97. The nomenclature of recommended quality indicators, as well as the main provisions for selection of indicators, is contained in GOST 51004–96.

Accessibility and reliability
According to the social standard [1], the indicator of territorial accessibility of stop points $K_{access}$ is determined by the ratio of the number of stop points within the normative values of the distances of the shortest walking paths from the nearest point to the stop point of the border of the land plot on which the object $O_{access}$ (pcs) is located, to the total number of stop points $O_{access}$ (pcs), followed by scoring of the received coefficient.

Let’s note that in relation to the conditions of the city of Moscow there are requirements for the territorial pedestrian accessibility of public transport stops approved in [13, 14].

The initial information for assessment of $K_{access}$ is proposed to be obtained through the analysis of measurements using open sources (Yandex maps, OpenStreetMap), as well as specialized software packages –GIS, Mosgortrans– and «ArcGIS».

The indicator of accessibility of stop points, bus terminals and bus stations for the low-mobility
Compliance with the schedule of regular transportation routes

Price accessibility of trips along municipal routes of regular transportation

Equipment of bus terminals, bus stations and stop points

Frequency of service of stop points

Compliance with the schedule of regular transportation routes

Noise level in the cabin of transport vehicles

Equipment of transport vehicles with means of informing of passengers

Temperature in the cabin of transport vehicles

Compliance with capacity rates

Number of transfers

Environmental friendliness

**Pic. 1. Structure of transport quality indicators.**

**Pic. 2. Vector representation of quality (the number n of indicators is three – X, Y, Z; K, and K – respectively, the initial and normative quality of service).**

population groups $K_{\text{sp}, \text{bt}, \text{bs. lmp}}$ is determined by the ratio of the number of stop points, bus terminals and bus stations that are served by regular transport routes and meet the requirements of $Q_{\text{Min}, \text{bt}, \text{bs. lmp}}$ [15, 16], to the total number of stop points, bus terminals and bus stations $Q_{\text{bt}, \text{bs. lmp}}$ with subsequent scoring of the received coefficient value. However, since May 15, 2017, it has become invalid [15], except for the points included in the list of national standards and codes of practice, as a result of which compliance with the requirements [17] in connection with the publication [18] is ensured on a mandatory basis. That is, in the future, when assessing compliance with requirements, it is necessary to be guided by [18, points 8.4.9–8.4.14].

Assessment of compliance with the requirements [16, 18] is proposed to be carried out by analyzing the accessibility passport of facilities for disabled people and other low-mobility groups of population, and by the method of full-scale survey with photographing of transport infrastructure facilities.

When carrying out a full-scale survey, it is proposed to create a commission involving the owner of the facility or his responsible representative and one of the public associations of disabled people which operate in the city of Moscow.

**Pic. 1. Structure of transport quality indicators.**

**Pic. 2. Vector representation of quality (the number n of indicators is three – X, Y, Z; K, and K – respectively, the initial and normative quality of service).**

The indicator of accessibility of transport vehicles for low-mobility population groups $K_{\text{tv.inst.}}$ is determined by the ratio of the number of vehicles equipped with devices for transportation of low-mobility groups of population meeting the requirements [16, 19] $Q_{\text{tv.inst.}}$, to the total number of vehicles intended for transportation of passengers and baggage transportation by road transport by regular transportation routes $Q_{\text{tv}}$, with the subsequent scoring of the received value.

Assessment of compliance with the requirements [16, 19] is proposed to be carried out by analyzing the accessibility passport of vehicles for the disabled and other low-mobility groups of population, and also by the method of field survey with photographing.

When carrying out a full-scale survey, it is proposed to create a commission involving the owner of the facility or his responsible representative and one of the public associations of disabled people which operate in the city of Moscow.

**Pic. 2. Vector representation of quality (the number n of indicators is three – X, Y, Z; K, and K – respectively, the initial and normative quality of service).**
number of trips for carrying passengers and baggage by road transport on the routes of regular transportation performed at the time specified by the schedule or within the permissible deviations from the traffic schedule \(Q_{\text{trans}}\), to the total number of passengers making transfers within the same trip on the municipal routes of regular transportation \(N_{\text{trans}}\).

Methodological approaches to determining the transfer rates are given in [21].

\(D_{\text{cap}}\) is defined by the number of vehicles of ecological classes no lower than Euro-4, intended for the transportation of passengers and baggage by road transport on regular transportation routes \(Q_{\text{trans}}\), to the total number of vehicles on regular transportation routes \(Q_{\text{tv}}\).

Implementation of an additional assessment of compliance with the environmental class in accordance with TR TS 018/2011 in the city conditions is impractical in connection with the approved resolutions of the Government of Moscow dated April 20, 2010 No. 322-PP and from July 1, 2014 No. 354-PP environmental requirements for vehicles, used for transportation of passengers.

**Problems of quality assessment**

Basing on the results of the study, the main problems of assessing the quality of transport services for population are identified:

1. There are non-optimal or incorrect provisions of the standard.
2. Difficulties are created by the absence of scales of indicators when calculating the integral estimate.
3. For a number of positions, there is a lack of data available to local authorities and open sources of information, including official statistics.
4. There is no methodology for carrying out field surveys to obtain relevant data.

**Conclusion.**

In order to improve assessment of quality of transport services of population the following approach is suggested:

1. Adjustment of relevant provisions of social standards [1], development and introduction of methodological recommendations for conducting field surveys.
2. Approval of requirements for accessibility of stop points for low-mobility population groups.
3. Establishment of requirements for monitoring compliance with measures for accessibility of vehicles for low-mobility groups and quality of services provided by municipal transport.

**REFERENCES**

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