QUALITY INDICES OF PUBLIC TRANSPORTATION SERVICES

Ayriev, Radion S., *SUE Mosgortrans, Moscow, Russia.*
Kudryashov, Maxim A., *SUE Mosgortrans, Moscow, Russia.*

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

Methods for calculating the integral quality indicator

Method for assessment of the integral quality indicator	Calculation formula
Arithmetic sum of the partial indicators	$Ku = \sum_{i=1}^{n} K_i Z$
Weighted sum of the partial indicators	$Ku = \sum_{i=1}^{n} K_i A_i Z$
Product of the partial indicators	$Ku = \prod_{i=1}^{n} K_i Z$
Weighted product of the partial indicators	$Ku = \prod_{i=1}^{n} K_i A_i Z$
Geometric mean of the partial indicators	$Ku = \sqrt[i]{\prod_{i=1}^{n} K_i Z}$
Value of a vector constructed in the system of coordinates of the partial indicators	$Ku = \sqrt{\sum_{i=1}^{n} K_i Z}$

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 Ki is a particular quality indicator, Ai is a weighting coefficient at the exponent, and Z is an operator that reduces the value of Ki 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.

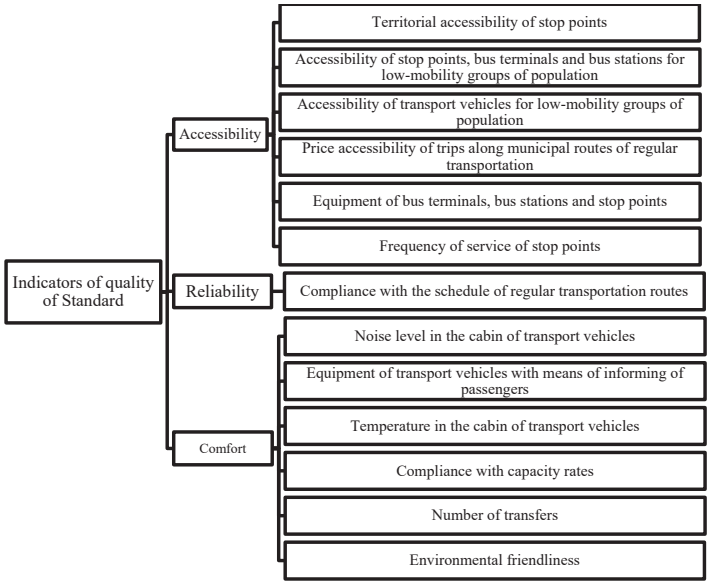
Accessibility and reliability

According to the social standard [1], **the indicator of territorial accessibility of stop points** $K_{access.\ sp}$ *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* $Q_{sp\,access}$ *(pcs) is located, to the total number of stop points* Q_{sp} *(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 $K_{access\ sp}$ *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



Pic. 1. Structure of transport quality indicators.

population groups $K_{sp,\,bt,\,bs.\,lmp}$ *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* $Q_{sp,\,bt,\,bs.\,lmp}$ *[15,16], to the total number of stop points, bus terminals and bus stations* $Q_{sp,\,bt,\,bs.}$*, 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.

The indicator of accessibility of transport vehicles for low-mobility population groups $K_{tv.lmp}$ *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]* $Q_{tv.inst.}$*, to the total number of vehicles intended for transportation of passengers and baggage transportation by road transport by regular transportation routes* Q_{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.

The indicator of price accessibility of trips on the municipal routes of regular transportations k_d *is determined by the ratio of the average monthly passenger expenses for these trips (equal to the cost of a long-term ticket granting the right to unlimited trips within a month) to the average weighted arithmentic per capita income of population of Moscow with a subsequent score of the obtained value of the coefficient.*

Information on the cost of a long-term ticket is offered to be assessed by analyzing the cost of a «single» ticket for 30 days, recorded on a card «Troika» [Moscow multiple travel e-ticket with replenishable account].

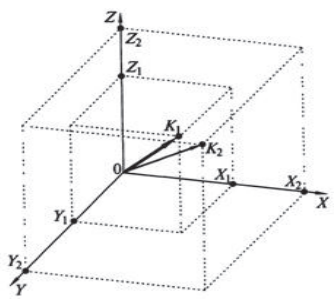
The calculation of the average per capita monetary income of the population is performed on the basis of the data of the territorial body of the Federal State Statistics Service.

The indicator of the equipment of bus terminals, bus stations and stop points $K_{equip.sp,\,bt,\,bs}$ *is defined as the ratio of the number of stop points, bus terminals and bus stations equipped with visual information for passengers and other elements required in accordance with the requirements [20], to the total number of bus terminals, bus stations and stop points* $Q_{sp,\,bt,\,bs}$ *with the subsequent scoring of the received coefficient.*

Assessment of compliance with the requirements of [20] is proposed to be carried out by the method of full-scale examination with photographing.

The indicator of frequency of service of stop points $D_{minfreq}$ *is assessed by the proportion of stop points serviced at the minimum standard frequency* $Q_{spminfreq}$*, to the total number of stop points* Q_{sp}*, followed by a scoring of the obtained coefficient.*

The indicator of reliability *is assessed by the coefficient of compliance of the schedule of regular transportation routes* K_{sched} *and is defined as the ratio of the*



Pic. 2. Vector representation of quality (the number n of indicators is three – X, Y, Z; K_1 ***and*** K_2 ***– 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 $Q_{tripsched}$ to the total number of trips when carrying passengers and baggage by road transport on the routes of regular transportations Q_{trip} with the subsequent scoring of the obtained coefficient.

The initial information for assessment of the values K_{sched} is proposed to be obtained by analyzing the actual data of the satellite navigation system GLONASS about the arrival of the vehicle at the stop point with the subsequent comparison with the planned schedule.

Comfort of passengers

The parameters of comfort of passenger transportation include: the coefficient of equipping vehicles with means of informing passengers ($K_{equiptv}$), the proportion of vehicles with a standard noise level in the cabin ($D_{tvnoise}$), the proportion of trips with the standard temperature in the passenger compartment of the vehicle ($D_{trip.temp.stand.}$), capacity compliance rate (K_{cap}), the transfer coefficient (K_{trans}).

$K_{equiptv}$ is determined by the ratio of the number of vehicles equipped in accordance with [20] with means of informing passengers on regular transportation routes $Q_{equip.tv}$, to the total number of vehicles intended for carrying passengers and baggage by road transport along regular transportation routes Q_{tv}, followed by scoring of the obtained coefficient.

Assessment of compliance with the requirements of [20] is proposed to be carried out by the method of full-scale examination with photographing.

$D_{tvnoise}$ characterizes compliance with the requirements established by GOST R 51616–200. However, it is recognized as invalid and on April 1, 2017 GOST 33555–2015 was put into effect. As an estimate of the internal noise, the sound level corrected for A (dBA) according to GOST 17187–2010 is adopted. To measure the internal noise of ATS, the devices specified in GOST 17187–2010 are used.

$D_{trip.temp.stand.}$ is determined by the ratio of the number of performed trips for transportation of passengers and baggage by road transport on the routes of regular transportation with the standard temperature in the cabin $Q_{triptempstand}$ according to [1] to the total number of trips performed on the routes of regular transportation Q_{trip}.

Measurement of the temperature level in the cabin is proposed to be carried out in accordance with GOST R 53828–2010 and GOST 30593–2015. The system of heating, ventilation, air conditioning must comply with the requirements of TR TS 018/2011. During testing, the measurement error is allowed in accordance with GOST 8.051. When carrying out road tests, the requirements of RF Government Decree No. 1090 of 23.10.1993 are to be complied with. The procedure for selecting the location of measuring devices is regulated by GOST 28261–89.

K_{cap} is determined by the ratio of the number of trips carried out by vehicles during transportation of passengers and baggage by road transport on municipal routes of regular transportation, in compliance with capacity rate requirements $Q_{tripcap}$ in accordance with the requirements in [1], to the total number of trips performed on the municipal routes of regular transportation Q_{trip}.

Let's note that in relation to the conditions of Moscow, there are requirements to the estimated capacity norm [14]. Information on the occupancy of the passenger compartment of the vehicle is proposed to be obtained by the method of full-scale examination during peak hours and inter-peak periods on weekdays.

K_{trans} is determined by the ratio of the number of passengers making no more than two transfers while moving to any point of the municipality within the same trip using the municipal routes of regular transportation $N_{trans.norm}$, to the total number of passengers making transfers within the same trip on the municipal routes of regular transportation N_{trans}.

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

D_{eco} is defined by the number of vehicles of ecological classes not lower than Euro-4, intended for the transportation of passengers and baggage by road transport on regular transportation routes Q_{tveco}, to the total number of vehicles on regular transportation routes Q_{tveco}.

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

1. Decree of the Ministry of Transport of the Russian Federation of 31.01.2017 No. NA-19-r «On approval of the social standard of transport services of population when carrying out transportation of passengers and baggage by road and urban land electric transport» [*Rasporyazhenie Mintransa Rossii ot 31.01.2017 No. NA-19-r «Ob utverzhdenii sotsialnogo standarta transportnogo obsluzhivaniya naseleniya pri osushchestvlenii perevozok passazhirov i bagazha avtomobilnym transportom i gorodskim nazemnym elektricheskim transportom»*]. [Electronic resource]: https://special.mintrans.ru/upload/iblock/736/rasp_mt_na_19r_31012017.pdf. Last accessed 31.01.2018.

2. European Union Standard EN 13816:2002. «Transportation. Logistics and services. Public passenger transport. Determination of quality of service, compilation of tasks and measurement» [*Standart Evropeiskogo soyuza EN 13816:2002. «Transportirovanie. Materialno-tehnicheskoe obespechenie i uslugi. Obshchestvenniy passazhirskiy transport. Opredelenie kachestva uslugi, sostavlenie zadanii i izmerenie»*]. [Electronic resource]: http://www.standards.ru/document/4025389.aspx. Last accessed 31.01.2018.

3. US Standard. Transit Capacity and Quality of Service Manual [Electronic resource]: http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_webdoc_6-a.pdf. Last accessed 31.01.2018.

4. Spirin, I. V. Scientific bases of complex restructuring of urban bus transport. D.Sc. (Eng) thesis [*Nauchnie osnovy kompleksnoi restrukturizatsii gorodskogo avtobusnogo transporta. Dis... dok. teh. nauk*]. Moscow, MADI publ., 2007, 421 p.

5. Bludyan, N. O., Antonov, M. N. Criterial assessment of provision of population of the region with transport services [*Kriterialnaya otsenka obespechennosti naseleniya regiona transportnym obsluzhivaniem*]. *Vestnik MADI (STU)*, 2009, Iss. 3, pp. 110–113.

6. Kudryashov, M. A., Shatalova, A. V. Methodology for assessing the quality of services of low-mobility population groups in transport and interchange hubs [*Metodika otsenki kachestva obluzhivaniya malomobilnyh grupp naseleniya v transportno-peresadochnyh uzlah*]. *Gruzovik*, 2017, Iss. 11, pp. 35–42.

7. Kudryashov, M. A., Maslova, V. Yu. Interaction of motor transport (personal and general use) in transport-interchange hubs [*Vzaimodeistvie avtotransporta (lichnogo i obshchego polzovaniya) v transportno-peresadochnyh uzlah*]. *Gruzovik*, 2018, Iss. 1, pp. 35–42.

8. Bludyan, N. O. Assessment of the level of transport services of population of the region [*Otsenka urovnya transportnogo obsluzhivaniya naseleniya regiona*]. *Avtomobilniy transport*, 2008, Iss. 2, pp. 24–27.

9. Tlegenov, B. N. An analysis of assessment methods and quality indicators of the urban passenger transport system [*Analiz metodov otsenki i pokazatelei kachestva sistemyy gorodskogo passazhirskogo transporta*]. *Sovremennie problemy nauki i obrazovaniya*, 2012, Iss. 3 [Electronic resource]: https://science-education.ru/ru/article/view?id=6121. Last accessed 31.01.2018.

10. Asaliev, A. M., Zavyalova, N. B., Saginova, O. V., Spirin, I. V., Skorobogatykh, I. I. [*et al*]. Marketing approach to quality management of transport services: Monograph [*Marketingoviy podhod k upravleniyu kachestvom transportnogo obsluzhivaniya: Monografiya*]. Novosibirsk, Publishing house of CRNS, 2016, 172 p.

11. Frolov, K. V. Development of indicators and standards for quality of urban bus transportation. Ph.D. (Economics) thesis [*Formirovanie pokazatelei i normativov kachestva gorodskih avtobusnyh perevozok. Dis... kand. ekon. nauk*]. Moscow, 2005, 156 p.

12. Antonov, M. N. Improving the methods of justifying the parameters of public transport services by bus routes of regular transportation. Ph.D. (Eng) thesis [*Sovershenstvovanie metodov obosnovaniya parametrov transportnogo obsluzhivaniya naseleniya po avtobusnym marshrutam regulyarnyh perevozok. Dis... kand. tehn.nauk*]. Moscow, MADI publ., 2010, 159 p.

13. Resolution of the Government of Moscow of 23.12.2015 No. 945-PP «On approval of regional standards for urban planning of the city of Moscow in the field of transport, highways of regional or intermunicipal significance» [*Postanovlenie pravitelstva Moskvy ot 23.12.2015 No. 945-PP «Ob utverzhdenii regionalnyh normativov gradostroitelnogo proektirovaniya goroda Moskvy v oblasti transporta, avtomobilnyh dorog regionalnogo ili mezhmunitsipalnogo znacheniya»*]. [Electronic resource]: http://www.consultant.ru/cons/cgi/online.cgi?req=doc&base=MLAW&n=167806#0. Last accessed 28.01.2018.

14. Resolution of the Government of Moscow of 25.01.2000 No. 49 (Edited on December 23, 2015) «On approval of norms and rules for planning and building of Moscow MGSN 1.01-99» [*Postanovlenie pravitelstva Moskvy ot 25.01.2000 No. 49 (red. ot 23.12.2015) «Ob utverzhdenii Norm i pravil proektirovaniya i zastroiki Moskvy MGSN 1.01-99»*]. [Electronic resource]: http://docs.cntd.ru/document/901753007. Last accessed 28.01.2018.

15. Code of Regulations SP 59.13330.2012 «SNiP 35-01-2001. Accessibility of buildings and structures for low-mobility groups of population». The updated version of SNiP 35-01-2001 (approved by the order of the Ministry of Regional Development of the Russian Federation of December 27, 2011 No. 605) [*Svod pravil SP 59.13330.2012 «SNiP 35-01-2001. Dostupnost' zdanii i sooruzhenii dlya malomobilnyh grupp naseleniya». Aktualizirovannaya redatsiya SNiP 35-01-2001 (utv. Prikazom ministerstva regionalnogo razvitiya RF ot 27 dekabrya 2011. № 605)*]. [Electronic resource]: http://base.garant.ru/70158682/#ixzz4xLiyt2F7. Last accessed 31.01.2018.

16. Order of the Ministry of Transport of the Russian Federation No. 347 of December 1, 2015 «On Approving the Procedure for Providing Accessibility for Passengers from Disabled Persons of Road Transport Vehicles and Urban Ground Electric Transport, Bus Terminals, Bus Stations and Services, and Providing them with the Required Assistance» [*Prikaz Mintransa RF ot 1 dekabrya 2015 g. № 347 «Ob utverzhdenii Poryadka obespecheniya uslovii dostupnosti dlya passazhirov iz chisla invalidov transportnyh sredstv avtomobilnogo transporta, avtovokzalov, avtostantsii i predostavlyaemyh uslug, a takzhe okazaniya im pri etom neobhodimoi pomoshchi»*]. [Electronic resource]: http://www.garant.ru/products/ipo/prime/doc/71294366/#ixzz4xLjTREoY. Last accessed 31.01.2018.

17. Decree of the Government of the Russian Federation of December 26, 2014 No. 1521 «On approval of the list of national standards and codes of practice (parts of such standards and codes of regulations), as a result of which mandatory compliance with the requirements of the Federal Law «Technical Regulations on Safety of Buildings and Facilities is provided» [*Postanovlenie pravitelstva RF ot 26 dekabrya 2014 № 1521 «Ob utverzhdenii perechnya natsionalnyh standartov i svodov pravil (chastei takih standartov i svodov pravil), v rezultate primeneniya kotoryh na obyazatelnoi osnove obespechivaetsya soblyudenie trebovanii Federalnogo zakona: Tehnicheskiy reglament o bezopasnosti zdanii i sooruzhenii»*]. [Electronic resource]: http://base.garant.ru/70835592/#ixzz4zKfskHSf. Last accessed 31.01.2018.

18. SP 59.13330.2016 «Accessibility of buildings and structures for low-mobile groups of population» (Order of the Ministry of Construction of Russia of November 14, 2016 No. 798/pr) [*SP 59.13330.2016 «Dostupnost zdanii i sooruzhenii dlya malomobilnyh grupp naseleniya» (prikaz Minstroya Rossii ot 14 noyabrya 2016* г. *№ 798/pr)*]. [Electronic resource]: http://www.minstroyrf.ru/docs/13225/. Last accessed 31.01.2018.

19. State Standard RF GOST R 51090-97 «Means of public passenger transport. General technical requirements for accessibility and safety for disabled people» [*Gosudarstvenniy standart RF GOST R 51090-97 «Sredstva obshchestvennogo passazhirskogo transporta. Obshchie tehnicheskie trebovaniya dostupnosti i bezopasnosti dlya invalidov»*]. [Electronic resource]: http://base.garant.ru/5921783/#ixzz4xLk16Zj9. Last accessed 31.01.2018.

20. Decree of the Government of the Russian Federation No. 112 dated February 14, 2009 (as amended on April 28, 2015) «On Approval of the Rules for Transportation of Passengers and Baggage by Road Transport and Urban Land Electric Transport [*Postanovlenie pravitelstva RF ot 14.02.2009 № 112 (red. ot 28.04.2015) «Ob utverzhdenii Pravil perevozok passazhirov i bagazha avtomobilnym transportom i gorodskim nazemnym elektricheskim transportom»*]. [Electronic resource]: http://www.consultant.ru/document/cons_doc_LAW_85364/. Last accessed 31.01.2018.

21. Modeling of places of transfer of passengers on the route network of public transport in medium cities [*Modelirovanie mest peresadok passazhirov na marshrutnoi seti obshchestvennogo transporta v srednih gorodah*]. [Electronic resource]: http://eprints.kname.edu.ua/39192/1/23.pdf. Доступ 31.01.2018.

Information about the authors:
Ayriev, Radion S. – Adviser to the Deputy General Director of SUE Mosgortrans, Moscow, Russia, ayrievrs@mail.ru.
Kudryashov, Maxim A. – Head of the Personnel Sector of SUE Mosgortrans, Moscow, Russia, sparky5@yandex.ru.

Article received 02.04.2018, accepted 17.06.2018.