Methodological Approach to the Formation and Evaluation of the Quality of Operation of Urban Public Transport Services

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ABSTRACT

         In this work, the theoretical aspects of the formation of operational qualities of rolling stock used in urban public transport, its services on the basis of operational characteristics are studied, and a methodology for assessing the operational quality of real routes served by bus companies is proposed.

Keywords-- Urban Public Transport, Rolling Stock, Operational Characteristics, Operational Quality, Technical and Operational Quality, Commercial Operational Quality, Level of Utilization of Operational Quality Potential

I. INTRODUCTION

There are a number of requirements set by consumers for the provision of public transport services to the population. These include the fact that the services provided are safe, reliable, fast, regular, inexpensive, convenient, complete, and so on. All the requirements of modern quality public transport can be summed up in one sentence: "Passengers have access to safe, cheap, fast, convenient and guaranteed transport service at any time, from any area to any destination".

Currently, the high rates of automation and the rapid use of private vehicles are leading to a decrease in traffic speeds in cities and, as a result, an increase in the time spent by the population on transport.

Therefore, the main criterion for the development of public transport in cities today is to reduce the time spent by passengers to reach their destinations.

In today's consumer-oriented economic environment, the population should be given the opportunity to choose a wide range and flexible modes of transport. The city needs not only a network of fast-moving and developed routes, but also a high level of service quality. The main factor that motivates passengers to choose a particular route and mode of transport is the speed of movement, which characterizes the operational quality of transport services, a set of technical and operational indicators required to ensure its required level.

In an environment where consumer demands are not limited, it is a very difficult task to assess what the high level of quality of transport services should be. However, it will be possible to achieve certain levels of satisfaction of these requirements. The level of continuous and effective achievement of the optimal level of satisfaction of these unlimited requirements determines the operational qualities of road transport services.

Operational qualities of road transport services are a complex concept and are described differently in different scientific sources. Due to this, the disclosure of the essence of this category is of scientific and practical importance.

The term "operational qualities of the car" was first introduced to science in 1928 by academician A. Chudakov.

Taking into account the specific features of the car, the scientist is based on the need to determine its design perfection not by a single generalized quality, but by a separate set of indicators that represent its performance, stability, controllability, smoothness of movement, ease of maintenance, capacity, walking reserve, weight utilization, dimensional use and maneuverability.

In addition, the durability of the car, its adaptability to loading and unloading, the level of active and passive safety, the period of movement of the vehicle during maintenance, the scope of maintenance, moisture and dust protection of the body or cabin, vibration protection, heating and ventilation system There are also operational qualities such as efficiency.

As a result of our analytical work, many researchers have applied the terms operational quality and operational characteristics directly to the design features and performance of vehicles, and it has been shown that the similarities and differences between these concepts are not sufficiently explained. For example, in a number of works the terms of operational characteristics, and in some of them the terms of operational qualities are widely used.

An operational feature is a change in the position or space of a vehicle in a unit of time due to external or internal influences on one or more functionally integrated structural elements.

Operational quality, on the other hand, arises from a combination of certain design features of road transport and is an indicator that characterizes the level of advantage or superiority of a car in a particular operating condition.

Quality of any product or service is a set of features that indicate its ability to meet certain needs in

accordance with its function.If we focus on the vehicle as a product, this definition applies to it as well.

The quality of transport services can be defined as the level of maximum satisfaction of consumer aggregate requirements for transport services provided under certain operating conditions.
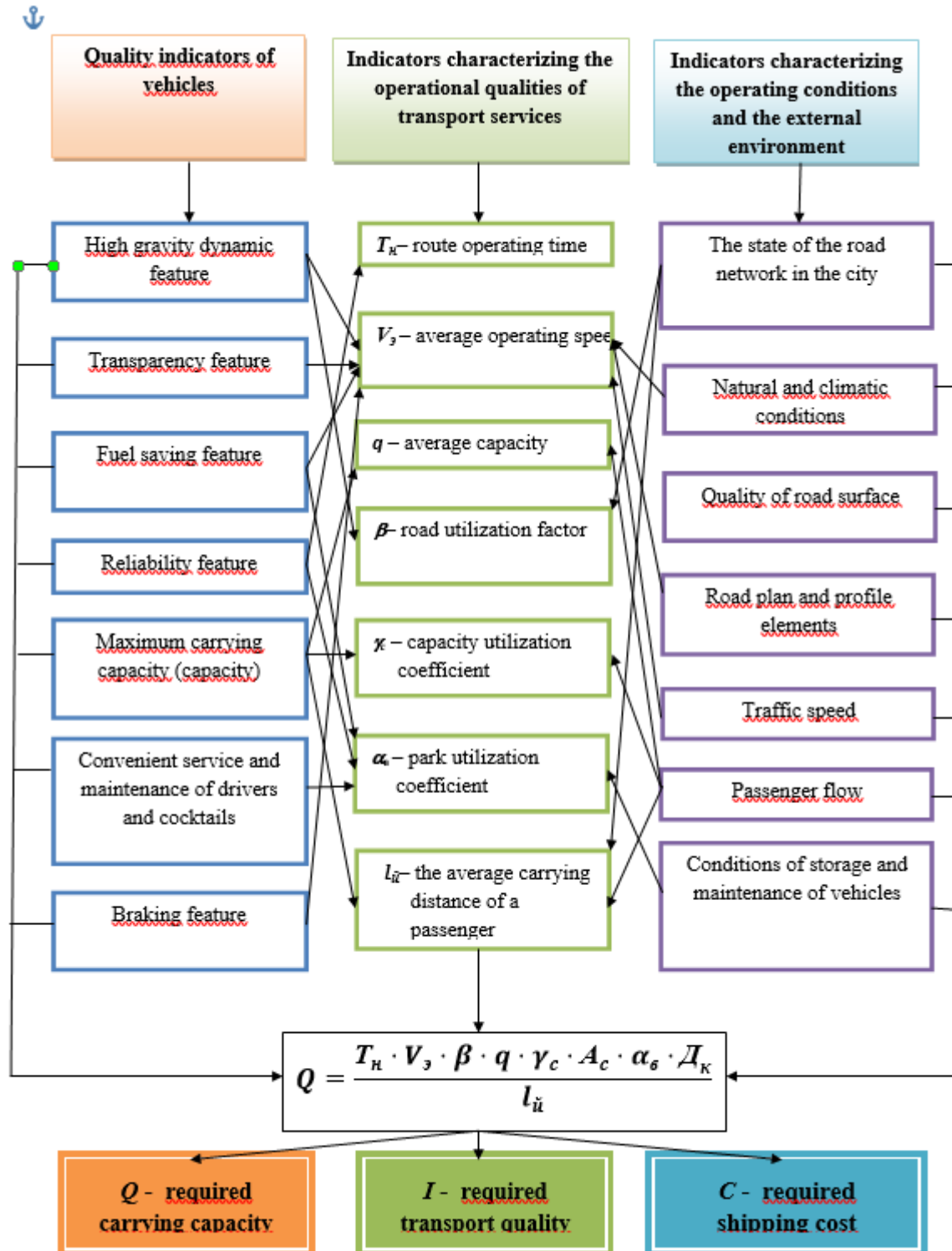

Figure 1: Structural mechanism of ensuring the operational quality of bus services

The provision of road transport services is a process of selling labor, and the quality of service is determined by the quality of the performance of this work, that is, the quality of work performed at all times can not provide quality service. Ensuring the quality of service processes by transport operators is directly related to the quality of the vehicles that are the subject of their work. Thus, while the operational qualities of vehicles are a separate category, the activity of the transport system is also a component that ensures the operational qualities, in some of which the quality of transport services is formed. In this regard, the operational qualities of transport as a service sector, in turn, are divided into technical-operational and commercial qualities.

Technical and operational quality of road transport is the ability to continuously fully meet the technical and technological condition of vehicles at the disposal of transport operators in the maximum satisfaction of consumer aggregate requirements for transport services.

The commercial operational quality of road transport services is the ability to achieve the optimal level of meeting the overall consumer demand for transport services.

The properties of structural elements form a systematic link with the relevant operational qualities, which in turn depends on the operational performance of road transport, which affects the value of transport costs.

Thus, the final product of the transport system - the quality of transport services and related costs depends on the operational qualities of the rolling stock, which is the main means of labor, and, of course, the technical and commercial operation that performs them optimally (Picture 1).

The operational characteristics of public transport services on buses are a dynamic process that requires an approach to determining its quality levels, taking into account various factors. We can conditionally divide such factors into static and dynamic parts. At the same time, there is a need to systematize the indicators of dynamic processes in terms of levels of importance, to develop methods for determining the most optimal options for them, taking into account the characteristics of a particular time and region conditions.

Operational qualities depend objectively on external environmental factors: natural and climatic conditions, location of population and productive forces, transport, financial and credit, tax, valuation and social policies of the state, to which ATCs are not able to influence.

Internal factors are directly related to the enterprise, which depends on the organization of production, personnel and management system, logistics, service, fleet structure, entrepreneurial ability, transportation technology, customer interaction and the level of settlements. It is advisable to evaluate the performance of ATC at the following stages:

- Formation of objectives for the assessment of operational qualities;
- To determine the scope of indicators for the assessment of operational qualities;
- Coordination of units of measurement of its individual indicators for the quantitative assessment of operational qualities of road transport enterprises;
- Bringing the selected indicators to a single unit of measurement;
- Determine the minimum level of operational qualities that can provide the required volume of passenger traffic on regular routes served by the bus company;
- Calculation of the level of operational quality on the basis of minimum values of indices of technical and operational indicators in certain sections.

We select the main technical and operational indicators used to determine the volume of passenger traffic for bus companies.

$$Q = \frac{T_н \cdot V_э \cdot \beta \cdot q \cdot \gamma_c \cdot A_c \cdot \alpha_в \cdot Д_к}{l_й} \qquad (1)$$

As can be seen from Formula 1, the technical and operational indicators that are functionally related to the carrying capacity are:

1. Q– annual traffic volume, tn, passenger;
2. $T_н$– average daily working hours of cars, hours;
3. $V_э$–average operating speed, km / h;
4. β– average distance utilization factor;
5. q– average passenger capacity of cars, passenger;
6. γ_c– average passenger capacity utilization factor;
7. A_c– the average number of cars on the list;
8. $\alpha_в$– average park utilization rate;
9. $Д_к$–number of calendar days;
10. $l_й$– The average carrying distance of a passenger, km;

Although the size of the vehicle fleet has a certain effect on the performance of the bus company on certain routes, it is not directly related to the traffic on the route. Because the stability of the operational qualities of the enterprise does not always depend on the size of its fleet. Also, since the calendar days are the same for everyone, As and Dk are not taken into account in subsequent calculations in order to simplify the matter.

In our example, we will form a group of 7 technical and operational indicators on the example of bus routes Number 2 in Tashkent, and for the simplicity and clarity of our calculations, we will select a group of technical and operational indicators directly related to the volume of traffic (Table 1).

To calculate the typical operational quality index, we determine the best of the indicators in this table. In determining the best technical and operational

indicators, based on the logic of the above statement, attention is paid to how big the speed is and how small

the denominator is.

Table 1: The main technical and operational indicators of bus routes Number 2 in Tashkent (2019 year)[1]

№	Indicator	Measurement unit.	M-14	M-17	M-24	M-60	M-63	M-72	M-89	M-96
1.	$T_н$	hour	13,500	11,900	14,100	12,600	12,300	13,500	14,000	13,000
2.	$V_э$	km/h	19,700	22,000	21,700	20,500	20,200	18,200	18,500	20,700
3.	q	passenger.	25,130	24,630	26,120	26,080	25,310	26,010	24,210	25,510
4.	$l_ŭ$	km	5,580	5,590	5,590	5,590	5,590	5,580	6,080	5,570
5.	β	-	0,910	0,901	0,946	0,962	0,901	0,934	0,951	0,952
6.	γ_c	-	0,580	0,509	0,611	0,811	0,567	0,420	0,471	0,710
7.	$\alpha_в$	-	0,740	0,700	0,750	0,660	0,520	0,820	0,600	0,660

For the quantitative assessment of the operational qualities of the ATC, its unit of individual indicators is coordinated. The selection of indicators should be based on the following principles:
- The principle of complexity. This principle determines the need to take into account the impact of individual indicators on the overall system;
- The principle of reasonable proportionality of indicators - involves the maintenance of a certain balance between individual indicators and their groups. Unreasonable overestimation or underestimation of the importance of certain indicators can lead to errors in the formation of the evaluation system and in drawing conclusions;
- The principle of ordering the system of indicators - represents the possibility of expanding or reducing the range of indicators, depending on the goals and objectives of the assessment.

- The principle of comparison of indicators. The fact that the indicators used in the assessment of the level of operational stability are obtained in different time and methods, as well as the diversity of units of measurement should be able to compare them in all parts of the system under study. In this case, the following requirements are set for the indicators:

a) logical interaction with the laws of scientific and technological development;
b) scientific validity and objectivity;
c) simplicity and ease of calculation;
d) accuracy and uniform interpretation of the results obtained;
e) the preservation of the content of indicators for a certain period of time, etc.

The selected parameters are converted into a single unit of measurement. As can be seen from the data in Table 1, the units of measurement of the given technical and operational indicators are different. To bring them to the same appearance, that is, to the coefficients, we calculate the index of each technical-operational indicator relative to their best (Table 2).

Table 2: Index of technical and operational indicators of bus routes Number 2 in Tashkent (2019 year)[1]

№	Indicator	Measurement unit	M-14	M-17	M-24	M-60	M-63	M-72	M-89	M-96
1.	$T_н$	hour	0,957	0,844	1,000	0,894	0,872	0,957	0,993	0,922
2.	$V_э$	km/hour	0,895	1,000	0,986	0,932	0,918	0,827	0,841	0,941
3.	q	passenger	0,962	0,943	1,000	0,998	0,969	0,996	0,927	0,977
4.	$l_ŭ$	km	0,998	0,996	0,996	0,996	0,996	0,998	0,916	1,000

[1] & [2] Source: Bus Enterprise Report Number 2

5.	β	-	0,946	0,937	0,983	1,000	0,937	0,971	0,989	0,990
6.	γ_c	-	0,715	0,628	0,753	1,000	0,699	0,518	0,581	0,875
7.	$\alpha_{\text{в}}$	-	0,902	0,854	0,915	0,805	0,634	1,000	0,732	0,805

The lowest levels of operational quality of bus routes are selected and calculated on the basis of the minimum values of indices of technical and operational indicators.

$$K_{эсн} = \sum_{i=1}^{m} a_i\, k_i \qquad (2)$$

Where:

$K_{эсн}$–the level of standard operational qualities of bus routes under given conditions; a_i – i-technical and operational performance weight; k_i - i-technical and operational index.

To determine the weight (quantity) of each technical and operational indicators, an intermediate equation is formed on the basis of their average values:

$$\sum k'_i x = 1 \qquad (3)$$

0,844x+0,827x+0,927x+0,916x+0,937x+0,518x+0,634x =1

5,603x=1; x=0,178;

where: a_1=0,844*0,178=0,150;

a_2=0,827*0,178=0,147;

    a_3=0,927*0,178=0,165

a_4=0,916*0,178=0,163;

a_5=0,937*0,178=0,167;

a_6=0,518*0,178=0,092;

a_7=0,634*0,178=0,113.

$K_{эсн}$=0,150$T_н$+0,147$V_э$+0,165q+0,163$l_и$+0,167β+0,092γ_c +0,113$\alpha_{\text{в}}$=0,826   (4)

From the result obtained by using expression 4, it can be seen that the bus company Number 2 cannot reduce the level of operational quality on the routes it serves from 0.826, otherwise it will not be able to carry out the required volume of passenger traffic.

Given that the maximum value of the level of operational qualities at the intersection of routes is 1 (of course, the probability of this is very low) and the minimum level is 0.826, it is possible to calculate the level of utilization of available capacity in each direction, ie the level of utilization of operational qualities:

$$I_{эc} = \frac{K_{эc} - K_{эcн}}{1 - K_{эcн}} \times 100, \qquad (4)$$

Table 3: Operational qualities and capacity utilization potential of bus routes Number 2 in Tashkent

Indicator name	M-24	M-60	M-96	M-72	M-14	M-17	M-89	M-63
$K_{эc}$	0,957	0,952	0,937	0,928	0,920	0,901	0,875	0,880
$I_{эc}$, %	75,3	72,4	63,8	58,6	54,0	43,1	28,2	31,0

The probable level of utilization of the potential of operational qualities due to changes in one or another technical and operational indicators can be determined by experts in the form of points. Evaluation intervals can be set symmetrically. We propose to assess the situation at a five-point frequency:

- the lowest - less than 20.0%;
- unsatisfactory - from 21.0% to 40.0%;
- satisfactory - from 41.0% to 60%
- good - from 61% to 75%;
- higher than 81%.

As can be seen from Table 3, the M-24 route has the highest operational quality, with a utilization rate of 75.3%. The lowest level of utilization of operational qualities is observed in the M-89 and M-63 routes.

Based on the analysis of the evaluation results, it can be concluded that the bus company has sufficient reserves to improve the level of operational quality in all the studied routes.

The convenience of this assessment method is that:

- Outcome indicator - an indicator of the stability of operational qualities Kes has a complex description, taking into account the impact of technical and operational indicators;
- Free from the influence of subjective factors, as it is assessed on the basis of available accurate data;
- It is easy to determine the effectiveness of measures to improve the aggregate and individual indicators of evaluation.

Changes in technical performance indicators are monitored on the basis of identifying the risks associated with the decline in the level of operational quality and comparing the established calculation values of their change assessment with a set of standard indicators. If the current indicators are outside the scope of the model indicators, it requires prompt management decisions to rectify the situation.

The methodology for assessing the level of operational qualities and utilization of its potential allows to solve three main interrelated tasks: panoramic

monitoring of the actual condition of technical and operational indicators, their assessment and monitoring of compliance with the required values, as well as identify problems with declining operational quality .

II. CONCLUSION

The author's approach to the formation of operational qualities of public transport services in this article serves as an integral assessment of the criteria for determining the operational quality of such transport services and the quantitative indicators that represent them. Then, at a given time, the assessment of the activities of public transport operators operating in different regions, based on the social significance of public transport services, can be used by the state in the fair distribution of special benefits and subsidies to transport operators, regardless of ownership.

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