Formation of Aggregated Scientific and Theoretical Approaches to Improving the Quality of Urban Passenger Transport on the Example of Vladivostok City

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Abstract. The article describes the processes of forming a scientific and practical approach in the formation of transport services in city passenger transport and gives the procedure for applying the Federal social standard of transport services, as well as an approach for an integrated indicator of the quality of passenger traffic. In addition, an analytical and mathematical model for calculating the optimal parameters of the structure of passenger transport in conditions of an uneven level of service in Vladivostok is presented.

1. Introduction

Before the bus transport has an important task: improving the quality of service of passengers, to achieve maximum efficiency in the use of the park buses and other resources. The solution to this problem should, first of all, be sought in improving all the constituent parts of the transport process, in the rational organization of transportation.

The quality of public transport services is a systemic indicator, and in general terms directly affects the satisfaction and level of service provided to passengers. In addition, processes aimed at improving the quality of transportation have a positive effect on the cost of passenger transportation, which is also a key factor in the activities of municipal and commercial passenger enterprises.

In this regard, the development of an analytical and mathematical model and the subsequent implementation of new design solutions, which determine the relevance of the topic and the need for research aimed ultimately at intensifying the quality and cost indicators of passenger road transport (PAP) in Vladivostok [1,2,3].
2. Main quality indicators according to a sociological survey

Pursuant to clause 2.1 of the instruction of the President of the Russian Federation dated July 1, 2016 No. Pr-177 and in order to implement clause 63 of the Action Plan for the implementation of the Transport Strategy of the Russian Federation for the medium term, approved by the order of the Government of the Russian Federation No. 1734 dated November 22, 2008 p the social standard of transport services for the population was approved for the transportation of passengers and luggage by road and urban land electric transport [4].

The main aspects of this standard should be analyzed and applied when developing a system for improving the quality of public transport in Vladivostok.

It should be noted that the standards of transport services for the population, similar to the above Standard, have been successfully applied for a long time and successfully in foreign countries, such as the EU countries and the USA.

The social standard of transport services is aimed at solving the problems most frequently encountered in the corresponding surveys of the population of different cities of the Russian Federation and is focused on 3 main indicators.

It is worth noting that on the investigated routes of regular bus transportation, a calculated assessment of the value of points was carried out for each parameter of the "Social standard ...".

As can be seen from the data obtained, the lowest scores also have indicators of vehicle availability for people with limited mobility (minimum values on routes - 15k, 85 and 38) and compliance with capacity standards (especially on passenger transport routes No. 89, 29, 85 and 38).

To confirm the calculated indicators of the quality of passenger transportation, the next stage of the study was a questionnaire survey of passengers on the named bus routes to conduct reference comparisons. The questionnaire was developed on the basis of the "Social Standard ..." and contained 12 questions. The results of the survey are presented in Table 1.

| Quality level | Routes 15 | 15k | 89 | 29 | 63 | 75 | 7t | 13 | 54 | 85 | 38 |
|---------------|-----------|-----|----|----|----|----|----|----|----|----|----|
| To dost op    | 7.1       | 6.87| 7.34| 6.29| 7.17| 7.34| 7.41| 7.07| 7.39| 6.44| 7.26|
| K dost ost mn | 6.72      | 6.33| 5.84| 5.78| 6.17| 6.25| 5.97| 6.03| 6.17| 5.59| 6.37|
| K of mn      | 6.75      | 3.96| 6.58| 4.27| 3.83| 3.72| 3.48| 4.13| 3.98| 1.05| 1.17|
| K d          | 7.15      | 7.07| 6.98| 6.53| 7.11| 7.09| 6.81| 6.95| 7.05| 6.99| 7.01|
| K tc main    | 9.13      | 8.78| 9.34| 8.64| 9.15| 9.11| 8.94| 8.87| 9.18| 8.82| 9.04|
| D min. frequent | 9.97     | 9.82| 9.1 | 9.87| 9.5 | 9.8 | 9.3 | 9.96| 9.6 | 9.93| 9.98|
| To scheduling | 6.52      | 7.73| 8.15| 5.81| 6.99| 7.16| 8.67| 8.32| 8.02| 6.72| 6.84|
| To main TT   | 8.9       | 7.25| 8.89| 5.56| 6.97| 7.03| 7.3 | 6.58| 7.53| 5.39| 7.17|
| D noise      | 9.4       | 9.8 | 9.1 | 9.1 | 8.6 | 8.7 | 9.9 | 9.7 | 9.8 | 9.2 | 9.9 |
| K flight pace | 8.51      | 9.93| 9.48| 8.18| 9.94| 9.33| 9.58| 9.47| 9.86| 9.26| 9.36|
| K km         | 5.17      | 5.33| 7.17| 4.58| 4.02| 3.88| 5.21| 6.94| 6.17| 3.32| 4.79|
| K transplants | 8.96     | 8.77| 9.18| 7.99| 9.12| 7.67| 8.15| 8.44| 8.64| 6.82| 6.88|
| D eco        | 9.4       | 9.5 | 9.7 | 3.68| 9.61| 8.5 | 5.16| 4.77| 5.08| 4.69| 5.34|
| Total, points | **103.68**| **101.14**| **106.85**| **86.28**| **98.18**| **95.58**| **95.88**| **97.23**| **98.47**| **84.22**| **91.11**|

The aim of the study was to calculate a generalized indicator of the quality of passenger transport services. For its calculation, a calculation method was chosen according to the criterion of the minimum variance of the generalizing indicator, taking into account the coefficients of the weight of particular indicators in the integral [5,6,7,8].
3. Mathematical methods and criteria for urban passenger transportation

Criterion for the minimum variance of the estimation functional. For each solution \( x \in X \), we determine the average value of the estimation functional and the variance. The variance characterizes the value of the risk, the spread of the random variable of the value of the estimation functional. The essence of the criterion for minimizing variance is to find a solution for which the variance (spread) would be minimal.

The disadvantage of the criterion is that the variance at \( X_1 \) can be less than at \( X_2 \), which still does not guarantee the overall minimum risk for the two decisions.

The main criterion for managing the quality and efficiency of transport production is integral quality. Its use is due to the presence in the passenger transport system of unequal sets of simple natural quality indicators for different levels of management and types of work [9, 10].

It is believed that the integral indicator of the quality of the services provided (\( Y \)) is a linear combination of individual quality indicators (\( X \)), the normalized values of which vary from 0 to 1:

\[
Y = \alpha_1 \cdot X_1 + \alpha_2 \cdot X_2 + \ldots + \alpha_n \cdot X_n
\]  

where \( \alpha \) are the coefficients of the weight of individual indicators of the quality of the services provided in the integral.

In addition, it should be noted that the weighting factors have discrete values.

Assuming that the unit indicators of quality service are independent variables (factor indicators), the variance of the integral indicator will be equal to:

\[
\sigma_Y^2 = \sigma_1^2 + \sigma_2^2 + \ldots + \sigma_i^2 \rightarrow \min
\]

Since the integral indicator and individual indicators of the quality of service change (normalize) from 0 to 1.

\[
a_1 + a_2 + \ldots + a_n = \sum_{i=1}^{n} a_i = 1
\]

Let us find at what values of the weighting coefficients the integral indicator has the smallest mean error (\( \sigma \)).

Taking into account the condition of equality to unity of the sum of the weighting coefficients of individual indicators of the quality of the services provided, and considering them unknown variables, we compose the objective function:

\[
\sum_{i=1}^{n} a_i^2 \cdot \sigma_i^2 \rightarrow \min
\]

with restrictions

\[
\sum_{i=1}^{n} a_i = 1, \quad a_i > 0\]

The nonlinear programming problem can be solved by the method of Lagrange multipliers (\( \gamma \)):

\[
F = \sum_{i=1}^{n} a_i^2 \cdot \sigma_i^2 \cdot 2\gamma (\sum_{i=1}^{n} a_i - 1),
\]

where \( F \) is the Lagrange function. Equating the partial derivatives of \( F \) with respect to \( a_i \) to zero, we obtain:

\[
a_i \cdot \sigma_i^2 = \gamma, \quad I = 1, 2, \ldots, n
\]

The economic and mathematical interpretation of the weighting coefficients is that the greater the variation of the integral indicator of the quality of the services provided relative to the change (variation) of a separate qualitative indicator, the higher its weighting coefficient. At the first stage of determining the integral indicator of the quality of services, the mathematical and statistical characteristics of the ratings of passengers, that is, the points assigned, were calculated for each individual service as random variables with a normal law of their distribution.
To calculate the integrated indicator, a number of iterative transformations of the initial data were carried out, obtained as a result of calculating the values of the indicators of the quality of transport services on the studied routes, taking into account the "Social standard ...".

4. Summary

Thus, according to the initial analysis of the indicators, the correlation dependence of the indicators obtained in the iterative calculations of the integral quality indicators according to the sociological survey and the data of the social standard is highlighted.

For long time integrated transportation quality indicators should increase. However, over short periods of time, the upward trend in the development of the quality of transportation for various reasons may stop or even worsen. In the first case, an increase in the quality indicators of transportation occurs in a certain proportion with the growth of other quality indicators.

For further application of the described method for calculating the integral quality of passenger road transport in practice, it is necessary to substantiate the correlation dependence of the practical and theoretical levels of dependence, as well as create a methodology for use at road transport enterprises.

5. References

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