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Theoretical Foundations of Intercity Railway Communication

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Abstract: The speed of communication on any route, directly and indirectly through the function of redistribution of traffic volumes, causes an increase in the number of movements, traffic volumes, transport work, in the network of the appropriate type, at the same time the values of the medium system coefficient of passenger capacity use and the number of vehicles may vary both in the direction of the increase and vice versa. The results of the calculations of the basic parameters of the functioning of intercity passenger route systems for various values of the speed of communication on intercity railway routes established the appropriate mathematical model for determining the parameters of this passenger communication. The conducted analysis of simulation methods has determined the possibility of using for the determination of quantitative parameters for changing the basic indicators of the operation of the system of intercity passenger route methods of mathematical and computer simulation. The results of the work determined the basic indicators of the functioning of the system of intercity passenger route transportation. These indicators include: the number of movements in the network; volume of transportation; transfer ratio; transport work; average distance of the route; average distance of the network ride; medium coefficient of passenger capacity use; required number of buses / cars. According to the analysis of the methods and models of calculations of the basic indicators of the functioning of the system of intercity passenger traffic, it was assumed that the change in the quantitative characteristics of the parameters entering into the system or the quantitative characteristics of its elements may lead to a change in the quantitative indicators of the functioning of the system itself or its individual elements.

Keywords: Transport System, Intercity Passenger Transport Route, Basic Parameters of Transportation, Efficiency, Model

1. Introduction

The results of the work determined the basic indicators of the functioning of the system of intercity passenger traffic. These indicators include: the number of movements in the network; volume of transportation; transfer ratio; transport work; average distance of the route; average distance of the network ride; medium coefficient of passenger capacity use; required number of buses / cars. According to the analysis of the methods and models of calculations of the basic indicators of the functioning of the system of intercity passenger traffic, it was assumed that the change in the quantitative characteristics of the parameters entering into the system or the quantitative characteristics of its elements may lead to a change in the quantitative indicators of the functioning of the system itself or its individual elements. The hypothesis about the possibility of dependencies of the basic indicators of the functioning of the system of intercity passenger route transportation from the parameters of the parameters or elements of the system itself is introduced. The analysis of scientific approaches to the substantiation of the theoretical foundations of systems of intercity passenger route transportations shows that the process of functioning of certain transportations does not fully take into account the complexity of interconnections of the basic characteristics of such systems and their mutual influence. The theoretical basis for studying the basic laws of the functioning of the system of interurban passenger route transportation should be based on scientific approaches that take into account the changes in the input parameters in this system.

2. Theoretical Background

The study of travel behavior was mainly limited to an understanding of transport models in urban and interregional areas [1-3], such as traveling outside of your “usual residence” using public transport, namely buses.

The modal choice for long journeys depends on the various characteristics of the trip, including the purpose of the trip and the destination to which the trip is being made. Models for choosing a logistic regime for life were created for night and single trips from urban and rural areas [4-6]. In addition, the time of year was a significant factor influencing long journeys [7–9].

All passengers are divided into several classes according to certain economic characteristics [10]. There are also several ways to transport passengers to choose from. To determine the passenger's behavior when choosing a vehicle, the theory of utility, the utility function, is given in the literature [11–13]. Usually passengers choose vehicles on the basis of their ideas about the advantages of their transportation, and not about others. In accordance with the characteristics of the passenger traffic structure, an organizational structure of passenger traffic was created taking into account the cost, time, safety and comfort of the passenger in terms of the average passenger. This demonstrates the fairness of the organizational model of interregional passenger transportation [14].

The quality of passenger road transport plays a large role in the future demand of urban and interregional passenger transport [15-17]. Analysis of the best practices in the organization and management of urban passenger transport shows that the main goal of public transport is not only providing services in the required quantity, but also meeting the growing needs of the population in passenger services [18]. Assessment of the passenger and quality depends on various factors that are evaluated by qualitative indicators.

The authors of the work [14] describe the delay time as a linear function of the number of passengers during loading and departure, which is influenced by certain parameters that reflect the speed of entry and exit, as well as indefinite time for opening and closing doors. Several functional forms are proposed. The well-known American model is the definition of the passenger capacity [12] and the transit capacity and quality of service for the stopping time [8]. In this study, intercity passenger transport correspondence, which was formed in the existing system, was considered. One of the most problematic places is the study of the actual values of sustainable intercity correspondence, which consists in obtaining uncertain correction coefficients that are used to calculate potential correspondence between cities. The obtained knowledge provides an opportunity to apply the considered method of calculation of correspondence between cities in relation to the market of passenger transportation in Ukraine.

3. Materials and Experiments

Influence of speed of connection in the railway network on its parameters was provided by modeling of the operation of the railway route network of intercity passenger routes in Ukraine taking into account the distribution of routes into two groups according to the maximum speed of communication on the route. The simulations take into account the existing 25 nodes, which are determined by the regional centers, and 92 railway tracks. Among the identified railway routes are those that provide a speed of driving up to 80 km/h. and up to 160 km/h. This is due to the division of the intercity passenger route network into two networks. The first route network of rail transport includes 76 routes with speeds up to 80 km/h, another one includes 16 with speeds up to 160 km/h. The variable input parameter in the system of intercity rail passenger routes is the speed of communication on the routes of the second group. It was chosen that the speed of the first group was unchanged, and the speed of the connection on the second routes increased by 10%, 20%, 40%, 60%, 80% and 100%. Based on the results of the calculations, the basic indicators of operation of the first and second railway network, which are summarized in tables 1 and 2, were determined.

Table 1. *Basic indicators of functioning of the first group of railway route networks with speed of communication ($V_{sp.mar.mer.1}$) 60km./h. when changing the speed of communication ($V_{sp.mar.mer.2}$) in the second group.*

Basic performance indicator	**The ratio of speeds between intercity rail networks $V_{sp.mar.mer.2}/V_{sp.mar.mer.1}$**					
	1,7	**1,9**	**2,2**	**2,5**	**2,9**	**3,2**
Number of movements $–P_{mar.mer.1}$, units.	39765	38676	35953	33228	30505	27781
Volume of transportation $Q_{jd.mar.mer.1.}$, thousand pass.	48105	46790	43495	40198	36904	33607
Transfer ratio $– k_{per.mar.mer.1}$	1,21	1,21	1,21	1,21	1,21	1,21
Transport work $W_{jd.mar.mer.1}$, thousand pass./km.	18214	17715	16467	15220	13973	12725
Average distance of a trip $– l_{ser.m.jd1.}$, км.	415	415	415	415	415	415
Average distance of a network trip $– l_{ser.mer.jd.mar.mer1.}$, km	458	458	458	458	458	458
Medium system coefficient of passenger capacity use $– k_{sal.mer.jd.mar.mer.1}$	0,38	0,38	0,38	0,38	0,38	0,38
Required number of buses $–_{jd.mar.mer.1}$, q=40	1351	1314	1222	1134	1046	960

Table 2. *Basic indicators of functioning of the second group of railway route networks with speed of communication ($V_{sp.mar.mer.1}$)) 60km./h when changing the speed of communication ($V_{sp.mar.mer.2}$) in the second group.*

Basic performance indicator	**The ratio of speeds between intercity rail networks $V_{sp.mar.mer.2}/V_{sp.mar.mer.1}$**					
	1,7	**1,7**	**1,7**	**1,7**	**1,7**	**1,7**
Number of movements $-P_{mar.mer.2}$, units.	14708	15797	18520	21245	23968	26692
Volume of transportation $Q_{jd.mar.mer.2.}$, thousand pass.	13275	14259	16716	19178	21636	24094
Transfer ratio $-k_{per.mar.mer.2}$	1,11	1,11	1,11	1,11	1,11	1,11
Transport work $W_{jd.mar.mer.2}$, thousand pass./km.	8381	9003	1055	1210	1365	1521
Average distance of a trip $-l_{ser.m.jd2.}$, km	529	529	529	529	529	529
Average distance of a network trip $-l_{ser.mer.jd.mar.mer2.}$, km	570	570	570	570	570	570
Medium system coefficient of passenger capacity use $-k_{sal.mer.jd.mar.mer.2}$	0,39	0,38	0,38	0,39	0,39	0,39
Required number of buses $-_{jd.mar.mer.2}$, q=40	204	221	259	294	329	367

4. Results

The information given in table. 1. and 2 provide an opportunity in building appropriate graphs of changes in passenger traffic $Q_{jd.mar.mer.1}$ and $Q_{jd.mar.mer.2}$ in the first and second group of intercity railway passenger routes. Figure 1 shows the corresponding graphs.

The functions of the dependence of $P_{jd.mar.mer.2}$ and $P_{jd.mar.mer.2}$ from $V_{sp.mar.mer.2}/V_{sp.mar.mer.1}$ are determined.

$$Q_{jd.mar.mer.2} = 98537.64 - 39032.89\left(\frac{V_{sp.mar.mer.2}}{V\ \ sp.mar.mer.1}\right) + 6300.12\left(\frac{V_{sp.mar.mer.2}}{V\ \ sp.mar.mer.1}\right)^2 \quad (1)$$

$Q_{jd.mar.mer.1}$ – the number of passengers carried by the first group of railway routes.

Figure 1 demonstrates that the speed of the connection on any route, directly and indirectly through the function of redistribution of traffic volumes, causes an increase in the number of movements, volumes of transportation, transport work, in the network of the corresponding type, while the value of the medium system coefficient of passenger capacity use and the number of vehicles may vary both in the direction of the increase and vice versa.

Figure 2 shows a graph of the dependence of $Q_{jd.mar.mer.1}$ from $V_{sp.mar.mer.2}$ / $V_{sp.mar.mer.1.}$ and $A_{jd.mar.mer1}$, where $A_{jd.mar.mer1}$ number of vehicles.

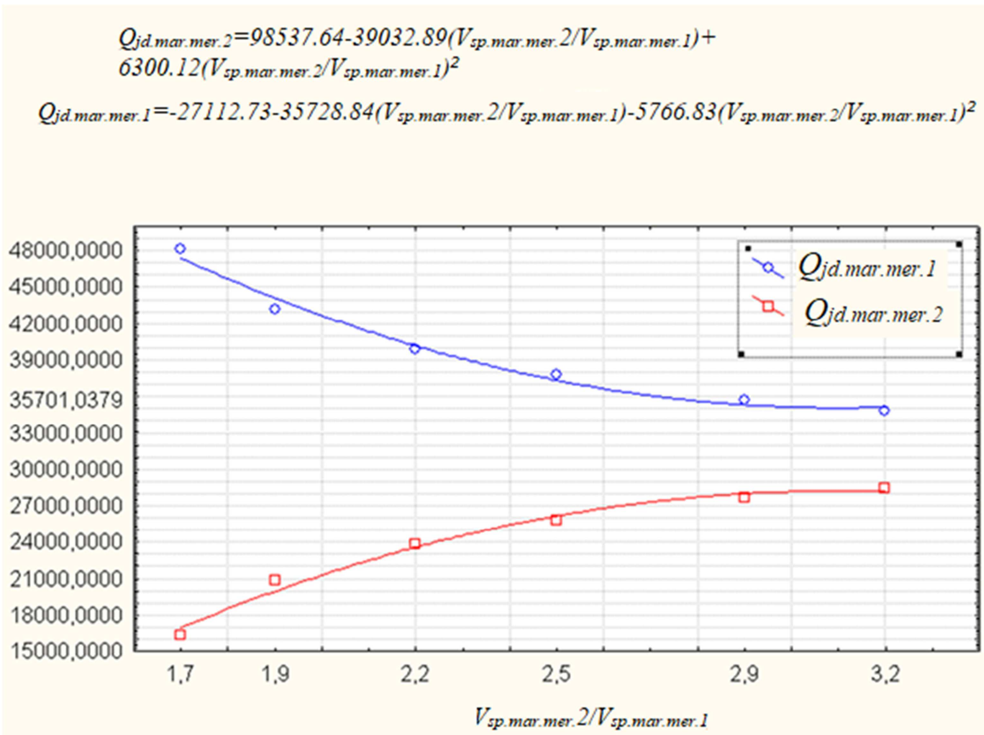

Figure 1. *Graph of changes in the parameters of passenger traffic $Q_{jd.mar.mer.1}$ and $Q_{jd.mar.mer.2}$ in the first and second groups of intercity railway passenger routes.*

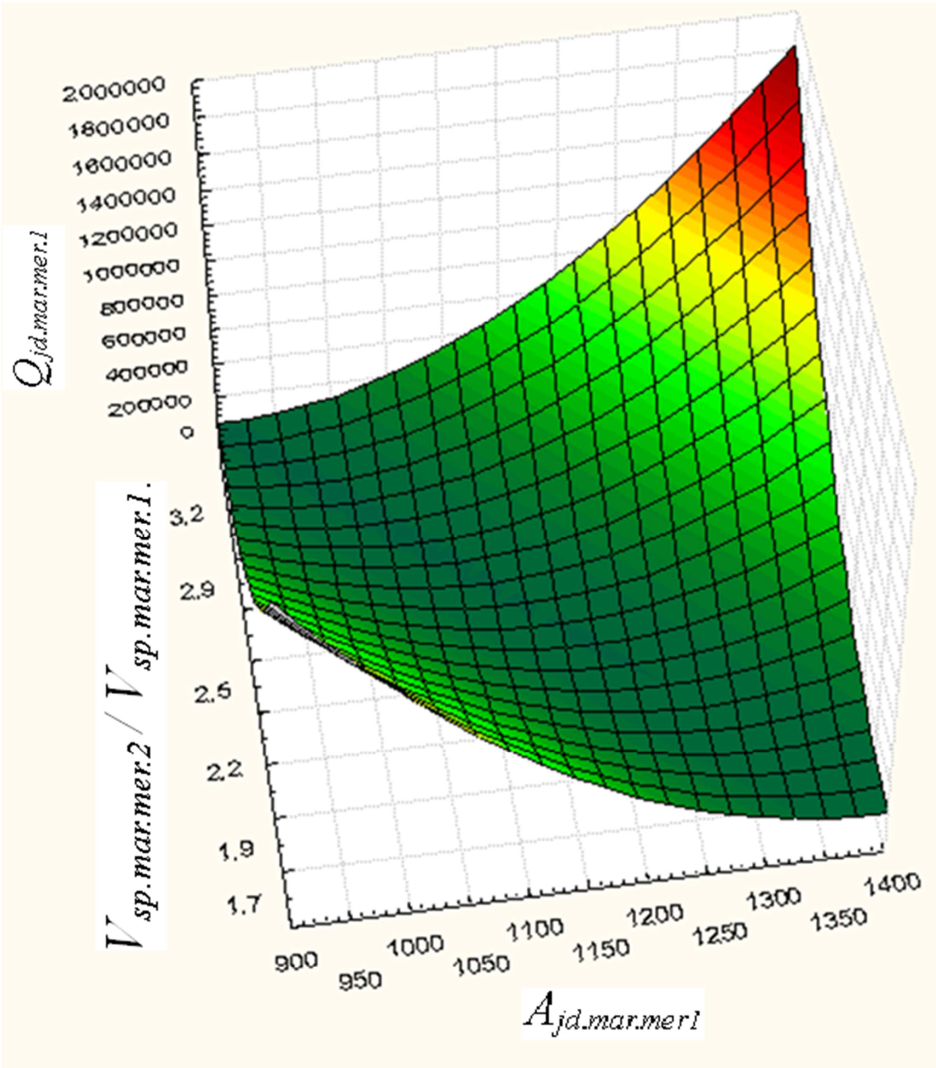

Figure 2. *Graph of dependency* $Q_{jd.mar.mer.1}$ *from* $V_{sp.mar.mer.2} / V_{sp.mar.mer.1.}$ *and* $A_{jd.mar.mer1}$.

According to the obtained functions, it is possible to carry out the corresponding calculations of the values $Q_{mar.mer.1}$ and $Q_{mar.mer.2}$ to compare them with the tabular ones according to the table. 1. and 2, which will ensure that $\Delta\ Q_{mar.mer.1}$ and $\Delta\ Q_{mar.mer.2}$ are calculated between these indicators. The results are summarized in Table 3.

Table 3. *Comparison of tabular and calculated values of* $P_{mar.mer.1}$ *and* $P_{mar.mer.2}$.

Tabular values		**Calculated values**		**|Δ $Q_{mar.mer.1}$, %|**	**|Δ $Q_{mar.mer.2}$, %|**
$Q_{mar.mer.1}$	**$Q_{mar.mer.2}$**	**$Q_{mar.mer.1}$**	**$Q_{mar.mer.2}$**		
48115	16294	51965	17598	5,79%	8%
43167	20823	45758	21865	3,13%	5%
39873	23841	45854	27180	5,97%	14%
37785	25749	39297	23818	9,22%	-8%
35701	27658	42127	30148	10,90%	9%
35870	28461	35870	31592	10,22%	11%
Total:				9%	9,08%

5. Conclusion

The speed of communication on any route, directly and indirectly through the function of redistribution of traffic volumes, causes an increase in the number of movements, traffic volumes, transport work, in the network of the appropriate type, at the same time the values of the medium system coefficient of passenger capacity use and the number of vehicles may vary both in the direction of the increase and vice versa.

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