The chance of transport behavior paradigm in the largest cities of Russian Federation

Denis Vlasov

National Research Moscow State University of Civil Engineering, 129337, 26 Yaroslavskoe shosse, Moscow, Russia

E-mail: vlasych@mail.ru

Abstract. This article discusses the issue of transit scenarios (or paradigm) changes in the largest Russian cities. Carrying out research and evaluation studies the authors surveyed the passengers of the new rapid off-street transit system, the Moscow Central Circle (MCC). The survey was prepared using the MCC reports data on passengers landing measured in the morning peak hours. Analysis of the survey results obtained by the authors, reveals shifts in pedestrian traffic and permits to estimate its size and main directions. It was noted a significant change in common behaviour regarding the increased length of the walking distance to the stations of rapid off-street transport. In view of the fact that the issue of the walking distance standard governs a huge range of further decisions, the research results can be used in sustainable transit travel planning and urban territorial development as well as in preparation of the regulatory documentation.

1. Introduction

There is no doubt that development of transport infrastructure during the reconstruction of the urban environment is aimed at the improvement of the environmental situation. Today, urban transport is a major source of urban air pollution in many cities of the world. However, we cannot ignore the obvious fact that it is impossible to create a favorable conditions for human life, sustainable socioeconomic and spatial development of the city without the developed transport infrastructure.

The capital of the Russian Federation was no exception among the cities. If in the middle of 90-ties the share of air pollution by motor transport in the total volume of emissions amounted to 83.2 %, in 2000 year this share already amounted to 93.7 percent, and, unfortunately, over the past 15 years, the situation has not changed significantly [1]. Fuel combustion contributes up to 500 types of pollutants. Major share of them are oxides of carbon, nitrogen, sulphur, hydrocarbons, soot, etc.

Aiming to reduce (or completely eliminate) the harmful effects of urban transport infrastructure pollutions on the environment, transport policy should consider the following activities:

1. restrictions on the movement of freight transport;
2. maximum increase of the road network capacity;
3. strict requirements for the environmental characteristics of transport;
4. developing networks of rapid off-street rail public transport;
5. developing various types of urban ground-electric transport;
6. enhancing competitiveness of urban land passenger transport;
7. promotion of small cars drivers to make individual trips and development of non-motorized vehicles.

Moscow Central Circle Rail Project implemented nowadays in Moscow, meets all the necessary requirements and methods to reduce harmful effect of air pollutants on the urban environment. The main purpose of this research is to determine the changes that Moscow Central Circle Rail has brought to the development of non-motorized trips and, particularly, to study the dynamics of the walking movements distances caused by the development of rapid off-street modes of transport.

The world practice shows that Transit Oriented Development approach (based among others on prioritizing urban public transport) and creation of safe and comfortable urban environment in the areas adjacent to the off-street transport stops have led to significant increase of non-individual vehicle travel. Thus, according to the US High Speed Rail Association data, the introduction of the TOD principles have reduced the dependence on individual transport for approximately 57 % [2]. The changes in population mobility behavior are indicated by acceptable length of walking access trip to the off-street transport station.

Moscow Central Circle (MCC) – is an urban rail line built at the beginning of the XX century and used mainly for freight service. Over the past 10 years, the road has been rebuilt and electrified, which made it possible to organize on the rout the rapid passenger traffic line. The length of the ring is 54 km, there are located 31 stops. When designing the ring, it was foreseen the possibility to transfer to the radial lines of the subway and to the railway.

It was decided to conduct a survey designed to seek passenger views on the introduction and effectiveness of the new passenger system and particularly, among others tasks, to define which types of transport are used or preferred to arrive to the MCC station and to determine the walking distance for the pedestrian access to the station.

2. Methods

Survey methodology was chosen as the main technics to gather information approaching passengers at the MCC stations with further statistical processing of the results obtained.

The reference values were those required by the following regulatory rules:
- The federal Code of Rules "Town planning" – 500 m (with possible increase, under certain conditions up to 800 m);
- Regional standards of Moscow in the field of transport – 500–700 m.

The survey is a sampling observation conducted in the morning «peak» hours on typical days (the days with the maximum size of passenger traffic – Tuesday, Wednesday and Thursday). To create sample collections, we'll use self-random selection and repetition-free sampling, since this allows us to minimize the sampling error [2, 3] ensuring its representativeness, for which it is necessary to ensure:
- sampling from homogeneous population subgroup;
- study of the characteristics of the general population;
- equal probability for each unit of the general population to be included in the sampling;
- sufficient number of units for the sample size.

Estimation of the sample size required to determine the representative number of TTH.

Calculations are carried out on the basis of a formula for repetition-free sampling.

$$n = \frac{N \times \sigma_x^2 \times t^2}{(\Delta_x^2 \times N) + (t^2 \times \sigma_x^2)}$$

where:
n – necessary sample size, people;
N – sample size or general population (determined on the basis of full-scale surveys);
б –standard deviation, variance;
t – the confidence coefficient. In calculations, the value of the confidence coefficient is assumed to be 3, which corresponds to a probability value of 0.997;
Δx – the sampling error limit .

The conducted calculations showed that the estimated value of the interviewed passengers was 350 people, with a total volume of the general population of about 35 thousand people. (The maximum amount of landing for all MCR stations per «peak» morning hour). The required number of passengers for the survey at each station was determined in proportion to the size of the passengers' landing.

The main task of statistical analysis is to identify homogeneous subgroups of passengers. We assume that the subgroup is homogeneous if the distribution of values in it is subject to the Gauss-Laplace law for ordinary distribution.

$$f(x) = \varphi' = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{(X-\overline{X})^2}{2\sigma^2}}$$

where:

φ' – the relative density of the distribution (the ordinate of the normal distribution curve);

$\pi = 3.14$, $e = 2.72$ – mathematical constants;

x – the average value of the characteristic in the distribution;

σ – square deviation.

3. Implementation

On February 2017, the structure of arrival to MCR stations is as follows:

- on the underground – 22.6 %;
- by rail – 10.5 %
- on land passenger transport – 22.2 %;
- by taxi – 1.6 %;
- on the individual car – 1.7 %;
- on foot – 41.3 %.

The absence of cyclists in the structure is explained by the fact that at the time of the survey the MCR functioned only in the autumn-winter period, when cycling in Moscow is not possible.

Thus, today, walking is the most simple, free and easy way to get to the stop points of the MCR. Which, in turn, makes it particularly interesting to study the possible length of a pedestrian access routes using the Central Ring as an example.

The total number of passengers arriving to the MCC on foot (from a representative sample) was 150 people. For statistical processing, all passengers were divided into subgroups – intervals, relative to the length of access routes. The interval value was taken equal to 0.25 km. The results of the distribution are shown in the Table 1.

Table 1. Evaluating pedestrian routs length distribution

Interval of the access length, km	Number of the passengers, people	Rate, %
0–0.25	7	4.67
0.251–0.5	36	24.00
0.51–0.75	50	33.33
0.751–1.0	31	20.67
1.0–1.25	9	6.00
1.251–1.5	6	4.00
1.51–1.75	6	4.00
1.751–2.0	2	1.33
2.01–2.25	1	0.67

Interval of the access length, km	Number of the passengers, people	Rate, %
2.251–2.5	1	0.67
2.51–2.75	1	0.67
Total	150	100.00

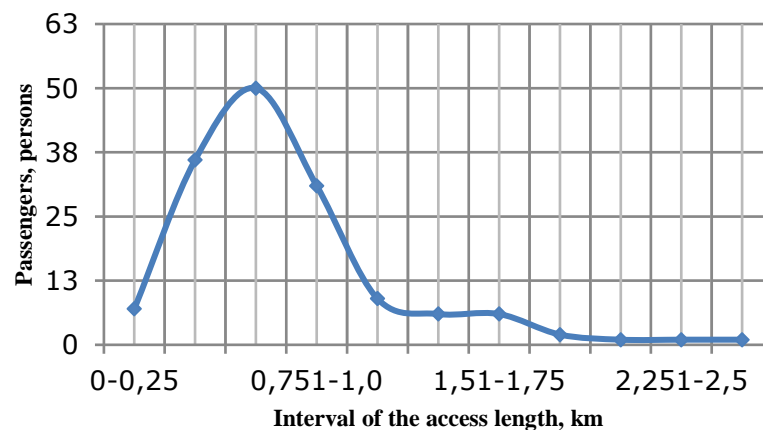The distribution obtained from these values is shown in Figure 1.

Figure 1. Distribution of the passengers' access length to MCC stop points

The performed calculations showed that the curve obtained, actually, is an ordinary distribution curve, which indicates the homogeneity of the resulting population. At the same time, it is obvious that analyzing it by using the law of variation of the individual characteristic values (Pearson's law), the interests of pedestrians following long (in comparison with the average) distances will not be taken into account sufficiently. In this connection, in future we'll use a cumulative curve.

4. Experiments
When processing survey data, we have established the routes from the departure points to the stop points of the MCC. This allows us to determine not only their air access distance but also actual distances of the pedestrian road network. The grouped survey results and calculations for the construction of cumulative curves are given in the following Table 2.

Table 2. Survey results and calculations

№	Interval value, km	Air distances			Actual walking distances		
		Number of the passengers, pass.	Rate, %	Cumulative frequency, %	Number of the passengers, pass.	Rate, %	Cumulative frequency, %
1.	0–0.25	7	4.67	4.67	6	4.00	4.00
2.	0.251–0.5	36	24.00	28.67	24	16.00	20.00
3.	0.51–0.75	50	33.33	62.00	28	18.67	38.67
4.	0.751–1.0	31	20.67	82.67	33	22.00	60.67
5.	1.0–1.25	9	6.00	88.67	15	10.00	70.67
6.	1.251–1.5	6	4.00	92.67	24	16.00	86.67

№	Interval value, km	Air distances			Actual walking distances		
		Number of the passengers, pass.	Rate, %	Cumulative frequency, %	Number of the passengers, pass.	Rate, %	Cumulative frequency, %
7.	1.51–1.75	6	4.00	96.67	4	2.67	89.33
8.	1.751–2.0	2	1.33	98.00	5	3.33	92.67
9.	2.01–2.25	1	0.67	98.67	5	3.33	96.00
10.	2.251–2.5	1	0.67	99.33	2	1.33	97.33
11.	2.51–2.75	1	0.67	100.00	1	0.67	98.00
12.	2.751–3.0	–	–	–	2	1.33	99.33
13.	3.01–3.25	–	–	–	0	0.00	99.33
14.	3.251–3.5	–	–	–	1	0.67	100.00
	Total	150	100		150	100	

The obtained cumulative curves are shown in the figure. To determine the maximum length of a comfortable access route, by analogy with the current standards of JV "Urban Development" on the maximum travel time in settlements, we use the requirement of 90 % of the security of the results. The calculations performed show the following:

- the air distance is equal to 1.2 km;
- the actual distances of the pedestrian road network is equal to 1.7 km.

A comparison between the results obtained from the experiments shows that the actual distances are longer than the air line for more than 40 %, which indicates the potential for increasing the standard distances, when implementing the principles of TOD and creation of comfortable and permeable urban environment [4–8].

5. Results
The main factors for increasing of the standard access distance by more than 2 times are the following:
- the requirements of JV "Urban Development" are based on outdated researches of the 60s – 70s of the last century;
- intensive implementation of infrastructure, improvement and beautification projects in Moscow causes changes in the paradigm of transport behavior, in particular, in increasing the time and distance of the walking access to stopping points of out-of-street transport;
- six months of operation evidently are not enough for the completed formation of the route network of land passenger transport and the main consumers of MCR services are residents of the adjacent construction;
- relatively high fare in public transport.

The results obtained can be used as for the territorial development, dynamics planning and preparation of regulatory documentation [9], so in scientific research [10, 11]

References
[1]   2003 *Moscow at the turn of XX–XXI century*: *collective monograph under the General editorship of Professor A Kuzmin* (Moscow: Moscow textbooks and kartolitografiya) 214 p
[2]   Batrakova L 2009 *Theory of statistics* (Moscow: Knorus) 528 p
[3]   Samoylov D 1998 *Sociology in urban and regional planning* (Moscow: MSCU) 97 p
[4]   Sherbina E, Danilina N and Vlasov D 2015 *Int. J. of Appl. Engin. Res.* **10** p 43131–138
[5]   Vlasov D and Danilina N 2013 *Public transport transit hubs system and "Park-and-Ride" facilities* (Lap Lambert Publ. Germany) 81 p
[6]   Vlasov D 2009 *Transport transit hubs of big cities (on the Moscow example)* (Moscow: ACV) 96 p

[7]   Bakhirev I 2016 *Gradostroitel`stvo* **2 (42)** p 12–19
[8]   Mihailov A and Kopylova T 2015 *Vestnik IrGTU* **7 (102)**, p 168–74
[9]   Vlasov D 2016 *International Conference on Sustainable Cities* (*ICSC 2016*) **6** Available from: http://dx.doi.org/10.1051/e3sconf/20160601012 [Accessed 6th May 2017]
[10] Vlasov D, Menshutin A and Danilina N 2016 *International Conference on Big Data and its Applications* (*ICBDA 2016*) **8** (Electronic Edition) Available from: http://dx.doi.org/10.1051/itmconf/20160801002 [Accessed 6th May 2017]
[11] Danilina N and Vlasov D 2016 *International Scientific Conference "Integration, Partnership and Innovation in Construction Science and Education* (MATEC Web Conf.) **86** Available from: http://dx.doi.org/10.1051/matecconf/20168605017 [Accessed 6th May 2017]