«SAFETY INTERVALS» AT THE BUS STOPS OF THE CITY OF VOLZHSKY

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ABSTRACT

Analysis of the street-road network in the city of Volzhsky, a tense security situation with embarkation and disembarkation of public transport passengers is provided. The discrepancy between the lengths of stopping points and the incoming traffic of buses is determined. Proposals are made to improve the quality of passenger transportation, taking into account safety intervals at bus stops and optimizing the routes of urban public transport, private buses and fixed-route taxis.

Keywords: urban public transport, bus, stopping point, safety interval, route network, route optimization.

Background. *The uncontrolled introduction of private carriers led to a rapid increase in the number of buses and, as a result, to overloading the street-road network. The absence in the traffic rules of the requirements for stop of public transport at the stopping point only in the extreme right lane led to the fact that the buses began to stop without taking into account the safety interval, in two lanes and on the carriageway, thus not providing the proper conditions for carriage of passengers.*

With the established transport infrastructure of cities, it was established that the stopping points were designed for the use of large and medium capacity buses on routes, and therefore their throughput was ensured taking into account a safe stop of transport in accordance with the requirements of normative documents [1]. The length of stopping points provided for a safe stop of public transport in one right-hand lane, taking into account the safety interval defined by the standards [3].

Objective. *The objective of the authors is to consider «safety intervals» at the bus stops of the city of Volzhsky.*

Methods. *The authors use general scientific methods, comparative analysis, evaluation approach.*

Results.

1.

On the city routes in the city of Volzhsky there are 107 large and medium buses of the municipal passenger motorcade and 512 small buses. Due to their growing incoming traffic at the stops, there was a problem with ensuring safe transportation of passengers.

The length of a stopping point should correspond to intensity of the incoming traffic of buses, so that there are no congestion, waiting and stop of passenger cars in two lanes.

Pic. 1. The stopping point «pl. Sverdlova».

The layout of the city is rectangular, and stretched along the Akhtuba river, and therefore routes are mostly focused on longitudinal streets Mira, Druzhby, Karbysheva, prospect Lenina (Pic. 2).

The public transport system of Volzhsky consists of bus and tram sectors.

All bus lines are located in an area which is limited from the side of Volgograd by the streets Loginova, Naberezhnaya, Kirova, Sverdlova, Karbysheva, Engelsa, Pushkina, Volzhsky Voennoi Flotilii, 87 Gvardeiskoi Divizii, prospect Lenina. In total, there are 55 city routes and 47 suburban destinations. The length of the street-road network is 97,114 km, the length of the routes is 885,581 km.

The most loaded with public transport are the streets Mira and Kommunisticheskaya, Boulevard Profsoyuzov, prospect Lenina, along which from 1100 to 3500 buses a day run. Basically all city municipal routes are duplicated by routes of private carriers. In addition, all suburban routes that depart from the city bus station, Lenin Square, the 18th and 32nd microdistricts, also pass through the city center – prospect Lenina and Mira street.

The route scheme with the number of routes on the streets of the city is shown in Pic. 3.

The largest number of buses a day passes along Mira street from Olomutsky street to Truda square and prospect Lenina from Molodogvardeitsev street to Stroitelei square (2000–3000 buses per day), along Kommunisticheskaya street (1100–2000 buses a day), so almost all the stops do not have enough length to accommodate concurrently arrived buses. Less loaded (1100–2000 buses per day) are the streets Khimikov, Engelsa, a section of the Druzhby street from 40 let Pobedy street to Olomutskaya street, section of Mira street to Olomutsky street, Karbysheva street from the Profsoyuzov Boulevard to Karbysheva square.

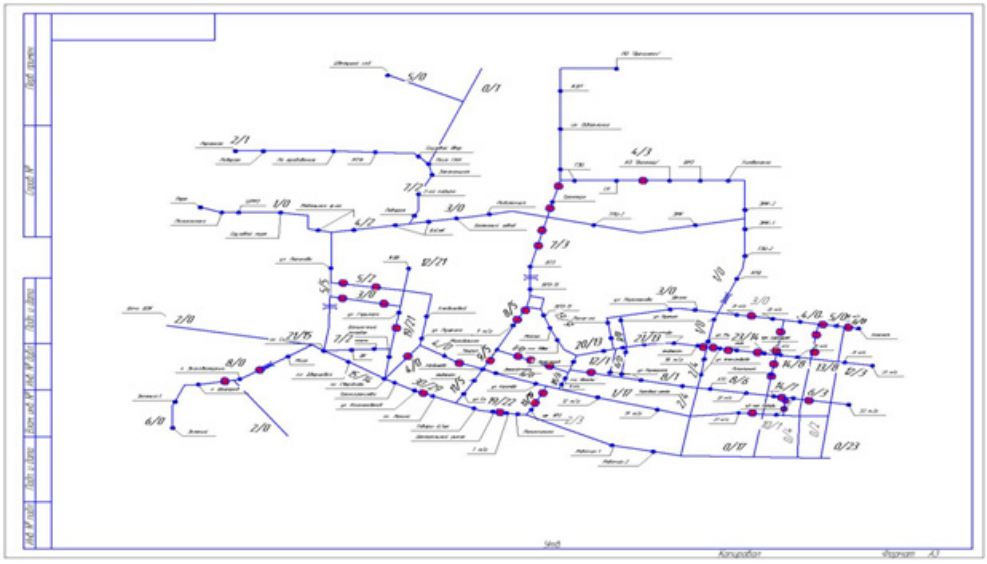
The flow of buses at rush hour at the stopping points in the forward and reverse directions is: prospect Lenina – 226 and 294, Mira street – 281 and 280, Profsoyuzov Boulevard – 240 and 240, Druzhby street – 183 and 141, Karbysheva street – 129 and 120, Olomutskaya street – 139 and 139, Engelsa street – 150 and 150.

2.

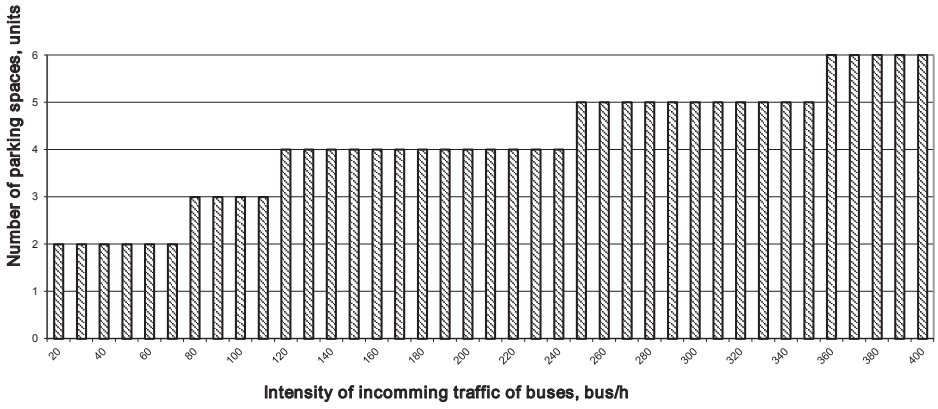
In this situation, there are two ways to solve the problem. The first is to increase the length of the stopping points for the existing flow of buses; the second is to reduce the incoming traffic of buses at the stopping points.

The main factor in determining the length of stopping points is the safe placement of buses at

Pic. 2. Plan of the city of Volzhsky.



Pic. 3. Number of routes on the streets of the city of Volzhsky
(in the numerator – city routes, in the denominator – suburban routes).



Pic. 4. Nomogram for determining the number of parking spaces at the stopping points,
depending on the intensity of the mixed incoming traffic of buses.

Table 1

Indicators of stopping points at maximum load in the hour-peak from 7 to 8 hours

No.	Name of the stopping point	Indicators of the stopping point				
		Length, m	Incoming traffic of buses, units/h			
			At present		After optimization	
			required length, m	required length, m	urb/suburb	required length, m
Pushkina street from 37 microdistrict						
1	37 microdistrict	40	93	40–60	31/–	20–40
2	30–37 microdistricts	28	81	40–60	19/–	20–40
3	24–30 microdistricts	27	60	40–60	19/–	20–40
4	School	27	37	40–60	19/–	20–40
5	Narimanova street	30	37	40–60	19/–	20–40
Pushkina street from 32 microdistrict						
1	32 microdistrict	64	54/5	40–60	20/5	20–40
2	40 let Pobedy street	42	55/14	40–60	20/14	20–40
3	26 microdistrict	58	185/24	60–80	85/24	40–60
4	23 microdistrict	11	44/–	20–40	36/–	20–40
5	ATS-9	30	44/–	20–40	36/–	20–40
6	Pionerskaya, TC	40	44/–	20–40	36/–	20–40
7	Pionerskaya–Mira	>80	80/–	40–60	36/–	20–40
Olomutskaya						
1	Pharmacy «Vitapharm»	21,7	144/30	50–70	114/30	50–70
2	Tekila	80	144/30	50–70	114/30	50–70
Mira street from 37 microdistrict						
1	37 microdistrict	80	77/20	40–60	21/20	20–40
2	TC	48	94/48	50–70	24/48	40–60
3	HSS	82	118/49	50–70	46/49	40–60
4	24 microdistrict	52	118/49	50–70	46/49	40–60
5	Dom Torgovli	86	263/71	60–80	78/71	50–70
6	Aleksandrova	45	263/71	60–80	78/71	50–70
7	Universam	urb30/30 subur	234/74	60–80	62/74	50–70
8	Narimanova	30	234/75	60–80	62/75	50–70
9	Mira–Iskra	37	254/74	60–80	56/74	50–70
10	Mira (Pionerskaya)	37	232/62	60–80	75/62	50–70
11	Stimul	75	232/62	60–80	75/62	50–70

stops and an obligatory condition – the safety distance between standing vehicles (according to VSN23–75 it is taken to be 3 m) [1].

In accordance with these requirements and application of the queuing theory, the nomograms were developed [11] and used to determine the correspondence of the length of the stop points to the incoming flow of buses for the mixed flow and the flow of buses «GAZelle». The required length is refined based on the results obtained for the mixed bus flow. A nomogram concerning the number of parking spaces at stop points, depending on the intensity of the mixed incoming traffic of buses, is shown in Pic. 4.

To assess the provision of a safe bus stop at the Volzhsky stop points before and after the optimization of the route network, an inventory was made based on the route passports, which include the names of the points and the distance between them. The register of stopping points is made up, the following data are included: street, name of the stopping point, length of the stopping point, maximum incoming traffic of buses, required length of the stopping point.

The correspondence of the length of the stopping points to the incoming traffic of buses was determined on the basis of a survey of the loading of the stopping points in the direction from the new part of the city and the number of buses stopping in the hour-peak was counted from 7 to 8 hours.

Table 1 shows the indicators of stopping points based on the results of a survey of their load: length and incoming traffic of buses. According to the nomogram (Pic. 4), the required length of the stopping points is determined.

Of the 54 surveyed 22 stopping points with the existing organization of transportation, passengers do not provide a simultaneous safe stop of buses. Therefore, the city was faced with the issue of measures to ensure the safe stay of people and buses at stops.

3.

Based on the planning document (in accordance with Federal Law No. 220 dated July 13, 2015) in Volzhsky, optimization of the route network was carried out, consisting in the abolition of routes duplicating the social routes of convoy No. 1732, and in bringing the number of buses on the routes in line with passenger traffic. As a result of optimization, the number of routes for private carriers decreases from 25 to 14, and the number of especially small capacity

Khimikov street						
1	Idea	52	104/50	50–70	18/50	40–60
2	10 microdistrict	64	89/50	50–70	3/50	40–60
3	10 microdistrict-2	30	15/–	30–40	15/–	30–40
4	VPZ	56	93/50	50–70	7/50	40–60
Engelsa street						
1	8 microdistrict	40	99/21	40–60	12/21	20–40
2	Pl. Karbysheva	46	121/21	50–70	13/21	20–40
3	Sovetskaya street	37	121/21	50–70	13/21	20–40
Boulevard Profsoyuzov						
1	K-n Yunost'	60	190/16	50–70	51/16	40–60
2	12 microdistrict	47	190/16	50–70	51/16	40–60
Karbysheva street						
1	Koroleva	25,6	64/–	30–40	32/–	20–60
2	Energotekhmash	17	64/–	30–40	32/–	20–60
3	Pl. Karbysheva	45,8	49/–	30–40	17/–	20–40
4	Molodezhnaya	80	49/–	30–40	18/–	20–40
5	Pushkina	80	33/–	30–40	18/–	20–40
Aleksandrova street						
1	Volgamoll	80	33/44	40–60	20/44	30–40
2	Lenta	30	33/44	40–60	20/44	30–40
Prospect Lenina						
1	Man (pos. Rabochiy)	80	33/33	30–40	20/33	30–40
2	Policlinic	27	164/67	50–70	54/67	40–60
3	Koroleva street	44	164/67	50–70	54/67	40–60
4	Central market	61	164/67	50–70	54/67	40–60
5	Central park	53	171/69	60–70	60/69	50–70
6	Tovary dlya shkolnikov	53	171/69	60–70	60/69	50–70
7	Pl. Lenina	80	291/95	80–100	107/95	50–70
8	Kosmonavtov street	35	291/95	80–100	107/95	50–70
9	Bolnichniy gorodok	40	140/49	50–70	59/49	40–60
10	Pl. Sverdlova	80	175/64	60–80	65/64	50–70
11	DK VGS	80	175/61	60–80	65/71	50–70
12	Pl. Stroitelei	48	201/71	60–80	84/71	50–70
Kommunisticheskaya street						
1	Gorkogo street	34	140/49	50–70	63/11	30–40

buses is reduced by 193 units (there were 512 as of January 1, 2016).

The calculation of the number of buses that will pass through the stopping points as a result of optimization of the route network on the basis of [10] and a reduction in the number of fixed-route taxis has been carried out. The correspondence of the lengths of the stopping points for the new bus flow is determined on the basis of the nomogram (Pic. 3). The resulting flow of buses (units per hour) to the stopping points and the corresponding length of the safe stop are given in Table 1.

Since the optimization of the route network does not ensure safe stopping of buses at all stopping points, measures are needed to improve the quality of passenger service.

In connection with the high intensity of the bus flows approaching the stopping points, the following solutions are possible:

1. To increase the length of the stopping points.

2. To construct new stopping points for buses of especially small capacity.

3. To bring the number of buses on the routes to the optimal value corresponding to the maximum passenger traffic.

4. At stopping points with a length corresponding to the intensity of the incoming traffic of buses, to allocate individual parking spaces for buses of large and extra-large capacity.

5. To redistribute suburban buses to TIH (transport-interchange hubs) located on the outskirts of the city

The increase in the length of stopping points and the construction of new ones is the prerogative of municipal bodies, which are charged with organizing the transport service by Federal Law 131-FZ dated October, 6 2003 «On general principles of the organization of local bodies in the Russian Federation», paragraph 7, Article 14 [9] and which are customers of transportation.

Table 2 shows the loading of 22 stops, which do not provide a safe bus stop, even as a result of the closure of 14 routes of private carriers, and network optimization measures.

4.

During the events held:

1. On Olomutskaya street a safe bus stop at the stopping point (SP) »Pharmacy «Vitapharm» is not provided. It is necessary to increase the length from 21,7 to 50–70 meters.

Table 2

The results of decreasing the number of buses at stopping points during the optimization process

No.	Stopping point	Length of SP, m	Incoming traffic of buses, units/h		Required length of SP, m	Provision of a safe stop of buses at SP as a result of optimization	Measures
			At present	After optimization			
			urb/subur	urb/subur			
Druzhby street							
1	26 microdistrict	58	185/24	85/24	40–60	Is provided	–
Boulevard Profsoyuzov							
2	K-n Yunost	60	190/16	51/16	40–60	Is provided	–
3	12 microdistrict	47	190/16	51/16	40–60	Is provided	–
Olomutskaya street							
4	Pharmacy «Vitapharm»	21,7	144/30	114/30	50–70	Is not provided	To increase the length of SP
Mira street from 37 microdistrict							
5	24 microdistrict	52	118/49	78/71	50–70	Is provided	–
6	Aleksandrova	45	263/71	78/71	50–70	Is not provided	Redistribution of suburban routes to TIH. It is impossible to increase the length of SP.
7	Universam	Urb30/ 30subur	234/74	62/74	50–70	Is not provided for total traffic.	
8	Narimanova	30	234/75	62/75	50–70		
9	Mira–Iskra	37	254/74	56/74	50–70		
10	Mira (Pionerskaya)	37	232/62	75/62	50–70		
Prospect Lenina							
11	Policlilnic	27	164/67	54/67	40–60	Is not provided for total traffic.	Allocation of a separate space for private cars.
				Redistribution of suburban route to TIH.			
12	Koroleva street	44	164/67	54/67	40–60	Is provided	–
13	Central market	61	164/67	54/67	40–60	Is provided	–
14	Central park	53	171/69	60/69	50–70	Is provided	–
15	Tovary dlya shkolnikov	53	171/69	60/69	50–70	Is provided	–
16	Lenina square	80	291/95	107/95	50–70	Is provided	–
17	Kosmonavtov street	35	291/95	107/95	50–70	Is not provided for total traffic. It is impossible to increase the length of SP	Redistribution of suburban routes to TIH.
18	Bolnichniy gorodok	40	140/49	59/49	40–60	Is provided	–
19	Sverdlova square	80	175/64	65/64	50–70	Is provided	–
20	DK VGS	80	175/61	65/71	50–70	Is provided	–
21	Pl. Stroitelei	48	201/71	84/71	50–70	Is provided	–
Gorkogo street							
22	Gorkogo street	34	140/49	63/11	30–40	Is provided	–

2. On Mira street there is no safe stop of buses at the stopping points «Aleksandrova street», «Universam», «Narimanova street», «Mira street. Iskra shop», «Mira street. Pionerskaya». Redistribution of suburban routes to TIH in the south direction is required.

3. On prospect Lenina at the SP Policlinic, special parking areas for cars should be allocated. Buses stop in the second lane. In case of redistribution of suburban routes to TIH, the solution of the problem is ensured.

4. At the ST «Kosmonavtov street» the length of 35 meters does not provide a safe bus stop, a length

of 50–70 meters is required. The length of the SP cannot be increased due to insufficient space. Redistribution of suburban routes to TIH will not help.

5. On Stroitelei square, due to the lack of coordination of the work of carriers, there are occasional situations when buses stop in two lanes. It is necessary to coordinate the timetable for movement of municipal and private buses.

6. There are no stopping points on 40 let Pobedy street, therefore it is required to change the routes of the routes leaving from the 27 microdistrict to 87 Gvardeiskaya street with a turn to Druzhby street. Pedestrian accessibility of stopping points for residents living and working in the area of 40 let Pobedy street is provided to the stops located on the streets of Karbysheva, 87 Gvardeiskaya, and is about 250–300 meters at a standard of 500 meters.

As a result, at ten stops in the streets Mira, Olomutskaya, prospect Lenina, even after reducing the number of buses, a safe bus stop is not ensured (Table 2).

Conclusion. *The main disadvantages of organizing passenger transportation by public transport are:*

1. The lack of co-ordination of the bus exit from the initial stopping point of municipal and private buses, which can lead to a simultaneous approach of several buses.to stopping points.

2. The passage of suburban routes through the city, which gives an additional load of the street-road network.

There are proposals to improve the situation:

1. To ensure a coordinated exit of buses from the initial stopping points.

2. If it is not possible to ensure a safe bus stop, to organize new stopping points.

3. To plan the construction of transport-interchange hubs on the outskirts of the city for suburban routes, thereby excluding the passage of suburban buses through the city.

4. To continue the optimization of the route network, to streamline the use of fixed-route taxis, to exclude the dubbing of urban public transport routes by them.

REFERENCES

1. VSN23–75 «Instructions for marking of highways». [*VSN23–75 « Ukazanija po razmetke avtomobil'nyh dorog*»].

2. GOST 25869–90. Distinctive signs and information support for rolling stock of passenger ground transport, stopping points and passenger stations. General technical requirements [*GOST 25869–90. Otlichitel'nye znaki i informacionnoe obespechenie podvizhnogo sostava passazhirskogo nazemnogo transporta, ostanovochnyh punktov i passazhirskih stancij. Obshhie tehnicheskie trebovanija*].

3. SNiP 2.05.02–85 «Roads» (approved by the decision of the USSR Gosstroy dated 17.12.1985 No. 223, as amended on 30.06.2003) [*SNiP 2.05.02–85 «Avtomobil'nye dorogi»* (*utv. postanovleniem Gosstroja SSSR ot 17.12.1985 № 223, v red. ot 30.06.2003 g.)*].

4. SP 42.13330.2011. Set of rules. Town planning. Planning and development of urban and rural settlements. (Updated version of SNiP 2.07.01–89* – approved by the order of the Ministry of Regional Development of the Russian Federation dated 28.12.2010 No. 820) [*SP 42.13330.2011. Svod pravil. Gradostroitel'stvo. Planirovka i zastrojka gorodskih i sel'skih poselenij. (Aktualizirovannaja redakcija SNiP 2.07.01–89*.– utv. prikazom Minregiona RF ot 28.12.2010 № 820)*].

5. Order of the Ministry of Transport of Russia dated 15.01.2014 No. 7 «On Approval of the Rules for Ensuring the Safety of Transportation of Passengers and Goods by Road Transport and City Ground Electric Transport» [*Prikaz Mintransa Rossii ot 15.01.2014 № 7 «Ob utverzhdenii Pravil obespechenija bezopasnosti perevozok passazhirov i gruzov avtomobil'nym transportom i gorodskim nazemnym elektricheskim transportom*»].

6. Decree of the Government of the Russian Federation dated 23.10.1993 No. 1090 «On Traffic Rules» (as amended on January 21, 2016) [*Postanovlenie pravitel'stva RF ot 23.10.1993 № 1090 «O Pravilah dorozhnogo dvizhenija»* (red. *ot 21.01.2016 g.)*].

7. Rules for transportation of passengers and luggage by road and urban land electric transport. Decree of the Government of the Russian Federation No. 112 dated 14.02.2009 (as amended on 07.09.2011 No. 757, on 14.05.2013, No. 411, No. 1073 on 26.11.2013, No. 528 on 09.06.2014) [*Pravila perevozok passazhirov i bagazha avtomobil'nym transportom i gorodskim nazemnym elektricheskim transportom. Postanovlenie pravitel'stva RF № 112 ot 14.02.2009 g. (v red. ot 07.09.2011 № 757, ot 14.05.2013 № 411, ot 26.11.2013 № 1073, ot 09.06.2014 № 528)*].

8. Charter of road transport. FZ No. 259 dated 08.11.2007, as amended on 03.02.2014 [*Ustav avtomobil'nogo transporta. FZ № 259 ot 08.11.2007 g., v red. 03.02.2014 g.*].

9. Federal Law No. 131 dated 06.10.2003 «On general principles of organization of local bodies in the Russian Federation» (amended on March 30, 2015) [*Federal'nyj zakon № 131 ot 06.10.2003 g. «Ob obshhih principah organizacii mestnogo samoupravlenija* v RF» (s *izm. 30 marta 2015 goda)*].

10. Federal Law No. 220 of 13.07.2015 «On organization of regular transportation of passengers and baggage by road and urban land electric transport in the Russian Federation and on introduction of amendments to certain legislative acts of the Russian Federation» [*Federal'nyj zakon № 220 ot 13.07.2015 g. «Ob organizacii reguljarnyh perevozok passazhirov i bagazha avtomobil'nym transportom i gorodskim nazemnym elektricheskim transportom v RF i o vnesenii izmenenij v otdel'nye zakonodatel'nye akty RF»*].

11. Chernova, G. A. Organization of safe transportation of passengers, taking into account the operational and environmental components. Ph.D. (Eng) thesis. [*Organizacija bezopasnoj perevozki passazhirov s uchjotom ekspluatacionnoj i ekologicheskoj sostavljajushhih. Dis... kand. tehn. nauk*]. Volgograd, 2005, 197 p.

12. Highway Capacity Manual 2000. Transportation Research Board, National Research Council (A technique for studying transport flows). Washington, D.C., USA, 2000, 1134 p.

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