

## **TENDENCIES AND PROBLEMS OF THE TRANSPORT INFRASTRUCTURE OF THE CITY AGGLOMERATIONS (CASE-STUDY OF YEKATERINBURG, KAZAN AND PERM)**

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### **Abstract**

Transformation of urban transport infrastructure is one of the most dynamic city processes. Changes occur continuously and connect both with the technology and with the city development. For Russian cities, the most common trends that affected the transformation of the transport system at the turn of the 20th century were the growth in the number of personal transport and the active development of city agglomerations. In addition to the general features, there are specific features of changing public transport, street-road network in each city and agglomeration. Comparison of these changes, taking into account the global trends, allows you to draw conclusions and give practical suggestions that may be of interest for both management practices and the development of science. It is important to realize that the transport system of cities-nuclei of agglomerations is under pressure not only of traffic flows within urban displacements, but is an open system integrated into agglomeration processes.

In the article, the transformation of the transport infrastructure of the Russian cities of Yekaterinburg, Kazan and Perm is considered by its two main components - public transport and the street-road network. The selected three cities are not only regional capitals, but also nuclei of monocentric agglomerations. The comparison is made in the context of individual urban areas: the historical core, the zone adjacent to the historical core, and the outer zone. The main method used is the peer review method. This is due to the fact that it is not always possible to obtain a complete set of data for a formalized assessment of the section of the zones identified by the authors that do not coincide with the administrative-territorial cities. Although, where possible, the results of peer review are supported by statistical data and calculations. Real changes are compared with the version, which the authors consider to be optimal at this stage and described using a special score scale.

According to the results of the expert assessment, Kazan and Yekaterinburg took the leading positions. For Kazan is characterized by systematic activities to ensure the effective operation of public transport. The city occupies a leading place in Russia (excluding the capital) in terms of the number of corridors and the length of the allocated lanes for public transport. In the past five years, there has been a large-scale renovation of the park of trams, trolleybuses and buses in municipal ownership.

Ekaterinburg stands out as an urban tram network, which maintains a system-forming role in most areas of the city. It continues to develop: a new site appeared within a large center in 2017, at various stages of

discussion and implementation are plans to build lines in the micro-districts of the city's outer zone, and also (for the first time in Russia) - to two satellite cities in Yekaterinburg.. The relatively high quality of the track infrastructure, high-quality operation of the rolling stock of tram transport also influenced the increase in the score of the expert evaluation.

The most problematic aspects in all cities are:

Inadequate integration of electric trains into the urban transport system;

the lack of systematic work with drivers of personal vehicles on their compliance with the interests of all residents when using courtyard territories;

the lack of systematic and consistent measures to form multifunctional transport and transfer nodes on the border of zones adjacent to the historical core and external zones, the development of the street-road network in connection with the formation of these nodes.

Solving these problems will allow to proceed to the intensive development of city agglomerations.

**Keywords:** city, city agglomeration, urban, transport infrastructure, public transport, street-road network, Ekaterinburg, Kazan, Perm.

## 1 INTRODUCTION

The process of changing the transport infrastructure of the largest cities of Russia is one of the most dynamic and contradictory processes of transformation of the urban environment. Being influenced by other transformations (in the functional structure, architectural and planning environment, etc.), it has a significant impact on the development of all areas of urban life. Errors in the management of this process lead to the aggravation of many old problems and the appearance of new ones, the solution of which is very often impossible without significant financial costs. Active development of city agglomerations impose additional conditions and requirements for the transport system of city agglomerations cores. Essentially, the city-core transport system of the monocentric agglomeration is an open system that serves not only internal travel of citizens, in the case of urban transport, but also traffic flows of agglomeration. World experience demonstrates various models of the organization of traffic flows. A number of publications are devoted to the approaches of individual cities to the organization of the transport system, to mistakes and successes, but on the whole demonstrates a certain commonality of problems facing cities and their agglomerations. Current scientific publications are devoted to interconnection of the transport system and sustainable urban development; the reintroduction of tramway transport in the world cities; comfort and accessibility for low-mobility groups; interrelation and mutual influence of the transport system and public space, opportunities for pedestrians, bicycles, etc.; history of the formation of the city transport system and case-study of transport system of cities and agglomerations (Capasso A.,2014; Hirano K.,2009; Lois Gonzales,2013; Macdonald A.,2013; Naegely L., 2013; Plakhotich S.A.,2010). The experience of positive and negative transformations of the transport infrastructure elements of the largest cities should be studied, analyzed, used in the development of scientifically grounded recommendations for improving the urban environment and agglomeration development.

## 2 METHODOLOGY

We believe that the trajectories of optimal transformational changes in the transport infrastructure of the largest cities should be different in certain parts of the city: what is optimal for the urban outskirts can be completely contraindicative to the city center. E.N. Pertsik (Pertsik E.N, 1991) identifies in cities a historical core, a central zone and an outer zone. Based on this approach, we identified three parts: the historical core (HC), the zone adjacent to the historical nucleus (ZAtHN - between the historical core and the outer zone), the outer zone (OZ). Further, in the context of each zone allocated in Yekaterinburg, Kazan and Perm, the transformational changes in the most important elements of the transport infrastructure - public transport (PT) and the street-road network (SRN) - were compared with a picture that we, as experts, optimal (Table 1), and evaluated in points. The method of peer-review was chosen in this research as the main one in connection with the fact that in the context of the zones identified by us that do not coincide with administrative-territorial cities, it is not always possible to obtain a complete set of data for a formalized assessment. Although, where possible, the results of peer-review are supported by statistical data and calculations.

**Table 1.** Criteria for transformation of transport infrastructure

Sphere	Zone	The picture of transformational changes, which the authors at this stage consider optimal		
		N	Criteria description	Point
PT	All	1	Availability and development of comfortable public transport, primarily rail.	4
	All	2	Ensuring the movement of public transport strictly in accordance with the schedule, achieved mainly by administrative measures in the HC (dedicated strips, paid parking, paid entry into the historical core, the inevitability of punishment for jamming public transport), both administrative and technological measures in the ZAtHN (isolated the line of rail transport, the desire to bring traffic conditions closer to the LRT or the metro), mainly technological measures in the OZ, where administrative measures are concluded only in the creation of dedicated bands	6
SRN	HC	3	The development of pedestrian areas (the creation of pedestrian streets, the expansion and improvement of sidewalks), the creation of a network of predominantly underground parking spaces for those residing within the HC with the introduction of mechanisms that stimulate the mandatory use of them, the creation of a limited number of paid guest parking	6
	HC, ZAtHN	4	Creating conditions for cycling	4
SRN	ZatHN, OZ	5	In ZatHN: the creation of a parking network for residents within the zone and a limited number of paid guest parking lots, the presence of two-level interchanges at the intersection of the border of a large center with radii. In the OZ: the presence of intercepting parking lots, solving the problem of parking for local residents and guests. In both zones - the introduction of mechanisms that ensure the mandatory use of parking in residential complexes	6
	OZ	6	The presence (creation) of an external bypass road with multi-level interchanges	4

When determining the maximum score that can be assigned by criterion by experts, the weight of this criterion was also established. In this case, the total score for each criterion in general and in the context of individual zones should be the same (30 and 10 points, respectively).

### 3 RESULTS

Yekaterinburg's leadership in the development of public transport (Table 2), primarily rail, is determined by the fact that the tram network, which is based on six cycles (the sixth was formed at the end of 2017 as a result of the construction of a new line at Tatishcheva Street), preserves system-forming function in most areas of the city, differing in the relatively high quality of the track infrastructure, the contact network, as evidenced by previous studies. Among the tram systems of the regional centers of the Urals, which were estimated according to formalized quality indicators, Yekaterinburg took the leading position (unused capacity ratio was 41%) (Merkushev S.A. 2017). The qualitative exploitation of the rolling stock is also one of the strengths of Yekaterinburg, renewed, however, at a very slow pace (the average age of the tram fleet is 32 years). In addition, there are large-scale plans for the development of dendrites of the tram network in the outer zone: plans for a large-scale modernization of the urban electric transport infrastructure with the use of a concession mechanism were announced in the cities of Verkhnyaya Pyshma (via the new microdistrict North Crown), Berezovsky, and the Academic and Solnechniy microdistricts.

**Table 2.** Changes in the transport infrastructure

Sphere	Zone	Number of qualitative characteristics	The optimal picture, the maximum score	The actual picture in the cities, point		
				Ekaterinburg	Kazan	Perm
PT	HC	1	4	3	1	1
		2	6	2	4	3
	ZatHN	1	4	3	2	1
		2	6	3	4	3
	OZ	1	4	3	2	1
		2	6	3	3	3
	Total	1,2	30	17	16	12
	SRN	HC	3	6	5	5
4			4	1	2	2
ZatHN		5	6	3	4	2
		4	4	1	1	1
OZ		5	6	2	2	1
		6	4	3	3	3
Total		3-6	30	15	17	11
All		1-6	60	32	33	23

Kazan's policy of renewing the rolling stock of all types of OT can be considered a reference standard for modern Russia. As of August 2018, the average age of the tram park in Kazan is 5 years (in Perm and Yekaterinburg, only the bus fleet has been renewed in the past two years). In the city there are two-storey buses of the international network City-Sightseeing - transport intended for tourists. However, the actions of the city authorities in relation to the city tram are very contradictory. On the one hand, large-scale works to create a tramway urban ring, which are largely implemented, on the other hand, initiation of destructive processes that led to a network with three cycles according to Tarkhov's classification. (Tarkhov S.A., 2005) has become a network-tree, only fragmentarily present in the HC, which completely contradicts the global trend. Nevertheless, the project of the city ring remains uncompleted. The connection of tram lines along the streets of Tula and Baki Urmanche would lead to the creation of a direct connection between the forming transport hub at the Southern Bus Station and the Kazan-Passenger railway station, would strengthen the transport connectivity of the micro-districts of Gorki and Sunny City with the central part of Kazan. Previous studies have shown that the complexity of the topological structure in this section of the tram network will have a slight impact on its quality characteristics, but it can lay the foundation for further development.

The low result of Perm was influenced by: poor development of the tram network, lack of real construction of new lines, a significant reduction in the number of flights, especially on weekends, the continued deterioration of the quality of the track infrastructure, which in 2017 led to a significant decrease in the speed of tramway trains. The results of the analysis of the tram systems of the regional centers of the Urals testify to the unsatisfactory technical condition of the infrastructure - the Perm street streetcar network took the fourth place out of five (the unused potential ratio was 47.3%) (Merkushev S.A., 2017). Recently, it became known about the projects for the development of the tram network, within which it is planned to build a connecting dendrite along the Revolution street (as a result of which the third cycle according to Tarkhov SA classification will be formed) and the line to the Parkovy district (Petrov K., 2018) . According to the new transportation model, which is being prepared for implementation in the coming years, the transportation of passengers in the central part of Perm will be carried out mainly by trams, the lines of which form the basis of the new route network (Pelyavina I., 2018), but similar decisions were made earlier, but have not been implemented.

City electric trains are not sufficiently integrated into the urban transport system of all cities. In addition, recently it became known about a large-scale project to renovate the Perm city embankment within the framework of which it is planned to liquidate the railway traffic along the section of the Gornozavodskaya railway from the station Perm-II to the station Perm-I, and then to the island Motovilikha (Safina D., 2018). Instead of electric trains it is planned to build a tram line with the technology of autonomous movement. In connection with the disappearance of a direct route in this direction, passengers will be forced to lose time for transplantation to other modes of transport. According to our calculations, the annual loss of time of one passenger (in comparison with the existing version) in value terms will increase by 17.5 or even by 23.8 thousand rubles. (at different stages of the liquidation of the railway communication), which is absolutely

unacceptable on the main line and contradicts the world practice. In our opinion, the proposed model consists in the development of one type of public transport in place of another, which can lead to the final "washout" of electric trains from the urban transport system. We believe that in the absence of metro in Perm (as opposed to the other two cities), it is necessary to change the approach to the development of transport infrastructure. First and foremost, the tram infrastructure in OZ and ZAtHN should approach the level of the infrastructure of the LRT (Kołós A., Taczanowski J., 2016) and combined rail transport, based on the available experience (Batiss F., 2000; Rayskin B.M., 2009; Vuchic V., 2007). Secondly, the complex development of intermodal transport is necessary, which is a worldwide trend today (Rodrigue J., 2013; Vuchic V., 2007). We believe that as a result of the decision to liquidate the railway section, the chance of organizing the movement of the first combined tram-train in Russia combined with conventional and high-speed electric trains as well as long distance passenger trains is missed.

Speaking about the changes taking place in public transport systems of cities, it is also necessary to pay attention to the experience of Kazan, which occupies a leading place in Russia (excluding the capital) in terms of the number of corridors and the length of the allocated lanes for public transport. Implemented the introduction of paid parking lots with a differentiated payment depending on the location of the parking lot, payment through mobile applications was introduced, large parking lots were built at shopping centers. A consistent and strict policy in terms of evacuation and fines for violation of parking rules allowed to ensure the movement of public transport within a large center strictly on schedule, which is convenient to track by mobile application.

In Ekaterinburg and Perm, the allocated bands, especially outside the HC, are fragmentary. The large-scale plans of the Yekaterinburg authorities to implement them are slow. The severity of the situation is somewhat mitigated by the existence of a ban on the movement of motor vehicles on most tramlines located on a combined canvas in the HC and the good development of separate tram lines in ZAtHN and OZ. In Perm, the situation is similar, but the effect of this is much less because of the poor coverage of the city space by tram lines. The work on the widespread introduction of paid parking in the HC is typical for Kazan and Perm, in Yekaterinburg their appearance so far is more fragmented.

The most positive trends in the development of SRN are typical for the Yekaterinburg and Kazan HC. Pedestrian zones are developing on the Yekaterinburg embankment of Iset and Weiner st., which in the future should end with a promenade within Yekaterinburg-City, thanks to this, two pedestrian corridors are formed, crossing the HC from north to south. There are pedestrian areas in other blocks (part of Pushkin, Krasnoarmeiskaya streets, interquarter passage from "Greenwich" to Sacco and Vanzetti streets). The attractiveness of these areas is steadily increasing, and in 2018 the Isetskaya embankment is being reconstructed between Malysheva and Kuibyshev streets.

In Kazan, a pedestrian corridor has been created, which has a great attraction, which almost completely crosses the HC diagonally: the embankment of the r. Kazanki, the area of the Kazan Kremlin, Bauman street, Petersburg street, the embankment of Lake Kaban and Kayum Nasyri Street in Staro-Tatar Sloboda, where in 2018 it is planned to use electric cars (Vislavskaya E., 2018).

Pedestrian zones in the HC and ZAtHN of Perm were poorly developed (part of the Permskaya street, which has a weak attraction, the reconstructed Esplanade and the Kama embankment). Perm is the most distant from the solution of a common problem for all three cities: the lack of complete connectivity of pedestrian zones. To solve the problem of isolation of the embankment from the pedestrian zone of the Esplanade, the authors of the project for its reconstruction are aimed at creating a pedestrian bridge across Popova Street. In our opinion, this correct decision was late for many decades and was already relevant in the creation of the Esplanade, but even now it will not completely solve the problem of integrating the Perm embankment into the urban space, the pedestrian zone will never come to the river on a broad front.

It is important to note that pedestrian spaces are not only an element of a comfortable urban environment and improve its quality, but also with reasonable organization of parking spaces and public transport stimulate the development of small businesses - the opening of cafes, souvenir shops, attracting citizens and tourists.

Kazan and Perm were the most successful in creating the conditions for cycling in the HC. In all three cities, no systematic work is being done to create intercepting parking spaces at the borders of the ZAtHN and PT (at the intersection of radial highways and internal bypasses marking the border of the ZAtHN and PT). As we consider these parking lots as elements of future multifunctional transport-transfer nodes (TTNs), we believe that the intersections of internal bypass roads and radial highways, especially those with rail transport lines, should be multi-level. In this context, the most prepared for the creation of such TTN Kazan

(two-level interchanges are represented on the northern, northeastern and, to a lesser extent, the southern sections of the border). The function of urban intercepting parking in Kazan spontaneously carry out parking at shopping centers, especially located near metro stations (for example, the mall "Tandem" near the metro station "Kozya Sloboda"). In Yekaterinburg, two-level interchanges are created only on the western border of the zone. In the east, they are present at the Egorshin Approach, which is relatively close to the border. In Perm, there are no two-level interchanges at the intersections in question.

In all three cities, new housing construction is usually carried out with the creation of underground or ground parking, but there is no systematic work with the drivers of personal vehicles to respect the interests of all residents when using courtyard territories, there are some examples of successful solution of this problem at the level of Home Unit Companies.

All three cities have an external bypass road, but in Yekaterinburg there is no southern segment of this road, in Kazan - southern and western, and in Perm - northern. In Yekaterinburg and Kazan, two-level interchanges are present at all major intersections with radial directions, in Perm - on the western, southern and partly eastern segments.

#### 4 CONCLUSIONS

Thus, the processes of transformation of public transport and the street-road network, occurring in the three cities, do not yet correspond to the optimal representation of experts about them. It is necessary to intensify them while simultaneously adjusting and using modern technologies and approaches. Nevertheless, the cities have accumulated a positive experience of transformation, which can also be used in making future managerial decisions.

In particular, this is the experience of Yekaterinburg in preserving, developing and improving the efficiency of the tramway system, Kazan's experience in updating the rolling stock of public transport, creating corridors for its unimpeded traffic through the effective application of a system of dedicated lanes and toll parking, the experience of Ekaterinburg and Kazan in the formation of extensive pedestrian zones, saturation of their attractive activities.

In general, the most problematic in all cities are the processes of formation of multifunctional transport-transfer nodes on the border of large centers with external zones, coordinated with the development of the street-road network of the agglomeration nucleus. In this case, it is more necessary to treat the rich world experience, especially European cities, similar to Russia's in genesis and planning structure.

#### REFERENCE LIST

- Batiss F. (2000). The combined systems of public rail transit. *Zheleznnye dorogi mira*, 8. <http://www.css-mps.ru/zdm/08-2000/00909.htm>.
- Capasso A., Giannini G., & Lamedica R. (2014) Eco-friendly urban transport systems. Comparison between energy demands of the trolleybus and tramsystems. *Ingegneria Ferroviaria*, 69 (4), pp.329-347.
- Hirano K., Kitao Y. (2009). A study on connectivity and accessibility between tram stops and public facilities WIT Transactions on the Built Environment. *15th International Conference on Urban Transport and the Environment*, 107, pp. 247-264.
- Kołoś A., Taczanowski J. (2016). The feasibility of introducing light rail systems in medium-sized towns in Central Europe. *Journal of Transport Geography*. 54, pp. 400-413.
- Lois González, R.C., Otón M.P., & Wolff J.-P. (2013). The tramway between transport policy and tool for urban rehabilitation in certain European countries: Germany, Spain, France and Switzerland *Annales de Geographie*. 123 (694), pp. 619-643
- Macdonald A., Coxo S. (2011). Towards a more accessible tram system in Melbourne - Challenges for infrastructure design. *34th Australasian Transport Research Forum*.

- Merckushev S.A., Popov A.V. (2017). Streetcar networks in transforming urban environment of regional centers of Ural economic region. *Geographical bulletin*, 3 (42), pp 31–42. doi 10.17072/2079-7877-2017-3-31-42.
- Naegeli L., Orth H., Weidmann U. (2013). High-quality public transport and promotion of nonmotorized transport - Compromise or complement? *Transportation Research Record*. (2350), pp . 26-36.
- Pelyavina I., Sukhanov V. (2018). Modelno govorit. Gubernatoru predstavili novuyu transportnyu model Permi. Available at: <https://www.kommersant.ru/doc/3702772> (accessed 05.08.2018).
- Pertsik E.N. (1991). The urban geography (geourbanistics). Moscow, Vysshaya shkola Publ.
- Petrov K. (2018). Business Class had known the details of Perm-II reconstruction and “New Parkoviy” project. Available at: <https://www.business-class.su/news/2017/09/25/vokzaly-kvartaly> (accessed 05.08.2018).
- Plakhotich S.A., Chemodanova K.E. (2010). New technologies of transport service of the population in industrial-city agglomeration. *Bulletin of the Ural State University of Railway Transport*. 2 (6), pp.14–21.
- Rayskin B.M. (2009). Tram-train car by Alstom in Kassel. *Zheleznye dorogi mira*, 12 pp 21–28.
- Rodrigue J., Comtois C., Slack B. (2013). The Geography of Transport Systems 3rd edition. New York: Routledge Publ.
- Safina D. (2018). Expanding horizons. Program interview of Michael Syutkin first vice premier of government. Available at: <https://www.business-class.su/news/2017/10/30/rasshiryaya-gorizonty> (accessed 05.08.2018).
- Tarkhov S.A. (2005). Evolutionary morphology of transport networks. Smolensk, Universum Publ.
- Vislavskaya E. (2017) Tourists will be able to study the Old-Tatar Sloboda on electric cars. Available at: <https://www.kzn.ru/meriya/press-tsentr/novosti/turisty-smogut-izuchat-staro-tatarskuyu-slobodu-na-elektrokarakh/>.
- Vislavskaya E. (2018). Tourists will be able to excursion in Staro-Tatarskaya sloboda by electrocars. Available at <https://www.kzn.ru/meriya/press-tsentr/novosti/turisty-smogut-izuchat-staro-tatarskuyu-slobodu-na-elektrokarakh/> (accessed 07.08.2018).
- Vuchic V. R. (2007). Urban Transit Systems and Technology. Hoboken: John Wiley & Sons Publ.