

AN OVERVIEW OF THE MAJOR CAUSES BEHIND THE LOW EFFICIENCY OF LIGHT RAIL SYSTEMS IN RUSSIAN CITIES: THE CASE STUDY OF THE PERM URBAN TRAIN PROJECT

Ekaterina Saveleva¹, Svetlana Maksimova²

¹ Department of Architecture and Urban Planning, Perm National Research Polytechnic University, Perm, Russia, ekaterina.starodubzeva@gmail.com

² Department of Architecture and Urban Planning, Perm National Research Polytechnic University, Perm, Russia, gradcenter@mail.ru

Keywords: light rail system, Russian cities

Abstract. Light rail systems seem to present an optimum solution to the current mobility issues of Russian cities. Yet most cities are not ready to invest in development of such systems and the attempts to create them on the basis of existing infrastructure fall short soon after the projects' launch.

Like many other Russian cities, Perm - a city of slightly under one million inhabitants in the European part of Russia - suffers from sprawl, inadequate transportation system and consequent mobility problems. The population is scattered over the comparatively large area (Perm is the 6th largest Russian city in terms of area being only 13th in terms of population) and most of the remote areas of the city are not well integrated with the city centre.

Being aware of the problem and seeking to improve the connectivity between different areas of the city local authorities have launched the project Perm Urban Train in 2004. The project was set up using the existing railway lines with an ambitious aspiration to become a skeleton of the city transport system. The goal, however, was not achieved so far. The paper analyzes 10 years experience of Perm to develop its system of light rail trying to reveal the factors that determined the project's modest performance and hampered its successful implementation. Based on the results of the analysis, optimisation steps and recommendations for further development of light rail system in Perm and other Russian cities are proposed.

1. Introduction

Urban mobility is one of the most critical issues for all Russian cities. Current mess in urban mobility is the result of the lack of effective planning and short-sighted and uncoordinated policies on land use and transportation. Tracing the history of urban transformation in socialist and post-socialist eras provides an insight into the roots of today's mobility problems. Starting from the 1960s many socialist cities adopted the pattern of massive residential development at the periphery of cities resulted in longer commuting distances (Golubchikov, Phelps, 2011; Becker et al, 2012). The problem was further exaggerated during the transition period characterized by suburbanization of housing, retail, and jobs.

At the same time, the system of public transport was completely devastated during the 1990s and was not longer able to cope with this growing demand (Engel, 2007). While the socialist cities generally possessed highly developed and efficient public transport network, the transition period was characterised by the heavy reliance on the private automobile and the fact that public transportation system was largely neglected and underfinanced. The current level of service in the field of public transport is far below that of the past.

The transition period was characterised by the heavy reliance on the private automobile. The majority of public policies of the last decades also have been aimed at accommodating the growing number of automobiles at the expense of undermining all other modes of transportation. Thus, most of the public financing for improvements in the transportation system has been directed to expanding the vehicle carrying capacity of streets by adding new traffic lanes and building multi-level intersections, with the main purpose of moving more cars faster. To date, it is generally known that this kind of policy is not able to solve the problem of traffic congestion instead creating a vicious circle of increasing automobile dependency. Such policies achieve little but induce more automobile use, thereby considerably aggravating the existing traffic and transport problems, and eroding the quality of public space (Stanilov, 2007).

In Russian cities these negative trends still persist today (Vuchic, 2011). Dispersed urban structure coupled with an ill-conceived approach to transport planning cause serious mobility problems. Post-socialist cities seem to repeat the mistakes made by Western European and North American cities after World War II when the West embarked on ambitious projects to reshape the urban environment in order to clear way for the automobile. In order to avoid repeating the mistakes made by Western cities, Russian cities should look for new ways to meet the growing transportation demands of the densely built periphery.

2. The Untapped Potential of Urban Railways in Russia

When it comes to improving the connectivity between different areas of the city, introduction of rail transport systems is one of the commonly used type of contemporary urban interventions. Starting from 1970s many cities around the world have introduced different rail transit systems and the most popular one is Light Rail Transit (Topp, 1999). LRT along with tramway and metro belongs to a rail transit family of transport modes providing fast and convenient service to large masses of people. Being a high capacity transport mode LRT at the same time requires much lower investment cost than underground metro (Vuchic, 2002). Depending on the city's structure and its transportation system LRT may function as a suburban feeder to metro or serve as the principal transport mode. In any case rail modes of transport are in most cases superior to motor transport in terms of stability, speed, comfort and environmental impact (Morozov, 2010).

In Russia there are no systems that fully comply with the concept of LRT in the conventional sense. To date seven Russian cities have underground metro systems, and most major cities have one or another kind of electric rail transport, be it a tram, commuter rail, or light metro (Table 1). There are also dozens of unrealised projects, some of which date back to the Soviet era.

Apart from underground systems the most successful example of urban railway is probably a light rail system operating in Volgograd. The Volgograd Metrotram was opened in 1984 and became a relief for the city which stretched for more than 80 kilometres along the Volga river. The line has a total length of 17.3 kilometres with 7.1 kilometres built underground and the rest is within a surface-level right of way rebuilt from the ordinary tram line. But the system of Volgograd remains unique for Russia, its efficacy is determined by the city's linear urban structure.

In most other cities without underground metro rail transit is far from being dominant transport mode. The transition period was marked by the gradual failure of tram systems in many major Russian cities (Merkushev, 2011). First, tram lines located in the street network were seen as an obstacle to the increase of road capacities. At the same time drop in manoeuvrability and speed of trams in the conditions of high traffic density (with cars often blocking the lines) led to a decrease in the number of passengers, which made city authorities abandon and dismantle the system. Tram

systems continue to operate efficiently and develop only when they are separated from the road traffic and put in the conditions of almost total exclusion of single-level crossings with other transport modes. However, isolation of the existing tram lines from the roadway is either not always possible at all in the current urban conditions or demands large capital investments.

Table 1. An overview of rail transport systems in Russian cities

City	Population, million people	Underground metro	Light rail system	Tram
Yekaterinburg	1,43	+ 1 line	- Medium-term plans	+ Highly developed
Chelyabinsk	1,18	- Uncompleted	- No plans	+ Highly developed
Kazan	1,21	+ 1 line	+ Segments of Big Kazan Ring	+ Moderately developed, dismantled in the city core
Khabarovsk	0,61	- No plans	- No plans	- Moderately developed but mostly separated from road
Krasnoyarsk	0,98	- Uncompleted, frozen until 2020	- No plans	+ Moderately developed, partly dismantled
Nizhny Novgorod	1,26	+ 2 lines	- No plans	+ Moderately developed, partly dismantled
Novosibirsk	1,57	+ 2 lines	- Long-term plans	+ Moderately developed, partly dismantled
Omsk	1,17	- Uncompleted, frozen	- No plans	+ Moderately developed, partly dismantled
Perm	1,04	- No plans	- No plans	+ Moderately developed
Samara	1,17	+ 1 line	- No plans	+ Highly developed
Volgograd		- No plans	+ Metrotram	+ Moderately developed

In addition to the reviewed modes of rail transport most major cities have electrified intracity sections of railways used for commuter trains and long-distance trains. In cities where these lines pass through the city centre they present a ready-to-use solution to the problem of connecting the cities' cores and peripheries. In the last decades several cities including Perm made attempts to use these existing lines for developing Urban Train systems. Urban Train is a kind of electric rail intracity transport, usually using an existing rail infrastructure. Urban Train projects were to become Russian version of LRT resolving the mobility problems without much effort and investment on the part of the cities.

Urban Trains are very similar to commuter trains with only two differences: 1. smaller serviced area, allowing a smaller number of trains serve the entire area while maintaining small intervals.; 2. shorter trains consisting of six or less carriages. One relatively successful example of such project is Yekaterinburg, where the Urban Train is the fastest and cheapest way to get from the southern outskirts to the city centre (SPK, 2014). However, even there the number of urban train's passengers is far below than for other transport modes.

In some cities the projects are shut down (Ryazan) or close to it (Omsk), in others it remains an experiment (Tuymen). In Ryazan, the project was cancelled due to the lack of demand. The Ryazan Urban train system was introduced in a test mode using existing lines and passenger stations on April 30, 2009. The test period, which lasted until 17 June, showed the need to build additional stations and bypass lines for overtaking commuter trains (RZN.info, 2013). In Rostov-na-Don the Urban Train Project was launched in 2012 and lasted for only five days.

In Perm the Urban Train system was introduced in 2004. Although the number of trains decreased threefold the service is still in place. Thus Perm presents an opportunity to an experience of developing the system of the Urban Train. Using the case study of Perm this paper will try to reveal the factors that determine the Urban Train projects' modest performance and hamper their successful implementation in Russian cities.

3. The Perm Urban Train: 2004-2014

Like many other Russian cities, Perm - a city of slightly under one million inhabitants in the European part of Russia - suffers from sprawl, inadequate transportation system and consequent mobility problems. The population is scattered over the comparatively large area (Perm is the 6th largest Russian city in terms of area being only 13th in terms of population) and most of the remote areas of the city are not well integrated with the city centre. Being one of the hubs of the Trans-Siberian railway Perm has more than 100 km of railway lines.

The idea of introducing some kind of rapid railway system in Perm also has a long-standing tradition. Soviet norms required that any city of 1 million people be equipped with metro. The first official project of Perm metro was published in 1982. However, construction has not begun due to the financial constraints. Since then Perm authorities have come back to this issue repeatedly. The in-depth analysis of the feasibility of the project was performed in the Integrated Transport Scheme of Perm (KTS, 2008) commissioned by the Department of Planning and Development of Perm. At that time the transportation planners have concluded that the efficiency of metro in Perm will be very low due to "the lack of sufficient volume of passenger traffic concentrated in one direction" (Petrovich, 2010). In the KTS (2008) it was proposed to make greater use of intracity sections of the Trans-Siberian railway and the further development of the existing tram network.

The project «Perm Urban Train» was launched in 2004 with an ambitious aspiration «skeleton of the city transport city». The new route was set up using the existing railway including intracity sections of the Trans-Siberian railway. It had a total length of 51 km and included 8 stations and 14 stopping points on both sides of the Kama River. All other modes of transport, namely buses, trams and trolleybuses, were to be connected with this newly established route.

The Perm Urban Train project was the first attempt to develop LRT-like system in Perm. As stated in the project's official description (PPK, 2013) the project pursued the following goals:

- Provision of the higher level of service at the rates equal to the rates of alternative modes of public transport (mostly buses) within the city limits;
- Increase in the number of passengers transported by rail and subsequent road transport load reduction in the same direction;
- Improving the environmental situation by reducing the number of bus routes;
- Ensuring the timely delivery of workers to the industrial sites with introducing the train timetable linked to work shifts schedule;

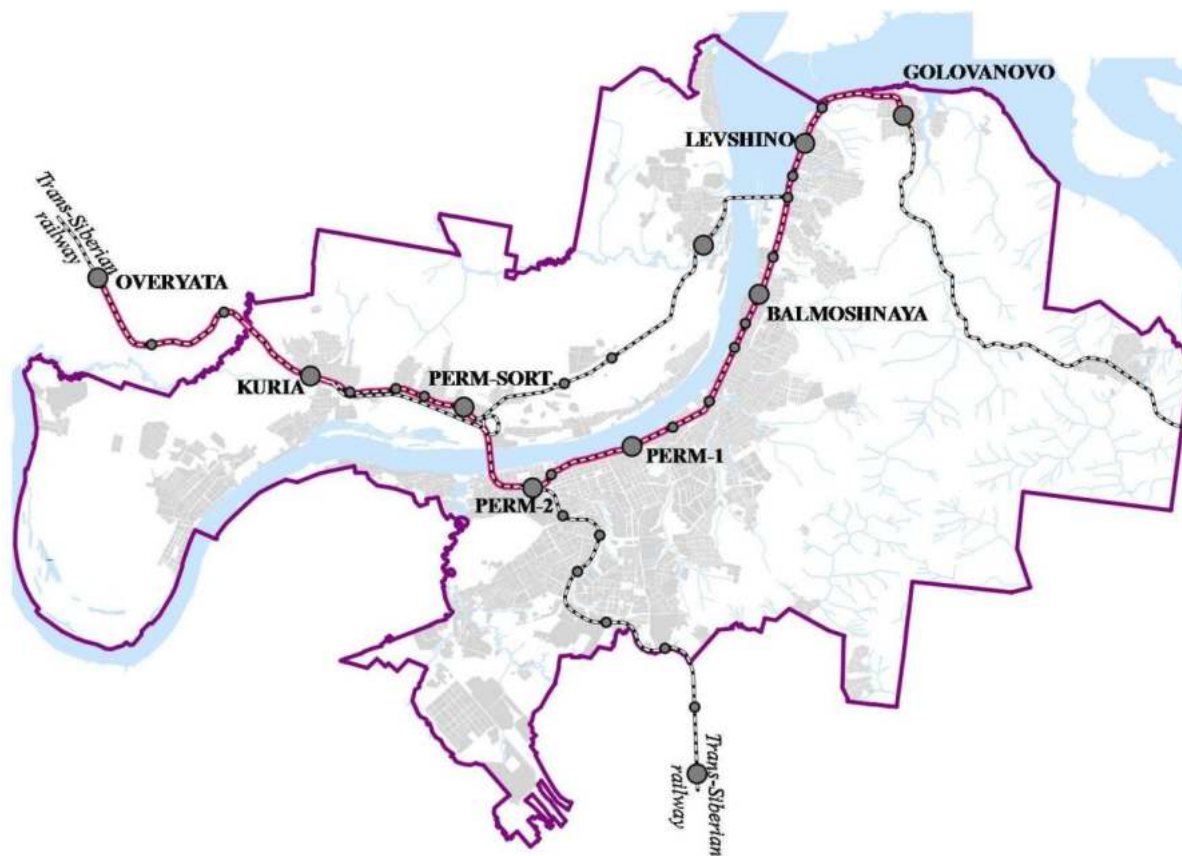


Figure 1. Railway network of Perm and the Perm Urban Train route

The city's form and the location of the existing railway in relation to the residential neighbourhoods and places of employment is a significant factor determining the success of the urban train project. For Perm with its linear urban form and the existing railway lines along its structural axis, the

project seemed like a perfect fit into the city's urban structure. If implemented properly it could potentially become the basic network for the city's new, more comfortable and efficient, transportation system.

A decade has passed since the project launch and it is possible to draw some conclusions. The total number of passengers of the Perm Urban Train from 2004 to 2013 amounted to more than 8 million passengers. In the years 2004-2008 the number of passengers was stable at around 1 million people annually but starting from 2009, when several trains were removed from the timetable, the number of passengers dropped significantly every year reaching around 0,6 million in 2013 (Figure 2).

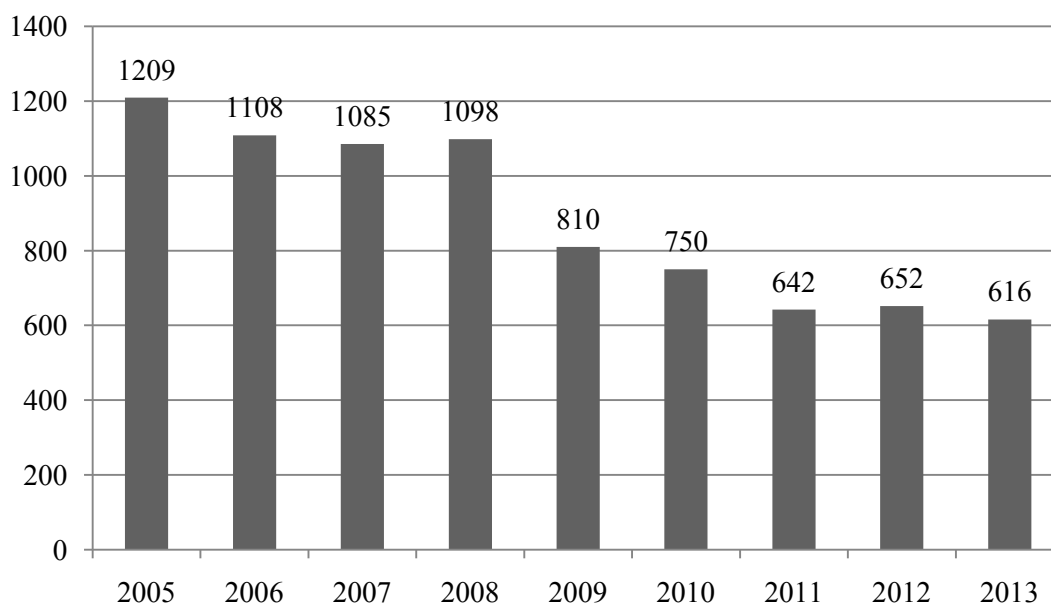


Figure 2. The number of passengers of the Perm Urban Train from 2004 to 2013, thousand people.
Source: PPK, 2013

Despite the fact that the Urban Train has obviously failed to become city's priority provided several remote areas of the city with comparatively fast and convenient way to get to the city centre. Perm Urban Train is the fastest means of public transport to the city centre from many areas. For example, it takes 38 minutes to get to the terminal station Golovanovo by train while the same trip by bus may last between 60 and 120 minutes depending on the time of the day. The table of comparison between travel times to some other stations by train and by bus is presented below (Table 2).

Table 2 Comparison of travel times by bus and by train. Source: personal observations

Points of departure and arrival	Travel time by bus, min	Travel time by train, min	Reduction
Perm I - Golovanovo	90	38	58%
Perm II - Levshino	60	39	35%
Kuria - Perm II	90	23	74%

So if this train does provide faster access to the city centre and backwards, what are the reasons for its low popularity and the constant decline in the passenger traffic?

4. Uncovering the reasons behind the Urban Train's low efficacy

The reduction in the number of passengers is due to the fact that a significant portion of them opt for alternative modes of public transport. The preferences of passengers were determined by the following factors:

- cancellation of a number of trains and simultaneous increase in the number of bus services, taxis, parallel to the route of the Perm Urban Train: there were 32 trains per day when the project was launched in 2004 and only 9 trains per day were running by the end of 2014 ;
- poor accessibility resulting in long travel times to the railway stations;
- high non-competitive price: by the end of 2014 the cost of the journey (regardless of the distance) was 21 roubles, while the trip by bus cost only 13 roubles;
- poor quality of station infrastructure.

According to passenger survey held in 2013 the factor having the greatest influence on the popularity of the Perm Urban Train is its irregular timetable (UralINSO, 2013). There is no regular interval timetable and there can be gaps up to 2-4 hours outside the rush hours. The inconvenience of the current schedule coupled with higher price outweigh all the advantages of the Urban Train over alternative means of transport.

Yet the need to increase the number of trains and to reduce the intervals of their movement is an issue that cannot be easily resolved. There are two main factors impeding this: 1. an insufficient capacity of rolling stock and 2. an insufficient capacity of railway lines in some sections. According to the General Plan of Perm (Generalnyi Plan Permi, 2010) the left bank section of the Perm Urban Train line (Perm II-Golovanovo) has an excess capacity and the main problem with the capacity of the railway network is related to the Trans-Siberian Railway. The latter is already running at its capacity while the two-track railway bridge over the Kama creates a real bottleneck.

One possible solution is to build a by-pass track to the south of the city (Perm Strategic Masterplan, 2010). The proposed track would remove the burden of immense freight traffic from the Trans-sib section going right through the city centre. However, the construction of the by-pass demands such amount of investment that is not currently available to the city. Increase in the number of trains will also require considerable investment.

It may be argued that using the same railway lines dedicated for fast trains and freight traffic generally creates a number of problems. In the Urban Train schedule there should be 'windows' left for passing long-distance trains. Moreover, deviations from the schedule of long-distance trains results in unexpected cancelations and delays of the Urban Trains. In Tyumen congestion on the Trans-Siberian section of the Urban Train route is also an obstacle to the realization of this project in full. After the launch of the project in 2009 finding timeslots for the Urban Trains turned out to be very difficult during peak hours (NashGorod, 2014).

However, implementation of these infrastructure developments may not guarantee the raise of the urban trains' popularity. Even when existing infrastructure is sufficient for launching an adequate number of trains, there still may be lack of interest on the part of passengers.

The root of the problem lies in the way public transport market is organized. In Russian cities there is a system of self-regulation of public transport services. Today regional and municipal carriers (running urban train, trams, trolleybuses) are put in conditions of uncontrolled competition with private carriers (running buses). Bus carriers offer services of low quality often delivered by obsolete fleets but at affordable rates.

The competition in the system of public transport in Russia leads to oversupply in some routes and irrational costs. In the last years private carriers almost completely replaced municipal carriers in the bus transport market. Private carriers become the main operator in this important sphere of municipal economy. They have entrepreneurial mindset and are not ready to carry the burden of social responsibility instead being focused on quick payback and revenue at any cost. Reducing tariffs without compensation make carriers reduce operating costs by saving on the repair and maintenance of the rolling stock.

Such a policy not only adversely affects the performance of the Urban Train and electric transport operated by the city but inevitably leads to the overall ridership losses and forces passengers to switch to private automobiles.

It the competition with other modes that became the main problem for the Urban train project in Omsk. Proliferation of routed taxis (a form of public transportation such as a share taxi using minibuses, often illegal) which is characteristic for most Russian cities make passengers opt for cheaper and ubiquitous mode. Although the company running the Urban Train in Omsk is looking for new ways of attracting passengers such as free Wi-Fi or a 'library on wheels', it does not make much difference (Top55, 2014).

The model of market self-regulation is regarded by most experts in the field as ineffective (Ganin, 2012). It does not properly work in most cases. State regulation is important to ensure compliance with public interest and protecting this area from undue commercialization. It is necessary to establish mechanisms for regulating public transport services in order to overcome chaotic patterns of today's public transport system, which 'steals' passengers from regular routes. Current legislation in the field of public transport in Russia does not imply centralized and coordinated transport planning and operational management but at the same time it does not prohibit it.

In order to facilitate integration of all modes of transport in one efficient system an intermodal transportation company may be established in cooperation with the Government of the Perm region. This will increase the level of coordination and co-operation between all public transport providers and allow to prioritize more sustainable modes such as urban railway.

The Perm Urban Train project is currently run by the Perm Suburban Company, which is a subsidiary of Russian Railways (51 percent owned by Russian Railways and 49 percent by Perm region). Around 58 percent of operating costs are covered by transportation fees, the rest is subsidised by the regional budget. In 2014 the regional government raised the question of the abolition of funding for the project since it was not ready to subsidy intra-urban public transport. The city budget also does not have the necessary funds. The service is still in place but the question of financing remains open.

Meanwhile, the problem is not unique for Perm. Many other Russian regions have similar Suburban companies operating commuter rail transportation. During their creation in the early 2000s the rolling stock was not included in their authorized capital. As a result the rental payment for the carriages and locomotives accounts for almost 70% of their operating costs. This rental

payment and the tariff for the use of railway infrastructure are charged in favour of Russian Railways. Many regions consider the pricing policy of Russian Railways as opaque and refuse to subsidise the Suburban companies (Terentyeva, 2015). This issue, however, lies beyond the scope of the current study.

5. Possible organisational and administrative reforms

In order to increase the effectiveness of the existing system of rail transit in Perm we propose several organizational improvements which do not require much capital investment but strong political will.

The following reforms are suggested in order to improve the service and to encourage rail transit ridership:

1. Reducing the intervals of the train, as already mentioned, is the most needed step towards attracting more passengers since the inconvenience of the current schedule for many passengers outweigh all the advantages of the Urban Train over alternative means of transport. This may be achieved either by rearrangement of the existing fleet, e.g. splitting longer trains into two on the routes running with intervals, or by investment into new rolling stock, thus improving both the intervals and the level of comfort.

2. Improved coordination among modes and integration of the Urban Train into the city's public transport system is a foreground transformation that may be beneficial not only for rail transport system, but also for the city's public transport network as a whole.

This can be achieved in several ways. The first and most obvious step is to introduce a single (and simple-to-use/understand) ticketing system compatible with other modes of public transport. Such systems are in place in most cities with developed public transit since the mid 2000s.

Better modal integration on stations and stopping points is also a very important step towards attracting the new passengers. Possible developments in this field include turning at least the major stations into proper transportation hubs with exchange opportunities from train to buses, trams and other modes of transport with simultaneous harmonization of their schedules. Other ways of modal integration include:

- Arrangement of near-station parking lots allowing car users to leave their vehicles safely and change to train;
- Organisation of short bus routes between places of residence and train stations as a feeder service to the Urban Train;
- Improving pedestrian accessibility and approaches to the stations and stopping points.

One of the feasible perspectives of mode integration in Perm is the formation of the tram-train system. The basis for such system will be the left bank section of the railway and the well-developed tram network in the south part of the city.

3. Finally, it is important to make the use of the Urban Train clearer and easier. Improved availability of passenger information combined with various marketing programs aimed at popularisation of the Urban Train and rail public transit in general will make a significant contribution to the development of the project.

6. Conclusions

To sum up, it may be argued that at the time of its establishment the Perm Urban Train Project presented a promising solution to the Perm's issue of low connectivity raised from fragmented urban fabric.

Unfortunately the Perm Urban Train has not received due attention from the regional authorities who initiated the project nor it has attracted enough support from the authorities of the city. Despite the initial plans it was not integrated into the city's network of public transport leading to the competition with other modes and the gradual loss of passenger volume.

Planning and developing of effective transport system requires an integrated approach. The fragmentation of urban administration, which is evident both in post-socialist and developing countries, hampers the success of policy planning and implementation. Many authors call for organisational change and for better co-ordination of structural units of administration having urban transport responsibility as a crucial element of efficient performance of city's transportation system (Cervero, 1998; Dimitriou, 1990; Stanilov, 2007). The creation of the intermodal transportation company or the local government body managing the whole transport system seems to be a most urgently needed reform in Perm and other Russian cities.

The development of the efficient transportation system with the rail transit as a backbone presupposes the abandonment of the current overreliance on private automobile transport and adopting a new systematic approach to transportation planning. Overcoming chaotic and inefficient traffic patterns characteristic of most Russian cities requires sufficient political will and civic drive to give the priority to more sustainable modes such as rail transit and to allocate needed resources. Subsidies in the system of public transport should be evaluated against the costs associated with road traffic: capital investment into road construction, the cost of road maintenance, road safety, organization and construction of parking spaces and so on. The investment into urban rail systems in the long term may be the most cost-effective solution improving mobility at a lower total cost, including costs to government, consumers losing time in traffic jams and the city's environment.

7. References

- Appenzeller, M., Gietema, R. (2010) *City regeneration today*, The International Review of Architecture and Urban Design, Topos, 73, pp. 18-27.
- Becker, Charles, S. Joshua Mendelsohn, and Kseniya A. Benderskaya (2012) *Russian urbanization in the Soviet and post-Soviet eras*. IIED.
- Cervero, R. (1998), *The Transit Metropolis: A Global Inquiry*, Washington, DC: Island Press.
- Dimitriou, H. T. (1990), *Transport Planning for Third World Cities* (ed.), London:Routledge.
- Engel, B. (2007) *Public space in the blue cities of Russia*. In K. Stanilov (ed.) *City: Urban Form and Space Transformations in Central and Eastern Europe After 1989*. Dordrecht: Springer, pp. 285-300.
- Ganin, O.B., Ganin I.O. (2012) [The conception of public transport development of megapolis], *ARS ADMINISTRANDI*, 2, pp. 55-63 (In Russian).
- *Generalnyi Plan Permi/General Plan of Perm* (2010), Perm: Perm City Administration.
- Golubchikov, Oleg, and Nicholas A. Phelps (2011) 'The political economy of place at the post-socialist urban periphery: governing growth on the edge of Moscow', *Transactions of the Institute of British Geographers* 36.3, pp. 425-440.
- KTS (2008) *Kompleksnaya Transportnaya Shema Permi/Integrated Transport Scheme of Perm*, Perm.
- Merkushev S.A. (2011) [Development of Urban Railway Transport in Perm City] *Geographic Bulletin*, 1 (In Russian).

- Morozov, A.S. (2010) 'Light Rail Transit as a Result of Integration of the Tram, Subway and Suburban Railway', Social and economic problems of the development and functioning of the transport systems of towns and areas of their influence. Proceeding materials of the XVI international scientific and practical conference, June 16 -17, 2010. (In Russian).
- NashGorod (2014) [Urban Train: 2 stages of the project realization] Our city Tyumen/Nash gorod Tyumen [online] Available at <http://www.nashgorod.ru/news/news64021.html> Accessed on 15 May 2015 (in Russian).
- Perm Strategic Masterplan. Transforming the City (2010), Perm.
- Petrovitch, M.L. (2010) 'Complex Transport Scheme of Perm: Scientific and Methodological Basis for the Study', Social and economic problems of the development and functioning of the transport systems of towns and areas of their influence. Proceeding materials of the XVI international scientific and practical conference, June 16 -17, 2010. (In Russian).
- PPK (2013) [Report on the implementation of the project "Urban Train" in the period 2004-2013], Perm: Permskaya Prigorodnaya Kompaniya/Perm Suburban Company. (In Russian).
- PPK (2013a) [Annual report of public corporation "Permskaya Prigorodnaya Kompaniya"], Perm: Permskaya Prigorodnaya Kompaniya/Perm Suburban Company. (In Russian).
- PPK (2014) [The Urban Train. Project Description], Perm: Permskaya Prigorodnaya Kompaniya/Perm Suburban Company. (In Russian).
- RZN.info (2013) V Ryazani vnov' mozhet poyavitsya gorodskaya elektrichka /Urban Train may again appear in Ryazan [online] Available at <http://www.rzn.info/news/2013/8/19/po-shpalam-v-ryazani-vnov-mozhet-poyavit-sya-gorodskaya-elektichka.html>. Accessed on 15 May 2015.
- SPK (2014) [Urban Train] Sverdlovskaya Prigorodnaya Kompaniya/Sverdlovsk Suburbab Company [online] Available at http://www.svrpk.ru/pages/page/url/Gorodskaya_elektichka. Accessed on 15 May 2015 (In Russian).
- Stanilov, K. (2007) Urban development policies in Central and Eastern Europe du period and their impact on urban form . In K. Stanilov (ed) The Post-Socialist City: Space Transformations in Central and Eastern Europe After Socialism, Dordrecht: Springer, pp. 347 360.
- Terentyeva, A. (2015) [Commuter trains are not a business for Russian Railways], Vedomosti, 1 Russian).
- Top55 (2014) [Urban train will apperar in Omsk in 2015] Top55 [online] Available at <http://top55.info/news/newsid/16528/> accessed on 15 May 2015 (In Russian).
- Topp, Hartmut H. (1999) 'Innovations in tram and light rail systems.' Proceedings of the Institution of Mechanical Engineers, Part F: Journal of Rail and Rapid Transit 213.3, pp. 133-141.
- UralINSO (2013) [Passenger survey, Perm Suburban Company], Perm: UralINSO. (In Russian).
- Vuchic, V. R. (2002) 'Urban public transportation systems', Encyclopaedia of Life Support Systems, UNESCO.
- Vuchic, V.R (2011) ['Transportation for liveable cities'], Moscow: Territoriya buduschego. (In Russian).