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OPTIMIZATION OF REGIONAL PUBLIC TRANSPORT SYSTEM: THE CASE OF PERM KRAI

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OPTIMIZATION OF REGIONAL PUBLIC TRANSPORT SYSTEM: THE CASE OF PERM KRAI[4]

Liberalization of regional public transport market in Russia has led to continuing decline of service quality. One of the main results of the liberalization is the emergence of inefficient spatial structures of regional public transport systems in Russian regions. While the problem of optimization of urban public transport system has been extensively studied, the structure of regional public transport system has been referred less often.

The question is whether the problems of spatial structure are common for regional and public transportation systems, and if this is the case, whether the techniques developed for urban public transport planning and management are applicable to regional networks.

The analysis of the regional public transport system in Perm Krai has shown that the problems of cities and regions are very similar. On this evidence the proposals were made in order to employ urban practice for the optimization of regional public transport system. The detailed program was developed for Perm Krai which can be later on adapted for other regions.

JEL Classification: R42.

Keywords: regional public transport system, trunk and feeder public transport system

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Introduction

The problem of optimization of public transport system has been extensively discussed in the field of urban and transportation studies [Nielsen, 2005; Vuchic, 1999; Vuchic, 2005], while the problem of regional public transport systems has been referred comparatively rarely. However, even in the countries that have reached very high levels in terms of urban transport planning and management the problems of regional and long-distance intercity transport still exist. The main disadvantages of regional transport are considered to be the following: the lack of intermodal interchanges, the lack of single ticketing service and the necessity to pay for the interchange, the imbalance of demand and supply [International Transport Forum, 2013]. The problem is especially urgent due to the growth of the market of the regional and intercity transport services [Yai, Fujisaki, Itoh, Kariyazaki, Kume, Pan, Rothengatter, Suzuki, Tomari, 2014]. The surpassing growth of the intercity connections compared to the interurban linkages has been observed already in the XX century [Kaplan, Kagan, 1976].

The developed countries haven't come to the conclusion which role should each transport mode play in the spatial structure of the regional public transport systems [Sippel, Mayer; The European Rail Research Advisory Council, 2006]. In some countries (ex. USA, UK, Sweden) the regional and intercity public transport is fully deregulated, the priority of rail transport isn't stated in any laws, long-distance bus services don't receive subsidies. In other countries (ex. Norway, Spain) bus transport receive subsidies and tendering system is in place. Germany has always been an example of strict policy for railway transport protection. Recently some changes have been made and the market of regional and intercity transport services has been partially deregulated, which have led to a massive 125% growth in bus services during a year (2012 – 2013) [Bus and coach, 2013]. But actually the regulations still in place are actually rather strict yet. The stops of the long-distance bus can't be closer than 50 km to each other. The long-distance bus route can't be introduced if there is a parallel railway service which allows moving between the proposed bus stops in less than an hour [Augustin et. al., 2014]. Such restrictions are needed to protect heavily subsidized local transport and railway transport.

Researches on regional transport systems conducted during the Soviet period are dedicated mainly to the interconnections between the transport networks and settlement distribution [Bugromenko, 1987; Gol'ts, 1981; Mosunov et. al., 1990]. Kaplan and Kagan [Kaplan, Kagan, 1976] reveal that due to the long distances and huge time losses "subcenters" emerge with their own areas of influence besides the areas of influence of regional centers which form and head the developing settlement systems. Meanwhile the sociological survey of the transport connections in Khabarovsk Krai [Litunenko, 1980] has shown that one of the leading

factors of regional transport links formation is the distribution of the social and commercial services, the overall level of development of which is considered to be low in the region. This causes the formation of the passenger flows to the largest centers for the basic services. Thus the insufficient development of the network of subcenters with the satisfactory level of services provision creates the additional demand for regional transport. The several surveys of Moscow region [Lappo et. al., 1988; Petrov, 1988; Tratynov, 1978] has revealed the existence of local settlement groups within the boundaries of the territory headed by Moscow. The authors have found out that in the zone of established daily contacts with Moscow the gravity of Moscow was much higher that the gravity of any other local centers even the most important ones.

The works of Russian specialists of the last 25 years are dedicated mainly to the transformations of the regional public transport and interconnected settlement patterns due to the transition to the market economy. The analysis of the changes of regional transport and factors that influence it in Sverdlovsk area [Sabitov, 1993] has revealed the growth of the disproportion in population distribution and its movement to the central and southern parts of the region accompanied with the reduction of the number of rural settlements. It has also been found out that the proximity of local centers has positively influenced the demographic processes: population decrease within the 30 km zones from local centers has been two times less sweep than in other territories.

In the surveys of urban public transport two approaches to urban public transport planning and management are distinguished [Nielsen, 2005]:

1) demand oriented approach;

2) supply oriented approach.

Demand oriented approach suggests the presence of unregulated market of transport services, where transport operators are free to decide which routes to choose for operation basing on the demand volume in different parts of the city. Supply oriented approach suggests the presence of obligatory network of routes which can be served by public transport operators. These two approaches have several crucial economical differences. Demand oriented approach used to be popular in developed countries [Vuchic, 1999], but was soon considered inappropriate mainly because of the low quality of public transport service which led to motorization growth.

There are two main spatial defects of demand oriented approach to public transport (Tab. 1). The first one is that some urban areas are not served by public transport because of the demand volume in these areas being not of economic interest for transport operators. Communities in these areas do not have access to public transport services and are socially excluded. The second defect is the presence of competition between routes and transport modes leading to decreasing demand for the services of each transport operator which causes revenue

reduction and diminishes ability to maintain and improve service quality. In particular operators usually use small vehicles like minivans. In supply oriented approach this problem is solved by organization of large number of convenient hubs which helps to raise the service quality on the most popular segments considerably. The small vehicles are only used on feeder routes.

In addition the insufficient number of hubs hampers the organization of express buses as the demand for such kind of service between the origin and destination usually is insufficient, while on some segments of the route the demand may be large enough.

The principle and functions of public transport systems in cities and regions are generally similar. The main peculiarities of regional public transport system are larger distances and accordingly lower share of commuting trips and lower passenger volumes [Gol'ts, 1981; Frick et al., 2014]. This creates additional problems as the lower demand causes the lower quality of service. Special problems are experienced by rail transport operators: the surveys show that the presence of competition of rail transport with interurban bus on one segment of the network has great negative impact on the whole system efficiency [Bataille, 2013].

Tab. 1 Spatial Structure Patterns of Urban Public Transport Systems

	Demand approach	Supply approach
Service area	Areas with lack of service are inevitable.	Entire urban area is under service according route plan
Competition between transport routes and transport modes	Competition between transport routes and transport modes exists.	No competition between bus routes, bus and rail transit. Role of each transport mode is clearly defined.
Interchanges	A few major hubs.	Significant number of comfortable hubs.
Capacity of transport vehicles	Small.	High capacity vehicles on major routes.
Express services	Express routes implementation is difficult.	Express service is organized on major routes

The role of rail transport is currently diminishing in the majority of Russian regions. Almost all suburban rail transport companies have to work in rather disadvantageous conditions and aren't able to compete with bus operators under the free market even though they have some advantages which are important for passengers. This situation is explained by the so called *tariff trap*. Even with the constant federal support in the form of exemption from the payment for the

use of the infrastructure, the income from ticket sales with current fares doesn't cover the maintenance costs.

The lines within the catchment areas of the largest cities are the most profitable and popular with passengers, but at the same time the price elasticity of demand at these lines is very high. When the price goes up the passengers with low income don't pay the full price of the ticket or stop paying at all. The passengers with higher income start using private cars or competing bus routes instead. When the operator can't increase income by raising the fare, the situation of a classical *tariff paradox* emerges. The core of this phenomenon is formed by the convergence of two factors: the growth of semi-fixed and therefore of fixed costs independently of the operator and the high price elasticity of the demand when the fare growth leads to the loss of the significant number of regular passengers and eventually to the income reduction. The border of the *tariff trap* (which in fact is the level of not operating at a loss) is situated strictly under the total cost curve (Fig. 1).

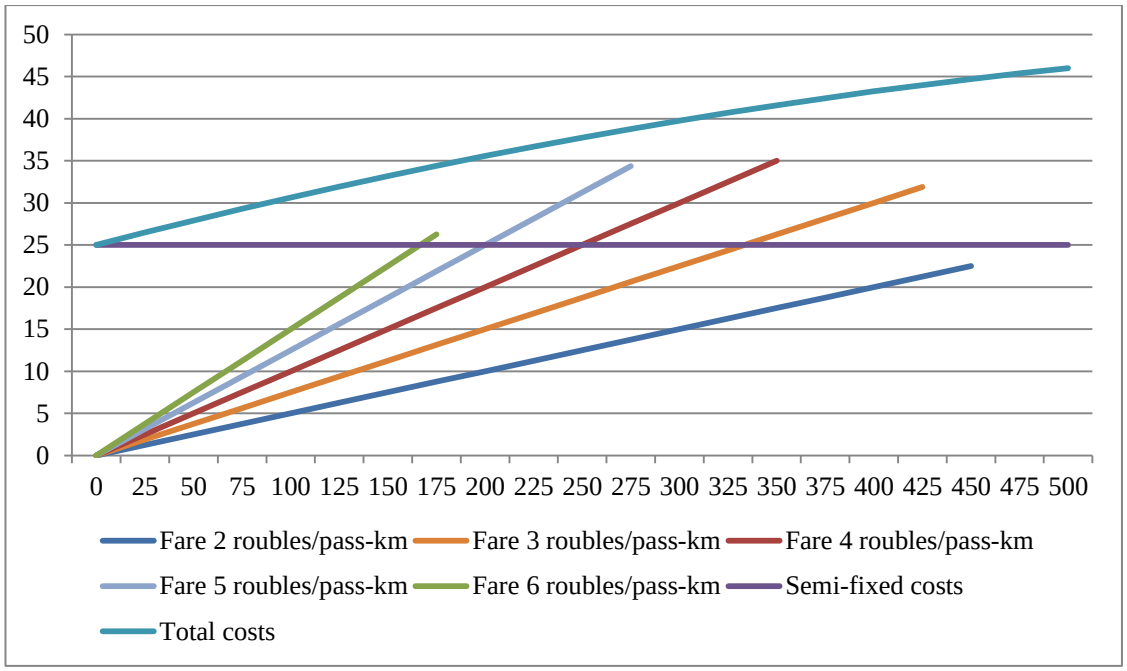

Fig. 1. *Tariff trap*: dependence of income and costs (axis of ordinates, ths roubles) from transportation (axis of abscissae, ths pass-km per day).

There is also a problem with lines serving remote settlements where transport demand is not sufficient. At these lines rail operators actually have an important social function ensuring transport accessibility instead of providing commercial transport services. Both common international practice and the Russian legislation states that the shortfall in income due to the fulfilment of socially important functions should be compensated from the regional budget because the region orders transport services.

As far as the regional public transport in the Russian Federation hasn't actually been regulated by the government since 1990s it is arguable that it faces the problems which also appear in urban areas which employ the demand oriented approach to public transport planning and management. If this is the case the spatial optimization of regional public transport system is possible and may be based on adaptation of instruments developed within the supply oriented approach in urban areas. In this paper the case of Perm Krai is surveyed.

Data, methods and case description

The main sources of information for current spatial structure of regional public transport system in Perm Krai are bus and rail timetables in 2013. Basing on this data the network of regional public transport was built in geographical information system. Data on settlements population from 2010 census was also included in geographical information system. The transport management system in the region was studying by the analysis of normative acts, strategic and territorial planning documents, reports by transport operators and interviews with representatives of authorities and transport operators.

Perm Krai is situated in the European part of the Russian Federation (Fig. 2). The territory is notable for its long and snowy winter. On average the temperature of January is −18,5°C; maximum temperature difference range from −56°C in winter to +42°C in summer.

Fig. 2. Perm Krai in the Russian Federation

The population of Perm Krai is 2 637 thousand people. The regional center (Perm) is one of the largest cities in Russia with over 1 million inhabitants. Population density changes from 2 persons per square kilometer in the northern territories to 1250 persons per square kilometer in towns and cities including Perm (Fig. 3). The northern part of the region is scarcely populated and doesn't have all year round transport services.

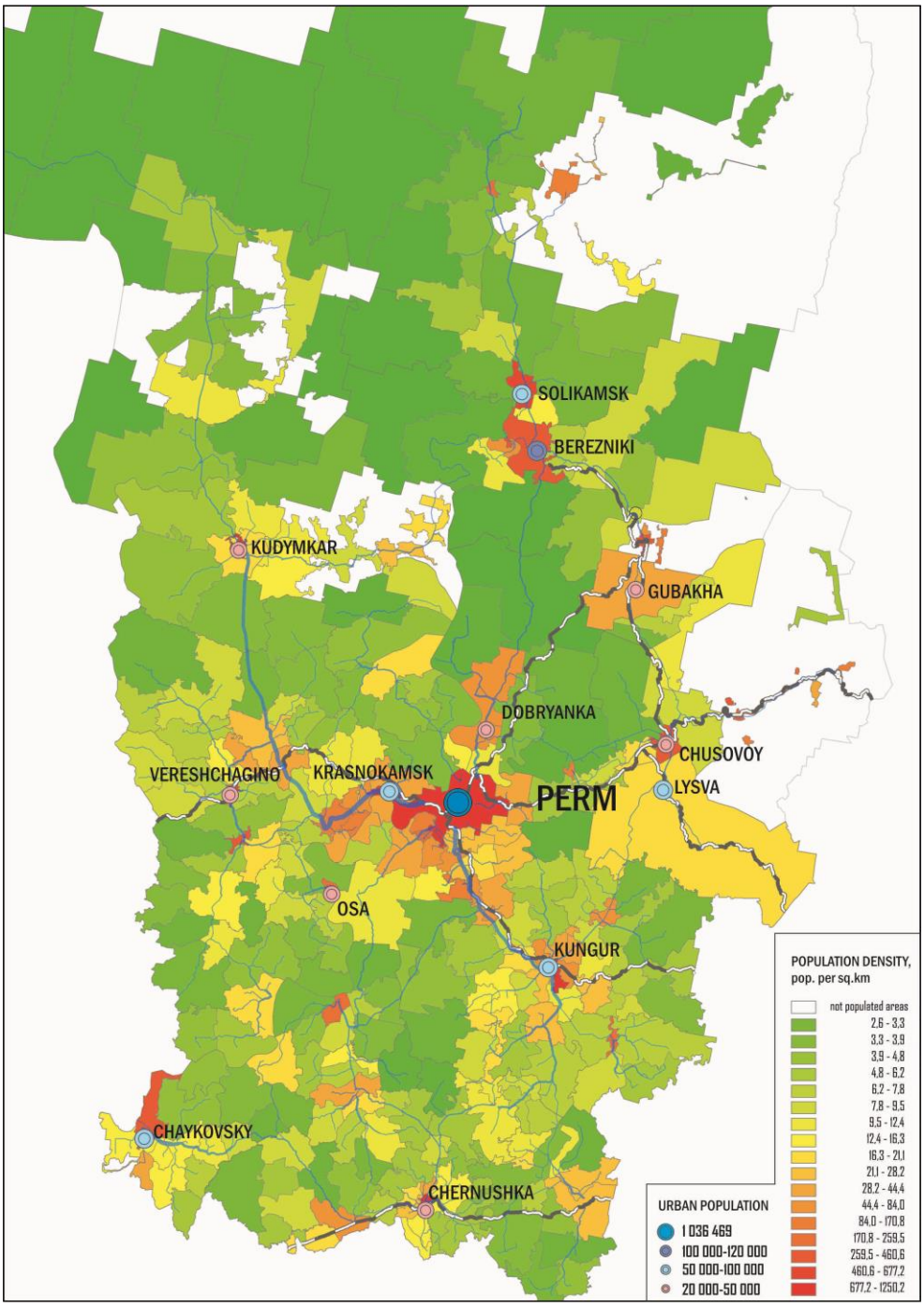

Fig. 3. Population density in Perm Krai

Tab. 2 contains information about urban settlements in Perm Krai. The motorization rate of urban settlements and of other territories in Perm Krai (as in the majority of the regions of the

Russian Federation) is comparatively low which makes the problem of the interurban transportation more urgent than in the countries with higher motorization rates.

Tab. 2. Urban Settlements of Perm Krai

№	Name	Population (2015)	Average monthly salary, rub. (2013)	Motorization rate (2012)	Road length, km (2012)	Share of paved roads, % (2012)
1.	Perm	1 036 469	32 661	220	1269,8	100
2.	Berezniki	148 955	28 724	229	265,6	82
3.	Solikamsk	95 514	25 162	175	196,5	71,2
4.	Chaykovsky	83 202	26 401	260	563,23	58,6
5.	Kungur	66 606	24 009	229	1316,7	82,3
6.	Lysva	63 558	19 912	211	431,4	85,6
7.	Krasnokamsk	53 939	24 843	221	274,93	93,1
8.	Chusovoy	45 719	21 531	166	702,93	60,2
9.	Dobryanka	33 291	29 830	252	498,33	85,1
10.	Chernushka	32 687	24 018	252	417,73	76,1
11.	Kudymkar	30 739	22 425	183	131,9	30,9
12.	Vereshchagino	22 328	19 816	188	763,83	44,8
13.	Osa	21 201	26 602	244	215,63	92,2
14.	Gubakha	21 160	22 820	229	106,3	92

Perm Krai has diversified extracting and manufacturing industries. The extracting industry includes oil extraction (Chaykovsky, Osa, Chernushka), potassium extraction (Solikamsk and Berezniki), timber production (all northern territories), reserve coal field (Kizel). The manufacturing industry includes titan production (Berezniki), petroleum chemistry and petroleum refining (Perm, Chaykovsky), galvanized metal production (Lysva), methanol production (Gubakha), cement production (Gornozavodsk), armaments industry (Perm, Krasnokamsk). About 50% of jobs in urban settlements belong to the tertiary sector of the economy.

Results and discussion

Spatial structure of regional public transport system in Perm Krai

Currently the main transport modes in Perm Krai and in the majority of Russian regions are bus and rail transport. Suburban river transport activity has been decreasing since 1990s and now there are only few lines in the region (most of them are ferry crossings). Bus transport dominates. The network of bus routes covers all the municipalities (Fig. 4).

In 2013 there were 549 bus routes in Perm Kray, total length of the network was 7817,8 km. The route network covers all the municipal regions and includes the direct routes without transfers from the remote northern territories to the regional center. Topologically bus route network doesn't have the evident central node. The number of incoming edges for Perm and Chernushka nodes is 7, for Karagay, Kungur and Vereshchagino – 6. The main connections from the regional center include Kungur, Yugo-Kamskiy, Krasnokamsk – Karagay, and Polazna. Such kind of topology reveals the spatial organization with rather high share of the peripheral routes bypassing the regional center. These peripheral routes are: Kudymkar—Usole—Berezniki, Berezniki—Kizel—Chusovoi—Lysva, Osa – Barda, Chernushka — Chaikovsky, Ilyinsky — Karagay, Ocher — Vereshchagino — Karagay. Some of the routes starting at Chaikovsky cross the boundary of Perm Krai and traverse Udmurtia (Bolshaya Sosnova—Votkinsk—Chaikovsky). In some municipal regions without rail transport service the areas of dense bus network have emerged (Kudymkar, Ocher — Vereshchagino — Karagay, Chaikovsky – Barda – Chernushka and Kungur).

The rail transport network comprises a frame with nodes at Perm, Chusovoy, and Kizel with branches to Vereshchagino, Kungur, Lysva, borders of the region and to the north from Kizel (Fig. 4). There is also the separate line Yanaul — Krasnoufimsk in the southern part of the region. All the route network of suburban rail transport is oriented towards the node in the regional center (station Perm II). Currently in the region there are 2 routes of urban rail transport, 14 suburban rail transport routes and 52 long-distance train routes traverse the region. The largest passenger stations at the network are Perm I, Perm II, Kaliynaya, Kungur, Chusovskaya, Chernushka, Ugleuralskaya. The total number of departures from the stations exceeds 20 million passengers per year. The most important stations at the network are served by 15 – 31 routes.

The largest demand volume is observed on the network segments within the Perm metro area which serve commuting trips (Merkushev et al., 2005), and on the segments kinking Perm to local centers. The demand volume on segments linking local centers to each other and to the smaller settlements is much smaller.

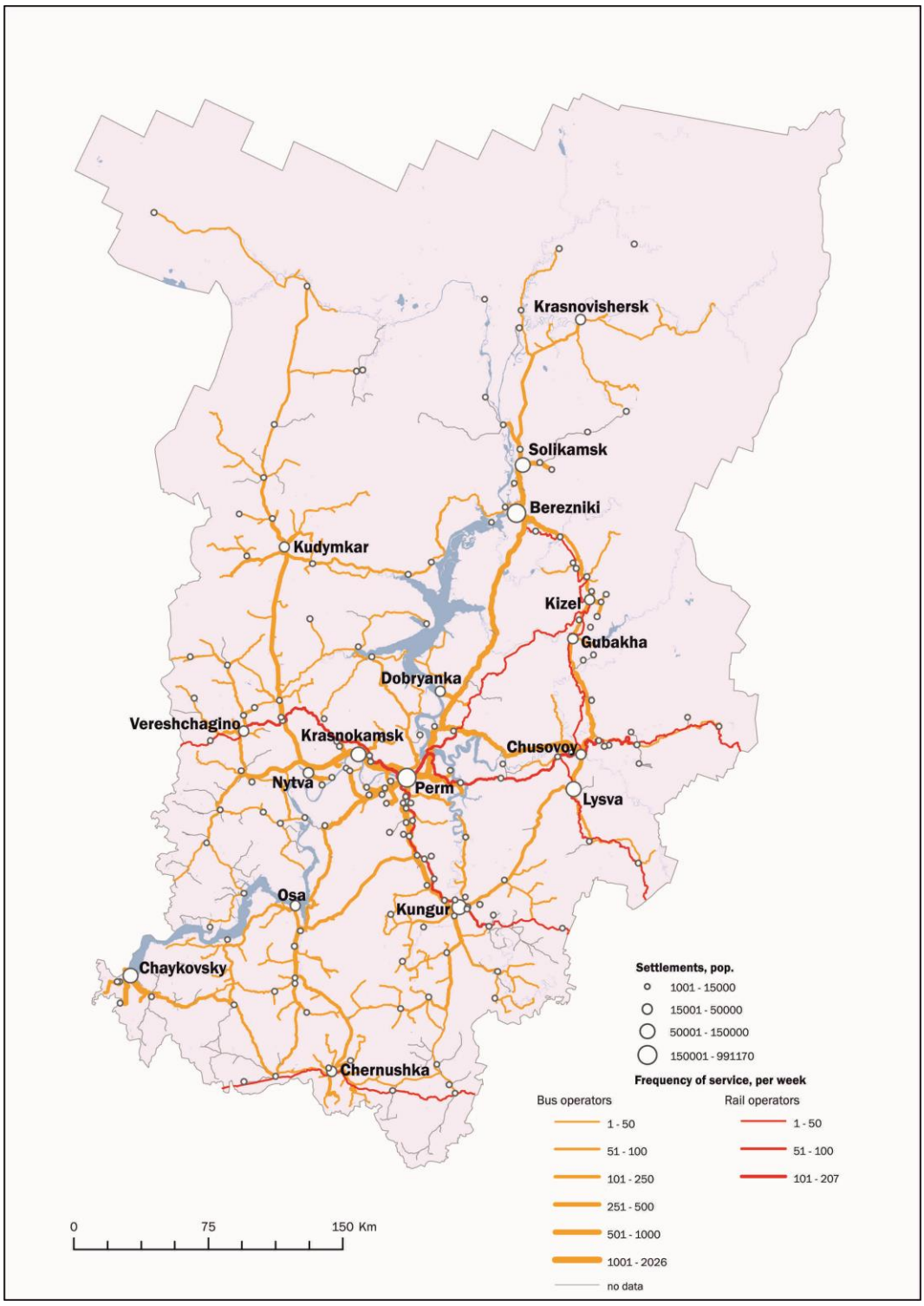

Fig. 4. Regional Public Transport of Perm Krai: Route Network and Transport Supply

It is arguable that on the network segments with the largest demand volume more comfortable large buses are used, while on the segments with low demand volume small vehicles are used. The analysis however shows that the average vehicle capacity on a segment doesn't depend on the total supply volume on it (Fig. 5a). And given the absence of any regulation the supply volume is approximately the same as the demand volume.

The situation can be largely explained by the fact that the majority of routes beginning in the remote small settlements go straight to Perm. The low demand in the origin conditions the usage of small vehicles on the whole route from the origin to Perm. Almost a half of the buses going from Perm to other settlements from 2 to 4 hours are buses with capacity lower than 30 passengers (Fig. 5b). At the same time on many segments the total demand volume allows using larger and more comfortable buses. Thus the low level of service is conditioned by the absence of route network regulation.

The analysis of public transport accessibility for Perm Krai population has shown that about 6% of the population live in settlements which are further than 2,5 km (30 minute walk) from the nearest public transport station (Tab. 3). The majority of these settlements are very small (less than 99 residents). About 90% of the population lives no further than 30 minute walk from public transport station (rail) or rout (bus). About 45,5% potential passengers have a bus route no further than 10 minute walk. Thus the potential effect from the bus network optimization is considered to be crucial. Only 31,6% of the population having access to the rail live no further than 10 minute walk from the rail station. For about 28,5 thousand people (2010 census) the rail transport is the only available transport mode. The largest settlements which are served only by rail are situated at Perm – Kungur line (Mokhovoye, Kordon and Berkutovo).

Tab. 3. Accessibility of regional public transport in Perm Krai

Type of service	Population, inh.	Share of population
No service	93 309	5,7%
Only bus service	1 080 894	65,9%
Only suburban rail service	16 628	1,0%
Bus and suburban rail service	449 071	27,4%

In Perm Krai the competition between bus and rail transport isn't regulated. The analysis of current route network shows that there are two types of competition: on links between local centers (arterial competition) and in areas where rail and bus routes are parallel (local competition). Local competition can be seen on links Perm – Kungur, Perm – Krasnokamsk, near Chernushka and Kizel. Arterial competition is present in the triangle Perm – Berezneki – Chusovoi/Lysva and on links Perm – Kungur, Perm – Vereshagino, Chernushka – Oktyabrsky (Fig. 6). Competition has a pernicious effect on rail operators as they lose many of potential clients.

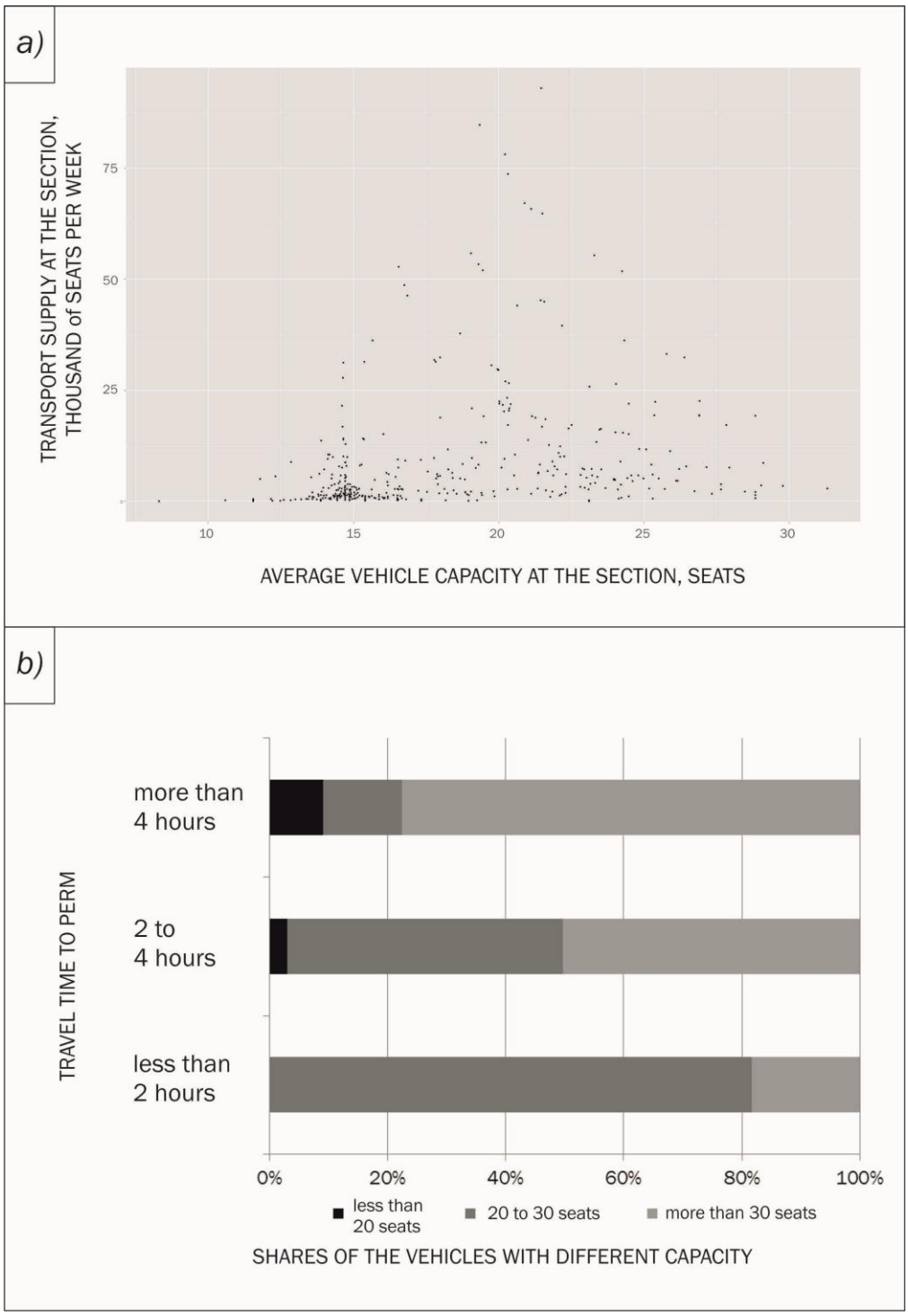

Fig. 5. The interrelationship between transport demand, travel time, and average vehicle capacity

On peripheral routes the competition has only been revealed at the section Berezniki — Chusovoi and at Chusovoi—Kungur line up to Lysva. At all other peripheral routes bus transport doesn't have an alternative which implies additional requirements for the bus network.

The competition between bus and rail transport seems to be ineffective due to the fact that rail transport is subsidized by the region. In 2014 333 million rubles (4,6 million euro) were transferred to the rail operator in form of subsidies from the regional budget. The volume of

necessary subsidies has grown in 2015 by 154,56 million rubles, but the transfers form budget haven't changed which have led to cancellation of 25 trains in Perm Krai.

On the majority of bus and rail routes the traditional compromise between the frequency of stops and the average speed is solved in favor of the first. Accordingly the number of stops is irrationally high and the speed is low which makes the quality of service lower. There are no truly express bus routes in Perm Krai. The only express rail route links Perm and Vereshagino (one train per day).

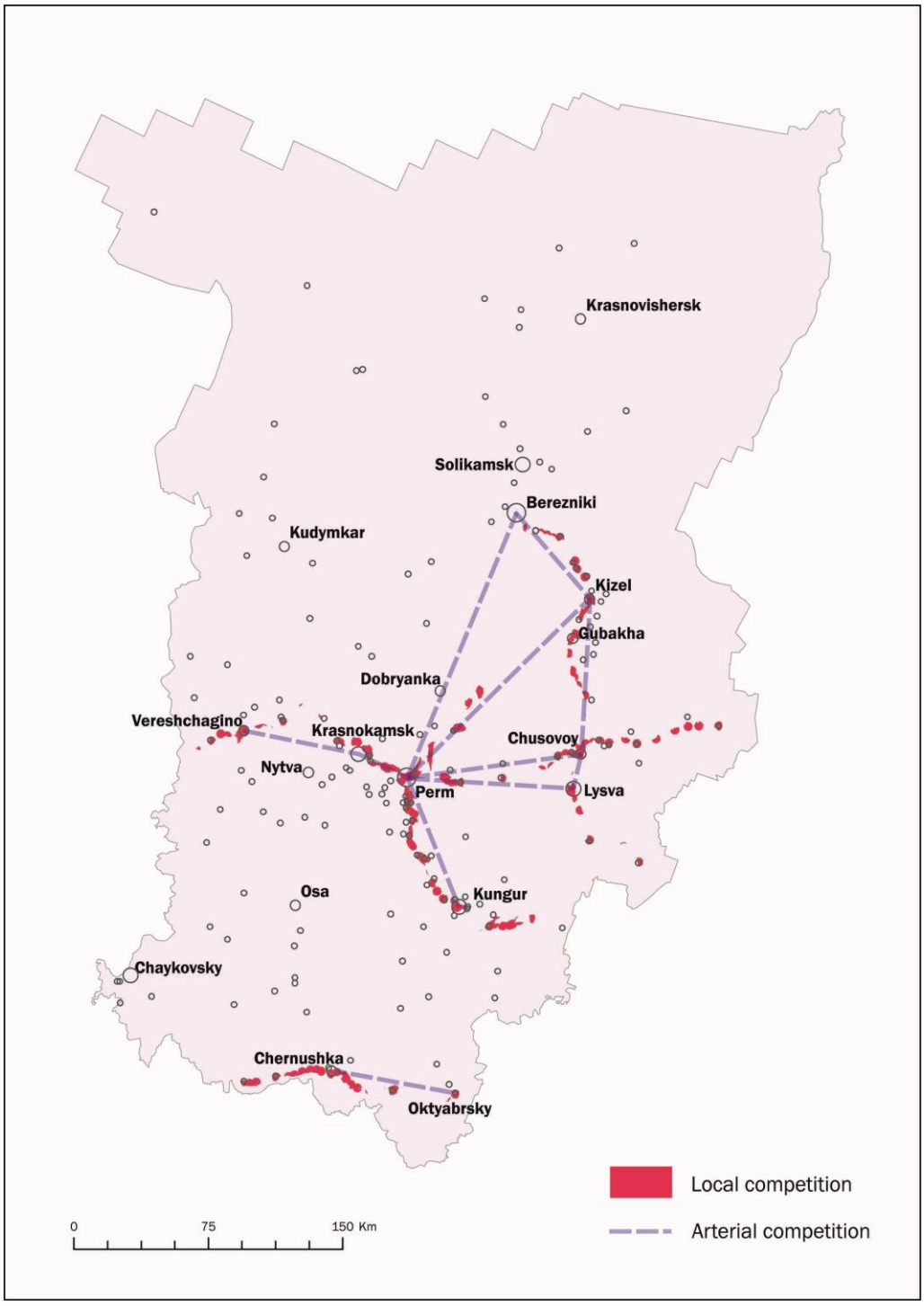

Fig. 6. Competition between bus and rail operators in Perm Krai

Thus the analysis of the spatial structure of regional public transport of Perm Krai has proved that the contemporary Russian regions are facing the same problems which appears in cities with demand oriented approach to public transport planning and management. These problems are:

1) presence of areas which are not served by public transport;

2) presence of competition between transportation modes;

3) usage of small vehicles and small number of hubs which allows using larger vehicles on the most popular segments;

4) absence of express routes.

During the last decades the previous regional transport management system has actually been abolished. The total market deregulation has led to the situation when the bus operators can get access to the routes through formal application without implication of any serious restrictions, and without the predefined route network. There is no single authority responsible for transport operators monitoring and control. These functions are currently divided between several bodies: Regional Energy Commission, National Road Traffic Supervision Administration, Main Directorate for Road Traffic Safety and regional Ministry of Transport. The rail transport operators have to follow the rules as bus operators do no matter that they are in unequal conditions. Such inequality is connected both with the specificity of infrastructure use and with the belonging to the white or grey zone from the taxation and legislative point of view.

For the defined problems the measures of spatial optimization of regional public transport system in Perm Krai are suggested. The measures are based on the practices of cities which employ supply oriented approach to transport planning and management.

Spatial Optimization of Regional Public Transport System in Perm Krai

Supply oriented approach suggests the introduction of so called trunk-feeder scheme of regional public transport system. These means the division of public transport routes into trunk (arterial) routes, feeder routes and combined routes, transfers between which are made within the hubs. Such scheme allows using larger vehicles on trunk routes due to demand concentration in hubs. It also becomes possible to organize express services on trunk routes with stops only in the largest settlements or in crucial nodes. On feeder routes stops are allowed everywhere. Combined route operates as trunk route on the most popular segment and as feeder route on other segments. Trunk-feeder scheme helps to avoid unproductive competition between public transport modes and creates background for using of each transport mode basing on demand volume and other factors. Centralized revenue redistribution between operators helps to cover all the population of the region with public transport services.

The timed transfer concept (or "time pulse transfer concept") also needs to be introduced. The concept requires that schedules are arranged in such a way that vehicles (buses and trains) on different routes meet at certain times at hubs to exchange passengers. The implementation of the scheme allows exchanging a larger number of passengers, and therefore serving a larger number of origin-destination flows by a lower number of routes. [Maxvell, 2003; Transportation Research Board, 1997]

Fig. 7 shows different types of the network structure depending on the transfer organization. Currently the regional public transport of Perm Krai corresponds to the monocentric type, while time-pulse transfer type discussed in the paper seems to be more productive one for the routes between several hubs taking into consideration the great distances. The high-frequency random-access grid can be successfully maintained only within densely populated urban core.

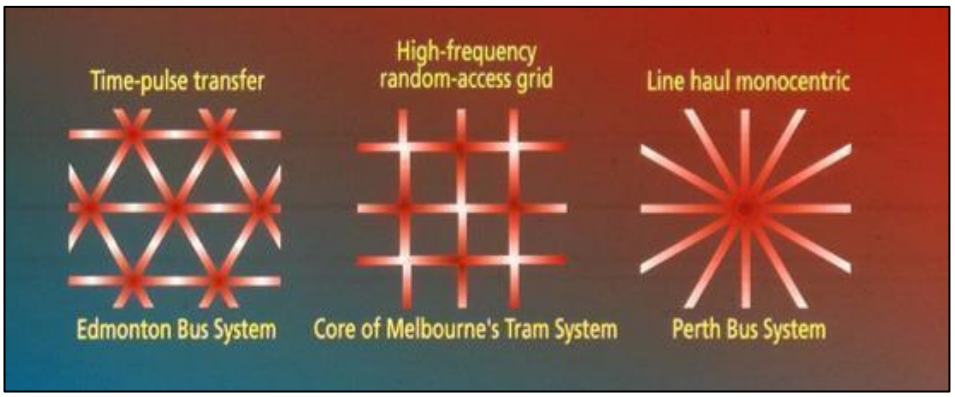

Fig. 7 Types of the network structure[5]

Trunk-feeder scheme for Perm Krai suggests organization of 5 levels of nodes: center of metro area, hub, sub-center, settlement and transfer point. The center of metro area is Perm – the largest city and administrative center of Perm Krai. Hubs are the key nodes and largest settlements. At the same time the hubs are the end points of feeder routes. Sub-centers are the existing local centers not included in the group of hubs. Settlements are all other settlements of Perm Krai. Transfer points are points where transfer can be made between bus and rail transport.

On the most popular segments of the network which links hub to the agglomeration center and with each other organization of express routes is suggested for both bus and rail transport. For smaller settlements the network of feeder routes connecting them with sub-centers and hubs should be developed.

The crucial requirement for system vitality is the coordination of timetables for feeder and trunk routes which helps to minimize transfer waiting time. This will reduce travel time and provide essential passenger volume for rail and express bus routes.

[5] Personal communication: Jeff Kenworthy, with material supplied by Dr. Felix Laube

Currently several routes in Perm Krai do operate in form of trunk and feeder system (buses serve as feeders for rail transport), but such cases are rare and do not form the coordinated system which is proposed.

The separate problem in spatial optimization of public transport system is the choice of hubs.

The choice of hubs should consider exiting settlement pattern, jobs location and strategic and planning documents.

In Perm Krai the following settlements should be considered when choosing hubs:

1) 12 most crucial transport nodes (Perm, Berezniki/Solikamsk, Gubaha, Gayny, Kudymkar, Kungur, Nytva, Chusovoy, Tchaikovsky, Cherdyn, Chernushka),

2) 11 local centers (Perm, Berezniki/Solikamsk, Kudymkar, Kungur, Vereshchagino, Oktyabrsky, Barda, Kizel, Chaikovsky, Chusovoy, Krasnovishersk),

3) 9 centers of services (Perm, Berezniki/Solikamsk, Kungur, Nytva, Tchaikovsky, Chusovoy, Gubaha, Kudymkar, Chernushka).

Currently among the settlements listed there are 12 which have transport supply greater than 20 thousand seats per week and more: Perm, Tchaikovsky, Berezniki/Solikamsk, Krasnokamsk, Kudymkar, Lysva, Nytva, Kizel, Gubaha, Vereshchagino, Chernushka, Kungur и Chusovoy. Around these settlements potential accessibility zones of 3-hour radii were built in (Fig. 8)[6].

For Krasnokamsk, Solikamsk and Lysva accessibility zones were not analyzed because they are overlapped by zones of Perm, Berezniki and Chusovoy and can be served from these centers. Other zones also overlap, but the overlapping areas are much smaller.

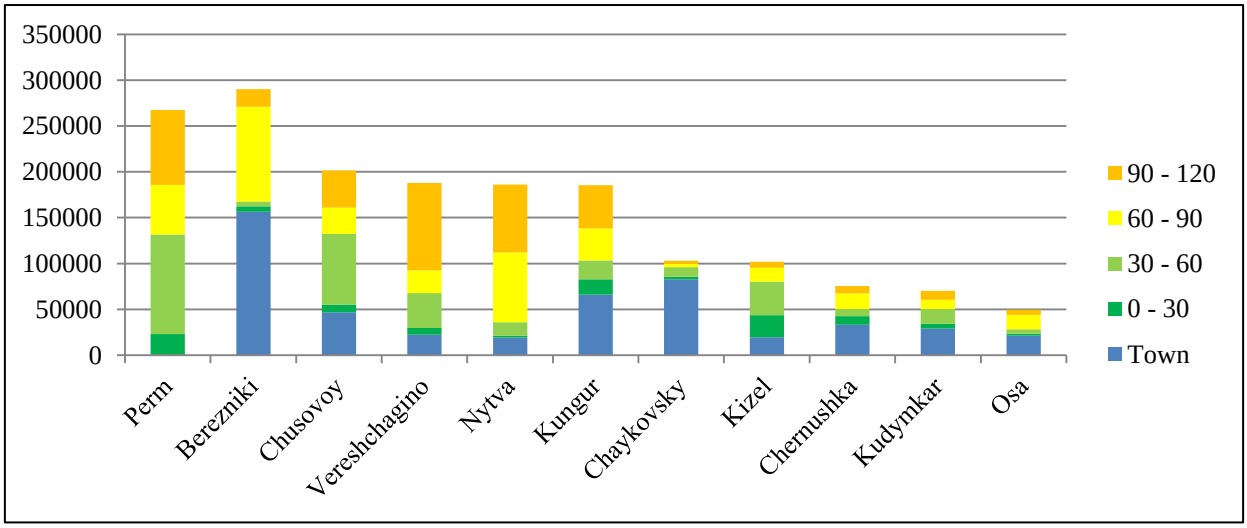

Fig. 8. Total population size within the potential accessibility zones depending on travel time (minutes). The population of Perm is not included.

[6] Average vehicle speed assumed to be 30 km per hour.

By aggregation of all the information above it is possible to appoint 9 hubs for regional public transport system in Perm Krai: Perm, Kudymkar, Chusovoy, Berezniki/Solikamsk, Kungur, Chernushka, Tchaikovsky, Kizel and Vereshchagino. The accessibility zone of each hub contains from 87 thousand to 340 thousand people. Osa, Barda, Lysva, Gubaha, Krasnokamsk and Nytva were appointed as sub-cenetrs together with existent centers of municipalities: Dobryanka, Ilyinsky, Krasnovishersk, Kuyeda, Gayny, Siva, Ochyor, Okhansk, Oktyabrsky, Chastyye, Uinskoye, Orda, Suksun, Beryozovka (Fig. 9).

There is also potential for rail station location optimization. The suggestions have been made to create one additional station, to eliminate one station and to change the location of 2 stations. In 2014 the new rail station was created in Perm at Popova Street as an implementation of the results of the research[7].

Reforming the Regional Transport Management System of Perm Krai

Two facts have to be considered when implementing the trunk-feeder system. Firstly, trunk and feeder routes are very different in terms of the income size while the costs are comparable. Secondly, it is very hard to control the operators' compliance with the requirements.

Thus the implementation of the trunk-feeder system is impossible without the creation of the appropriate legislative basis and the introduction of the necessary technologies which will help to solve the problems described.

There are two principal ways two organize effective joint work of the enterprises within the transport sector. The first way is the creation of the special authority (or enterprise) which will be able to organize and regulate the market. The second way is to organize tenders within the power of the existent authorities when the operator is given the right to organize at one time transport services at several routes some of which are trunk and others are certainly unprofitable. Both ways require the creation of the appropriate legislative basis which will provide regional authorities with effective instruments of monitoring and control.

The problem of transport operators monitoring currently is usually solved through the feedback mechanism – the analysis of the users' complaints. The technological development can make the control and monitoring easier and more effective. The satellite positioning systems and video monitoring systems can transfer information to the respective authorities. These will ensure the online monitoring of the vehicle position and registration of non-fulfillment of requirements and their reasons. The development and implementation of the respective technologies, the equipment of the vehicles and monitoring centers will require certain time and financial resources.

[7]Russian Railways. http://pass.rzd.ru/news/public/ru?STRUCTURE_ID=657&layer_id=3328&id=85501

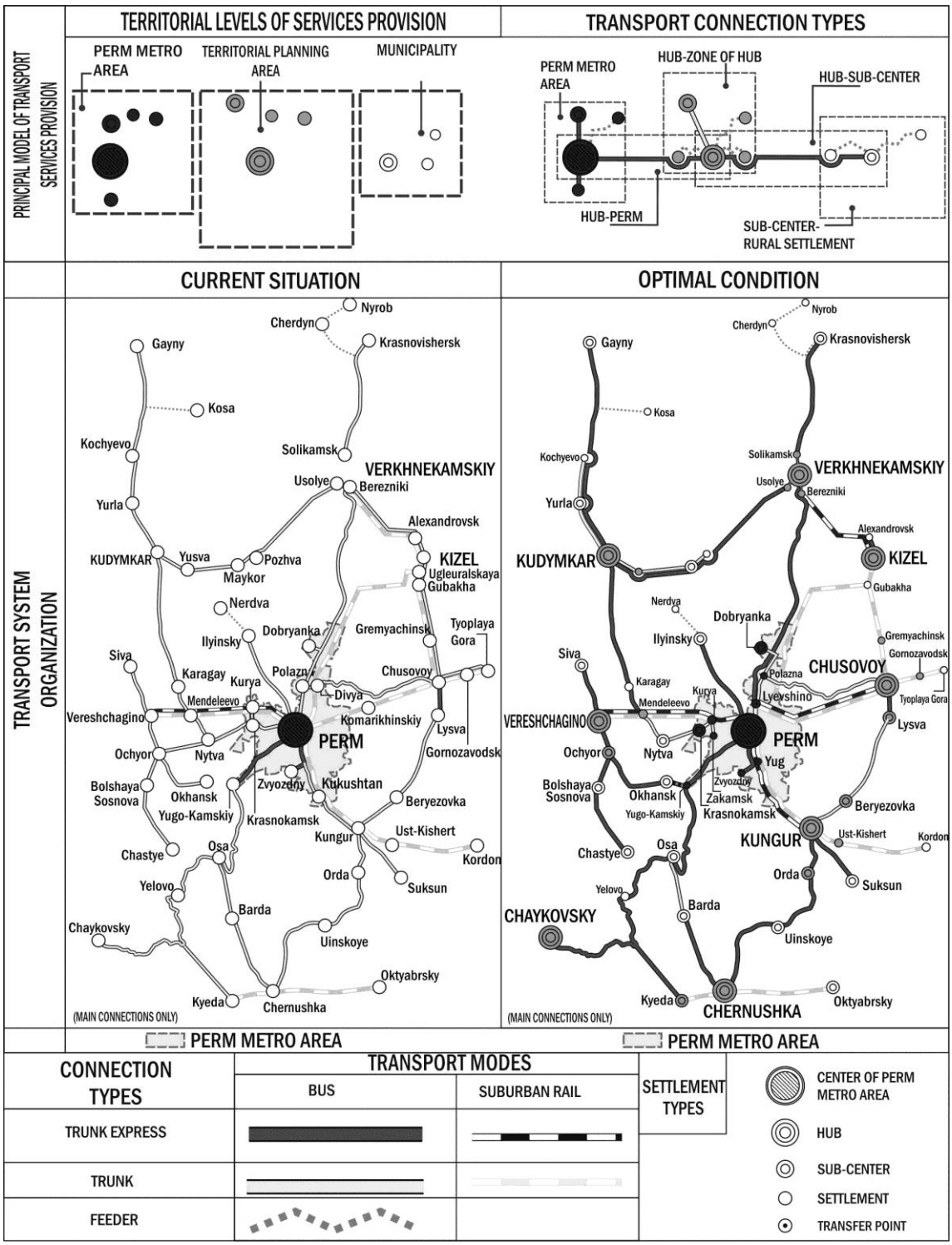

Fig. 9. Trunk-feeder transport system for Perm Krai

Ideally, the effective authority should be created which would be able to provide the transition to the new scheme of regional public transport organization and the monitoring of the program realization. The authority should have a real influence upon transport operators. The authority should also conduct the analytical support of the reorganization and make some amendments to the program basing on the practical experience.

The successful implementation of regional public transport bodies responsible for network design, control of operators and reallocation of income between operators on profitable and unprofitable routes can be observed in case of European countries, namely Germany, Austria and Switzerland, where they are named "Verkehrsverbund". The main aim of the formation of the Verkehrsverbund system was the improvement of the public transport quality as an alternative to the automobile. The research by Pucher and Kurth [Pucher, Kurth, 1995] has revealed the steady growth of public transport ridership in all case cities after the system introduction. The growth of ridership is explained by service expansion, better quality, more attractive fare structures and better marketing.

Zürcher Verkehrsverbund (ZVV) can serve as a good example of Verkehrsverbund system. The system is based on separation of strategic and operational tasks: the whole ZVV network area is divided into eight market regions with eight responsible transport companies. The transport companies ensure that regional operations proceed smoothly, timetables are maintained and budget guidelines are observed. Transport service providers are subordinate to this companies and area responsible for providing services on specific routes. The ZZV itself is accountable to Cantonal Government, municipalities are involved in timetabling and fares design (Fig. 10).

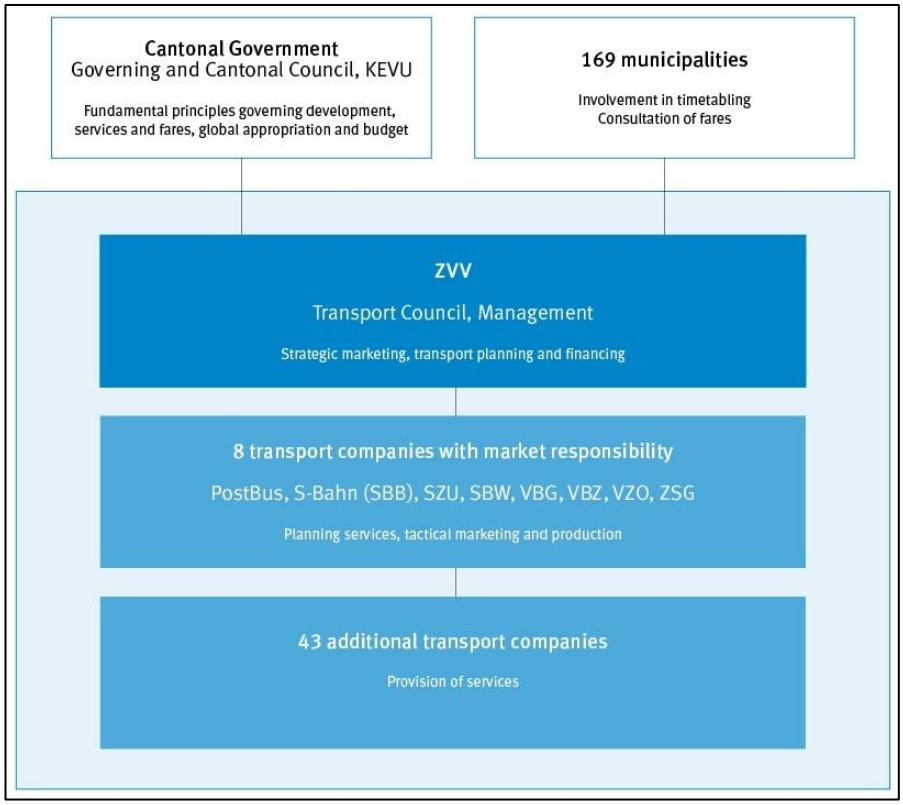

Fig. 10. Zurich regional transport management responsibilities and divisions of tasks [ZVV, 2015]

The Center for Regional Passenger Transport Management can become a similar authority for Perm Krai.

At the first stage of the Center establishment it is necessary to analyze all the reports which are currently provided by suburban transport operators. This will allow evaluating the compliance of current reports with the real transport monitoring requirements.

The following work of the Center should include the development of measures that will ensure cooperation of the authorities and the transport operators for strategic planning. One of the immediate tasks is the basic evaluation of the current regional public transport condition including its ability to comply with requirements concerning demand, accessibility, capacity and quality of service. It is also necessary to reveal the current risks and problems of the regional public transport which should be taken into account within the strategic planning process. The short list of the functions and specific measures can be the following points.

1. The in-depth analysis of the current situation, the defenition of the mission and vision for regional public transport, including:

— The creation of the extensive strategy of regional public transport development within the defined role and mission of public transport in the transport system of the region and with due regard for the main regional and federal strategic planning documents;

— The specification of the route network and the timetables. In 2014 «Perm Krai regional public transport route network development» was ordered by the region which is aimed at the route network optimization;

— The revealing of the fleet parameters and the analysis of the vehicles eligibility for the different conditions within the region. This will allow revealing the potential capacity of public transport and to evaluate its current usage.

— The development of the financial model for the current regional public transport market. This will allow evaluating the group of interrelated indicators characterizing regional public transport operators.

2. The establishment of the route network and the network of hubs. During the analysis it is necessary to reveal the sections of the network with ineffective competition, to develop the suggestions about trunk-feeder network organization with express services, to provide the quantitative criteria for hubs hierarchy development and for prediction and modelling of passenger traffic directions. In 2014 the express trains between Perm and Kungur and between Perm and Lysva were introduced.

3. The coordination of the timetables on different routes will make the usage of public transport easier for those passengers who need to make a transfer. The coordination of the timetables on different routes and transportation modes will provide a basis for the use of the

advantaged of the intermodal trips and will enable the introduction of the common ticket for different routes and transport modes (integrated ticket).

4. The integrated ticket implementation will improve the quality of intermodal trips because there will be no need to pay for the transfer and the transfer will become faster. The integrated ticket implementation will also lead to the financial transparency of transport operators.

5. The current optimization of the route network. There is a need for survey conduction and the development of the regional public transport basing on the revealed changes of the settlement patterns, trip directions, including the changes occurring as a result of the realization of the new infrastructural projects.

6. It is advised to employ the minimal transport standard to make regional public transport more effective. The minimal transport standard is a group of indicators of consumption of transport services by population and economic agents that eventually influence the level of economic development and the quality of live. The implementation of the minimal transport standard by regional authority (The Center for Regional Passenger Transport Management) will ensure the provision of certain level of transport accessibility to the people living in different areas of the region.

The minimal transport standard as applied to regional public transport should regulate:

— The level of transport accessibility and the level of public transport discrimination (including the existent frequency of service);

— The total time losses (hours per person);

— The safety requirements for vehicles used by transport operators;

— The requirements for emission control.

The minimal transport standard can become the crucial instrument for public transport provision in remote areas of the region. It should be considered within the development of transport schemes. The measures for the minimal transport standard implementation should be financed by the region and municipalities. The region should be responsible for the planning of regional transport system and its key elements.

Conclusions

Today there is a trend for liberalization of regional transport market in Russian regions and the aspiration for reducing public expenses on public transport subsidies. Usually regional public transport comprises bus, rail and air transport (in remote northern regions with insufficient level of road network development). While in developed countries the subsidies for public transport operators are usually explained by the necessity to provide the alternative to private

cars in the context of sustainable development, in Russian regions with low motorization levels the public transport is still the only available travel mode for the majority of the population.

The current model of regional transport services provision in Russian regions is independent operation of different transport systems:

- Public bus operators serving the most unprofitable routes which receive subsidies from the region;
- Private bus operators serving the most profitable routes (including services provision in peak-hours);
- Rail operators whose services are ordered by the region;
- Taxis uncontrolled by the authorities.

Regional authorities have been made responsible for financing and developing systems of regional public transport in Russian regions, but in current model they are mainly responsible for providing services on unprofitable routes in order to prevent social exclusion. There are no special bodies responsible for developing regional public transport networks, fare collection and redistribution and monitoring.

Thus the problems of regional public transport system in Perm Krai and in other Russian regions happen due to the absence of the government regulations and are similar to the problems observed in cities with demand oriented approach to transport planning and management:

a) presence of territories which are not served by public transport;

b) unproductive competition between different routes and transport modes which leads to lower service quality;

c) absence of express routes.

The spatial optimization of regional public transport system is possible which suggests organization of trunk-feeder system and convenient transfer points – hubs. The spatial optimization of regional public transport system will help to improve service quality. Introduction of additional financial mechanisms will help to extend the territory served by public transport.

The organization of trunk-feeder system requires certain changes in the management system of the regional public transport. The establishment of the Center for Regional Passenger Transport Management – the single authority for regional transport management can facilitate transport system monitoring and control, interaction with transport operators and provision of financing. The recommendations given in the paper are useful for the majority of the regions because currently the structure of the transport management system in Russian regions is rather uniform.

Annex: Images of Regional Public Transport in Perm Krai

Fig. 11. Bus transport: A- Bus Setra S215, B- Setra interior, C- PAZ 4234, D- PAZ interior

Fig. 12. Bus transport infrastructure: 1- Central bus station in Chusovoy, 2- Typical bus station (station «Gladkovo village» at Kungur-Beryozovka-Lysva line).

Fig. 13. Rail transport: 3 - Train type ED4 for electrified lines at a typical station outside urban areas (Nyar station 210 km from Perm), 4 - Train type RA-2 for non-electrified lines, 5 - Typical railway station with station building (Vereshchagino station), 6 - Typical railway station building interior (Yayva station, 260 km from Perm)

Fig. 14. Interiors of trains type ED4 of different classes: A- 2 class interior, B- 3 class plus interior, C- 3 class standard interior (the lowest class), D- 3 class standard with facilities for bicycles, E- Train type RA-2 interior

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