Cycling development in Moscow as part of the policy of sustainable development of the metropolis

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Abstract. Bicycle transport is a popular and promising means of transport in the largest cities, as well as the least developed in terms of business travel purposes. The paper substantiates the importance of developing bicycle transport infrastructure in the largest cities through the example of Moscow. The development of bicycle transport is inextricably associated with sustainable urban development and meets the goals of the VizionZero program, leads to the decrease in the use of individual motor transport, increases the physical activity of the population and also has a positive effect on the development of urban environment. The paper highlights the main purposes of the cycling movement of the population and emphasizes the importance of the development of business movement. The characteristics of the development of bicycle-transport network are given. The importance of the integrated approach in the development of a city is substantiated, including the development of a bicycle-transport network with provision of connectivity and safety during its construction. The problems of the development of cycling in Moscow are determined on the example of foreign and Russian cities, as well as strategies for the development of transport infrastructure. The value characterizing the quality of the network development in the city is determined presented by the length of cycle road network per 1 inhabitant. The main problems of the development of cycling transport in the city of Moscow are found and the prospects for the development of the bicycle transport network in Moscow are outlined through the example of the work of Moscow Transport Department and Moscow General Planning Research and Project Institute. The time spent on cycling along the selected routes is analyzed in comparison with car driving during rush hours in road network. As a result it is found that the time spent on cycling is lower compared to traveling by car. In addition, the possibility of developing a bicycle transport network in the red lines of Moscow road network is found. The authors put emphasis on the relevant character of the problem of social perception of cycling transport among the population and determine the directions for increasing the social approval of this type of transport.

1. Introduction
Nowadays more and more cities start to apply GreenMobility principles in their development. The main idea of this concept is to use environmentally friendly and safe means of transport, one of which is a bicycle. Therefore, the development of cycling infrastructure is the most important factor in the sustainable development of the city. At the same time, the Swedish program VizionZero is spreading in many countries, due to which the death rate on the roads is reduced. According to VizionZero program one of the main principles for reducing the rate of road deaths is to reduce the infrastructure for
movement by individual transport and develop a comfortable environment for pedestrian and non-motorized movement, the main means of transport is a bicycle.

In Russia there is also a “Road Safety Strategy for 2018-2024”, which provides a “zero tolerance policy for road deaths” [1], as well as a national project “Safe and High-Quality Roads” [2]. The purposes of the adopted strategies are similar to the VizionZero program, but the methods of their achievement differ significantly. The main objectives of this strategy are: improvement of control over road safety, development of first aid measures and security from road accidents, development of a system for fixing violations and improvement of road network. Thus, the basic principles of sustainable transport development and GreenMobility in the design of a new and operation of the existing road network are not included in the Road Safety Strategy of the Russian Federation, although road safety is inextricably associated with transport planning and urban environment design.

2. Materials and methods

The concept of sustainable city development is inextricably associated with the development of transport infrastructure. The integrated approach to its development includes the development of urban space not only for the movement of pedestrians, individual, public and truck transport, but also for cyclists. The integration of the bicycle infrastructure into the city transport framework will create a comprehensively developed transport system using alternative means of transport, as well as increase the physical activity of city residents and the comfort and attractiveness of urban environment.

There are the following purposes of cycling [4]:
- Leisure – the route length of such trips is 10-50 km;
- Business: can be both for the movement of the population from places of employment to residential areas at distances of 5-15 km and for small freight transportation.

In Moscow there are bicycle paths in almost every park, the development of a bicycle ring is included in the sectoral scheme of the bicycle road network of Transport Department [Figure 5], and there is already a pedestrian “green ring” in the parks of Moscow with a length of 160 km. This meets the need of Moscow residents in cycling trips for recreational purposes. Business routes are developed mainly in the central part of the city, it was there that the first bike paths and bike sharing stations appeared after the implementation of My Street program. However, in a city with a centripetal motion of the bulk of the population, combined cycling routes are practically not developed. This is due to the actual absence of bicycle road network in the middle and outskirts of the city, the lack of safe bicycle parking on the territory of the transport interchange hub and in places where people change from a bicycle to public transport, and in the territory of residents (courtyards, residential areas, residential buildings). Combined cycling have an untapped growth potential in Moscow and can become attractive for people outside of walking distance from high-speed off-street transport stations (more than 0.8-1.5 km).

According to Strava heat map of the activity of cyclists, we can conclude that the need for the development of cycling infrastructure is observed throughout Moscow. This approach was included during the creation of the branch scheme for the development of the bicycle transport network of Moscow (Figure 1).
Figure 1. Strava heat map of Moscow cyclists’ activity and BranchCycle Development Scheme developed by Moscow General Planning Research and Project Institute

The main features of cycling network include [6]:
- **Connectivity** – the provision of the ability to get to the destination via a continuous cycle transport network - the cycle and pedestrian network should be a continuous structure, connecting residential areas with destination objects. At the same time, the connection between residential areas and destination objects should be laid along the shortest routes.
- **Directness** – this parameter can be determined through the overrun coefficient (the indicator should be close to 1);
- **Possibility of free** transfer to other types of transport;
- **Safety** – in order to ensure this parameter, the following must be observed:
  - Reduction of conflict points – the intersections of the traffic current of cyclists with cars and pedestrians by separating cycle lanes and dividing flows. Mixed movement of cyclists and cars on the roadway is extremely unsafe due to the difference in speeds of at least 2 times. The reason is the high speed of vehicles with a “non-penalty” margin of 20 km / h, as well as the large width of traffic lanes, which allows car drivers to move comfortably at a speed of 60-80 km / h. Combining movement on pedestrian paths also entails the creation of emergency situations due to the difference in speed with a pedestrian;
  - limiting the speed of movement at intersections with other road users;
  - mutual visibility of road users, the visibility distance of a cyclist should be at least 10-30 m.

Only if these two basic features of the cycling network are ensured, it is possible to develop a convenient and attractive cycling infrastructure in the city.

In many foreign cities, due attention is paid to the development of cycling infrastructure. “The current leaders of the use of cycling are Holland, Denmark and Germany” [3]. Each of these countries has developed a special program for the development of cycling, which is different in its goals and objectives. Cycling rates in various cities are as follows: Amsterdam - 50%, Copenhagen - 33%, Munich - 17%, Berlin - 13%, London - 2%.
The formation of bicycle infrastructure in Stockholm began with the adoption of a program to develop the city bicycle network, providing the parallel movement of cars, cyclists and pedestrians. The city has a rental system called CityBikes. Bicycles are often used for excursions. This type of transport is popular among all segments of the population. Cyclists are regulated by the police. The popularity of this type of transport is justified by statistics: more than 60% of Stockholm residents use a bicycle for regular trips, every fifth Swede rides a bicycle daily to work, university or school, 18% use a bicycle during winter season. Cycle paths in the city are either separated by markings on the roadway, or laid along the sidewalk. Each house has a dedicated bicycle parking space.

The number of cyclists in Japan is constantly growing. In Japan, bicycles are mainly used for short distances. The principles for the development of Japan's bicycle infrastructure include the development of attractive routes, the creation of a comfortable and safe environment, information support, and the creation of an accessible environment.

The improvement of road safety is due to the development of cycling and the rapid bus system. Due to this, the death rate on the roads of the Colombian capital, Bogotá, has decreased by more than 60 percent.

In Brussels, the speed limit for cars in most of the city is 30 km/h. This limitation reduces road accidents and creates favorable conditions for the movement of cyclists and pedestrians.

The main goal of the development of cycling in London is to increase the physical activity of residents, improve public health and use this means of transport for short-term trips and transportation of small loads. Safe cycling routes for short-term and transit trips are being created in the city.

Cycling infrastructure must be adapted to any weather conditions, as in the Finnish city of Oulu, despite low temperatures, cycling is actively developing.

There are the examples of successful development of cycling infrastructure of city design in Russia. Almetyevsk is the first Russian city to create a full-fledged bicycle road network, taking into account the main parameters as connectivity and safety at the design stage. The city cycling infrastructure is built mainly separately from the roadway and sidewalks. It is planned to create a safe bicycle road network with a length of 250 km with the possibility of functioning at night and during winter season. The city has already equipped more than 600 bike parking lots.

According to the calculation data, a value was determined that characterizes the quality of the network development in the city, which can be the length of the bicycle road network per 1 inhabitant: London - 2.1 m/person; Oulu - 4.3 m/person; Malmo - 1.6 m/person; Almetyevsk - 1.6 m/person (after project completion).

Today in Moscow due attention is also paid to the development of bicycle infrastructure. Unlike foreign examples, the bicycle network of the capital is just beginning to form. 230 km of bike paths have been built: 90 km on the road network and 140 km in parks. Since 2015, Moscow cyclists have been allowed to use dedicated traffic lanes for public transport. Thus, the bicycle network is 773 km. Despite the impressive number of the cycle road network, it does not meet the requirements as it is discontinuous and needs to be carefully improved. The cycling infrastructure includes 1867 parking lots for 11656 spaces [5].

Today the total length of the city road network is 6064 km. Thus, the share of bicycle paths in Moscow road network is 3.8%, taking into account the allocated lanes for public transport - 12.8%, per one inhabitant - 0.06 m of bicycle paths.

The main purposes of the development of Moscow cycling network are to reduce the transport and environmental load, increase the mobility and physical activity of citizens [3]. For a number of reasons, Moscow is unlikely to develop as Amsterdam, where bicycles are the main means of transport, but with the proper development of bicycle infrastructure and the creation of the correct image of cyclists in the eyes of city residents, a bicycle can become one of the main alternative means of transport to a car, along with public transport. The residents of Moscow consider a car as an indicator of status and wealth. In order to change the attitude of the residents of Moscow to alternative means of transport, including bicycles, as not prestigious and unfashionable, it is necessary to conduct public and social campaigns.
The indisputable advantage of cycling is the ability to lay a convenient route along the shortest distance and the lack of attachment to the public transport schedule and traffic jams. According to the analysis, the time for cycling along the selected routes is often less than the time for driving a car during the rush hours of the road network. Moreover, in the areas with an existing cycle road network, the time for cycling is comparable to the time for driving a car, even during off-rush traffic hours.

Figure 2. Comparative options for the routes of car driving and cycling – the 2nd Brestskaya Street - Meshchansky district

Figure 3. Comparative options for the routes of car driving and cycling – Arbatskaya Square - Chistoprudny Boulevard

Route: the 2nd Brestskaya Street - Meshchansky district (4.3 km) is shown in Figure 2: travel time by car (without traffic jams) - 14 minutes (6.4 km); Cycling time: 11 minutes (2.6 km).

Route: Arbatskaya Square 14, building 1 - Chistoprudny Boulevard (4.3 km) is shown in Figure 3: travel time by car (without traffic jams) - 16 minutes; cycling time - 17 minutes.

Accordingly, during rush hour driving by car will take no less time than cycling. In addition, cycling, due to its maneuverability, allows reducing the distance between objects.

In comparison with a car, a bicycle has a number of advantages: a daily bicycle run of 2.5 km saves 180 liters of gasoline and reduces carbon dioxide emissions by 495 kg [8]; 1 parking space places 10 bicycles.
Figure 4. Scheme of the existing Moscow cycling network [11]
**Figure 5.** Scheme of the existing Moscow cycling network
Analyzing the existing position of the network of bicycle paths, there is a lack of structure and connectivity of the districts (Figure 4). Today, the share of leisure trips in Moscow is higher than business trips, due to the development of cycling infrastructure in city parks along the embankments. Despite this, during warm season, bicycles are actively used by couriers throughout the city, as well as by office workers and residents in the central planning zone of the city.

In Moscow, it is possible to arrange bicycle paths within the red lines of the road network along the existing streets, which have room for development, thus meeting the demand of Moscow residents for cycling. Through the example of Bashilovskaya and Chasovaya streets, it can be seen that the organization of cycle lanes is possible by reducing the width of the greening strip, the pedestrian area or narrowing the strip of the mainline (Figure 6). Along many Moscow streets there is a reserve for organizing bicycle lanes separately from the mainline and sidewalks [9].

The development of cycling infrastructure has a positive impact on other spheres of human life: social, transport, environmental.

Thus, the development of the city cycling network will meet the basic principles of sustainable development of the city and the trends for zero death rate - Vision Zero and will accelerate the achievement of the goals set within the framework of national projects Safe and high-quality highways “Road safety strategy for 2018-2024” and the national project “Safe and Quality Highways” [10].

3. Conclusion
Cycling is an integral part of the city transport service system, which is a necessary factor to increase the mobility of citizens and the share of personal and business trips on environmentally friendly transport. It leads to a balanced transport mobility of all population and also provides the accessibility and connectivity of territories, which is important for Moscow, so as in the metropolis there are many natural and man-made obstacles.
For effective work of Moscow cycling network the following is necessary: the development of cycling infrastructure, which primarily ensures the connectivity of the cycling network, providing safe conditions for travel, popularization of cycling - regular monitoring of the attitude of citizens to the level of development of cycling infrastructure is necessary, a policy for the development of cycling, the development of a public transport system, the organization of free transfers to other types of transport, the development of a system of intercepting parking lots for cyclists.

Thus, providing residents of megalopolises with high-quality, high-speed public transport, as well as a developed cycling and pedestrian infrastructure, will be the reason for citizens to prefer environmentally friendly and sustainable means of transport rather than personal car.

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