Managing smart-city transportation planning of “Park-and-ride” system: case of Moscow metropolitan

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Abstract. Modern trends in smart city development mean the priority of technological city transport infrastructures and control systems aimed to meeting the ever-increasing demand for mobility of a rapidly growing population as well as the needs to decrease traffic congestion. The world major city urban agglomerations have already accepted the intermodal techniques for transport service development which demonstrates strong potential for improving quality of transport services and reduction of spent trip time. The article presents factors with regard to the formation of “Park-and-Ride” system as part of an urban intermodal system that offer variety of transportation options and enable people to switch from a personal car to public transport. The article provides the Model of access control to the arterial road and city street network through the interception of personal vehicles. Such Model defines the main outcomes and advantages of the “Park-and-Ride” system on the territory of wide Metropolitan areas. The researches were done collecting and analysing current data of the Moscow agglomeration pursuing technical and commercial results. The aim is to improve transport imbalance in the distribution of passenger’s mobility between different city transport modes with priority use of passenger transport. Implementation of the proposed model within the concept of smart city will generate an intelligent transport system, which will allow for traffic flows optimization as well as for contribution for sustainable urban development.

1. Introduction
An intensive and fast population and economic growth undergoing recently in Moscow agglomeration calls for and causes the concurrent process of its transportation system development [1,2]. Globally, the main task of the smart city consists in effective improving quality of urban life intending to build a sustainable transportation system by means of reasonable optimization and extension of transportation process[3,4]. Current researches and analysis on metropolitan transportation systems from both demand and supply perspectives, make transportation-related planning institutions and policymakers of Moscow highlight the development of intermodal population mobility as the most effective way to meet the requirements for effective transportation service on the wide area of the Moscow Metropolitan area [6]. Aimed at increasing transit capacity and the number of combined public transport trips, this approach serves interchange between different modes of passenger traffic as well as between auto and passenger transport. For transit trips, the public Transport Transit Hub (TTH) in Moscow is a place of the densest concentration of passengers in terms of interconnected activity, so the quality of the services it produces becomes the main aspect for combined trip making. It is believed by the authors of the work, that integration of «Park-and-Ride» facilities as a part of a TTH
addressed to rise and accommodate the demand of car owners for transfer from individual car to high-speed passenger transport modes to make journey-to-work trip, can solve the complex of transportation problems in a sustainable-minded way [7,8].

At present, the system of «Park-and-Ride» facilities already exists on the territory of Moscow agglomeration. Like any other new plan, it still has deficiencies, lacks visible effective-ness and needs correct maintaining, renovating and expansion. This, according to the authors, requires a scientific approach conducting a thorough study on the Moscow agglomeration transportation process using the methods of system analysis aiming to develop the Design concept of the “Park-and-Ride” system as an integral component of the city transport policies [9,10].

In that way, the main task of presented research is to determine the place of smart technologies in the issue of implementation of “Park-and-Ride” facilities into transportation system of agglomerations [11].

2. **Methods**

This research study was based on the application of the scientific method of system analysis for the problem of “Park-and-Ride” as a part of transportation system of agglomerations. Also, the study is based on the basic principles of the theory of planning of transport demand and supply, which allows to assess the need for the implementation of the PP project [3,6].

These approaches provide a multifaceted view on the problem from the perspective of the principles of sustainable urban development, reflected in the implementation of the basic functions of “Park-and-Ride” facilities according to the classical principles of the sustainable concept: trinity of social, economic and environmental aspects [13]. Simultaneously, the priority is to fulfil the transport function of “Park-and-Ride” that contains in the satisfaction of demand for combined travel type “private car – passenger transport”. Let’s consider the main groups of “Park-and-Ride” facilities goals.

The goals and objectives of the «Park-and-Ride» facilities have many pressing planning issues at every level of urban transportation planning, design, construction and operation policies (fig.1). The development of the concept foundations of any transport service on the territories of a big city or a metropolitan area, determines the effective interaction of a facility being civic organization with external economic, politic and social institutions as well as with adjacent transport and urban infrastructures [13,14].

The strategic approach to the design and construction of a «Park-and-Ride» facility system should be based on its perception as a nodal point which links two transport modes: private auto and public transport, and it is recommended to be considered at several levels.

At the transport level, «Park-and-Ride» facility is involved in the process of arterial road access management and causes the redistribution of traffic flows addressing congested areas inside the city. So, it is able to facilitate intermodal transfers and traffic situation on the whole by intercepting part of the car flow on «Park-and-Ride». In this case car owner have to transfer on public transport. As a consequence, it will be increased the mobility of population on passenger transport and so solved the problem of transport congestion [9,13].

On the social front, «Park-and-Ride» facility is the civil organization embodying social equity and providing specific and accessible service for all categories of car owners including handicapped and senior ones [6,8]. Its uniqueness is in offering a trip choice for the car owner and offering the alternative to personal car. In this case, «Park-and-Ride» improves quality grade of population transport nation service that can be evaluated by some certain subjective perception parameters, such as: reduction of the trip difficulty, decreasing of trip cost, increasing of trip com-fort and security conditions.

On environmental protection side, «Park-and-Ride» should limit the number of vehicles providing lower emission and energy consumption [9,10]. It is to take into consideration also the negative impact on the territory of transport transit hub and surrounding area caused by increasing intensity of
Figure 1. Goals and objectives of «Park-and-Ride» system

car traffic, but it can be compensated building green infrastructures including landscapes and open
spaces that conserve ecosystem.

On economic side, «Park-and-Ride» system definitely is able to stimulate city economy by way of
increasing and improving the quality of population mobility [14, 15]. Here, the main task should be to
ensure effective and efficient managing of «Park-and-Ride» creating attractive loyalty programs
through effective strategic management techniques aimed at goal settings to ensure and optimize the
demand for «Park-and-Ride» facilities.

The lesson learned from the nowadays experience make it clear that the problem of «Park-and-
Ride» system inefficiency lies in its complexity and it is required an integrated multi-disciplinary
approach to determine the overall strategic concept for system operation which takes into account
every side of the matter.

Transport behavior of the Moscow agglomeration residents can be typically characterized. Every
day about 1 million of people travel from the agglomeration periphery to the core of the city. Current
statistics show the following trip distribution: overall, 30% of trips are made by personal car and 70%
trips are made by public transport. Despite the predominance of passenger transportation mode, the
problem of transport congestions on arterial road network caused by insufficient road density still
remains actual. There is an urgent need of the instrument permitting to solve the problem. This is
where «Park-and-Ride» facilities come into play redirecting a part of car owners to public transport
concentrated in transport hub. Figure 2 provides a projected concept model of «Park-and-Ride». It is
based on:

- the analysis of settlement system of the Moscow agglomeration settlement system;
- the analysis of street and road network transport planning structure;
- the analysis of the residents’ transport behavior.
The model provides for displaying the work of a «Park-and-Ride» facility and reflects the most effective way of its operation. Imposition of this model on a «Park-and-Ride» facility will determine the complex of policy decisions and transport planning activities addressed to reach the best results in achieving of its aims.

3. Implementation

The developed Concept defines the main approach to the «Park-and-Ride» system formation based on the consideration that every facility is integrated in various urban and transport activities. Closer consideration of how «Park-and-Ride» interacts with adjacent infrastructure objects will allow recognizing appropriate project solutions addressed to reach the best operational concept model. Let’s consider all of them.

«Park-and-Ride» as a part of Public transport transit hub.

The interrelation between «Park-and-Ride» and public transport hubs system is obvious. In fact, «Park-and-Ride» can be defined also as a subsystem within the TTH. On the one hand, as it is not involved in the transferring process between different modes of passenger transport, it can be

![Figure 2. Concept model of «Park-and-Ride» facility](image-url)
So, the effective functioning of a «Park and Ride» facility claims for planning design solutions matching the composition of a TTH. More than that, it is required also to ensure inter-connection with the external systems in order to provide both

- easy access from the road network and
- easy access from a parking to public transport. that provides by the quality of the hole TTH

The first task requires revision of the existing entrance traffic schemes taking into account eventual congestion of roadways due to the additional flow of cars. The second task is provided by the general quality level of the TTH structure.

High quality of these internal and external interactions provides for the effectiveness of «Park-and-Ride» and ensures the number of objective functions addressed at sustainable development of urban areas, such as:

- social service, convenience and safety which determines consumer loyalty;
- TTH spatial structure relationships with associated elements that determines the quality and environmental safety of the entire public space of the hub;
- transport transfer function consisting in interception of the car flow directed to the center of the city — the node of an employment gravity of the population, and subsequent transferring to high-speed public transport;
- organization of commerce that attracts customers and causes development of investment potential of the TTH.

3.1. «Park-and-Ride» as a part of passenger transport system

All over the world «Park-and-Ride» is considered to be an integral infrastructure part of passenger transport and, therefore, it requires the coordination of interior operation processes. This includes:

- availability of passenger transport providing maintenance of «Park-and-Ride» facility, with minimum parameters of traffic intensity, network coverage, comfort of rolling stock;
- availability of required infrastructure elements, providing transfer from a private car to passenger transport: pedestrian communications, payment terminals, fronts the landing, etc.
- implementing of special tariff policy to ensure the unity of the passenger transport system and the formation of economic conditions to attract passengers.
The strategic goal of the «Park-and-Ride» facilities as an infrastructure object of passenger transport is to increase the share of passenger users in the structure of population mobility.

«Park-and-Ride» as an element of road network

«Park-and-Ride» facilities are a part of the road traffic access control policy. It is an infrastructure object integrated in spatial city structure in those areas where they can provide the intercepting of a part of transport flow directed to the city center from residential areas of metropolitan area. It provides good opportunity to solve transport congestion problem on the level of urban planning policy by way of advancement of intermodal trips. The main aim is to ensure coordination of traffic access control management with «Park-and-Ride» system. Several key measures include:

• optimizing «Park-and-Ride» location on urban territories to match access control policy aims;
• maintaining, renovating and expanding road network to redirect traffic flow to «Park-and-Ride» facility until the entrance to the centripetal arterial road;
• providing promotion, information support, management policy, administrative and other activities to attract people to «Park-and-Ride» facility.

The strategic goals are the redistribution of traffic flows on the road network to reduce its workload and, as a consequence, to improve existing transport in morning and evening rush hours.

3.2. «Park-and-Ride» as a part of urban parking space

The organization of parking spaces in cities is one of the most complex social, environmental, transport, spatial and administrative tasks. «Park-and-Ride» is a special parking lot placed in public transport hubs and it plays a specific role in the process of spatial organization of the urban territories. The existing parking restrictions in the city center make city authorities develop alternative trip solutions for car owners. «Park-and-Ride» is one of the smooth methods to limit the number of car vehicles in the city center by way of providing off-city-center parking. So, «Park-and-Ride» acts as a compensatory parking space located in transport transit hub. To coordinate a unified system of city parking spaces management it is required a unified policy including administrative arrangements, for example, a unique parking tariff policy. The main goals of «Park-and-Ride» as a part of urban parking place are:

• control on parking behavior of car owners;
• meeting the demand of car-owners by creation of public parking system;
• improving quality of urban spaces in the city center.

3.3. «Park-and-Ride» as a part of social service industry

The main aim of urban management is to provide a vitality of the cities and in terms of transportation system arrangement means to provide high level of population mobility that today should be impossible without efficient, modern, high-duality urban transportation system. To manage population mobility and, as a consequence, to maintain business activity and economy in megaliecities and agglomerations it is critically important to develop multimodal connection as it is the only effective way to solve typical megalopolitan transport problems. In this aspect, «Park-and-Ride» facility plays the important social service role offering car owners the possibility of the trip alternative to private car and providing for the following:

• lower difficulty of daily labor trips to the focus of the employment gravity in city center;
• lower costs and monetary savings to commit everyday travel;
• possibility to use public spaces and services, located in transport hub.

To attract users, «Park-and-Ride» must meet such quality specifications as:

• free access;
comfort and security conditions for transferring and using accompanying services in a transport hub;

security car parking at «Park-and-Ride» lot during the day.

The quality of “Park-and-Ride” service is able to reimburse the owners the psychological and physical damage caused by implementation of road access policy and city parking restrictions on the territory of city core. That is the key issue of the city social-orientated policy.

4. Discussions
The relevance of the scientific research in the field of “Park-and-Ride” system development as a part of the transport system of metropolitan areas is very relevant for discussion in large cities and agglomerations in Russian Federation. Successful experience of implementation of such systems in European, American and Asian practices allows authors to conclude that it is necessary to discuss this issue at the stage of development of official transport concepts of urban development [9,10,11]. There is a request to develop this theme from authorities of regions of Russia and, in particular, the city of Moscow. The aim is to develop scientific grounds to make the right management decisions. This research is a part of the work on the scientific study of methodological approaches for sustainable development of transportation systems of agglomerations carried out as part of the scientific activities of the “Urban planning” Department in NRU MSUCE.

5. Results
As author’s original results of the study, relevant to the Russian Federation and representing the new domestic experience can be emphasized:

1. The original systematic approach to the formation of “Park-and-Ride” systems aimed at the implementation of the principles of sustainable development of urban areas;
2. Proposals on the organization of operating of “Park-and-Ride” systems taking into account principles of smart city in order to manage urban mobility of the population;
3. The multicriteria approach for strategic assessment of “Park-and-Ride” system purposes with the features of the development of monocentric structure of the Moscow Metropolitan area.

6. Conclusions
The approaches developed by the author allow to generate system of views on the organization of PP. The results of the study can be applied in:

- Development of the General Concept of «Park-and-Ride» system design for planning and managing intermodal transport service system in large cities and agglomerations.
- Development of normative and regulatory documentation for planning transportation systems.
- Decision-making for parking lots within the structure of transport hubs.
- Development policies in urban transport, street-road network access control policy, planning territorial schemes for transport infrastructure.
- Evaluating the influence of «Park-and-Ride» on economic, social, environmental city programs aimed at sustainable development and improving the quality and investment attractiveness of urban areas.

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