

# Management in the Model of Transport Behavior of Metropolis Residents Using the Concept of «Mobility as a Service»

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**Abstract.** The article discusses the era of maximizing road connectivity receding into the past, giving way to the broader challenge of creating livable, cost-effective, socially healthy and environmentally sustainable cities and metropolitan areas. A metropolis is defined as a “supercity”, the largest form of settlement and the highest link in the urbanization process, one of the main criteria of which is the rapid development of communications in general, and transport in particular. A modern metropolis is highly dependent on an efficient transport system, which ensures its livelihoods through the delivery of goods and provides the population with access to resources, jobs and residential areas. The effective mobility of economic development of cities and agglomerations, which are the locomotives of the modern economy, is considered. The extensive development of the transport systems of megalopolises through the construction of new roads becomes ineffective, since the increase in the number of private cars outstrips the pace of road construction. The paradigm of urban development in the 2000s changed from a “city for cars” to a simple, at first glance, “city for people” paradigm, and mobility was also considered.

## 1 Introduction

In the modern sense, the efficient transport system of the city provides a high level of mobility of residents, i.e., it guarantees the ability to get from one point of the city to another safely, quickly, comfortably and inexpensively [2].

The new paradigm of urban development implies the creation of a comfortable and safe environment in the city to ensure a high quality of life for all groups of citizens and meet their daily needs, one of which is the need to move around the city.

The steady growth in the popularity of personal vehicles led to the fact that in the period from 1940 to 1970 the number of cars in the world increased sixfold, reaching 250 million cars [15]. According to the International Organization of Automobile Manufacturers, in 2010 this indicator for the first time crossed the milestone of 1 billion cars, and today the global number of cars is estimated at 1 to 1.2 billion cars [15].

The increase in the number, length and duration of congestion on the roads of megalopolises negatively affects the ecological situation in cities. The impact of road transport on the environment is very significant, since transport acts as the main consumer of energy, and burns most of the world's oil [9].

Transport pollution of the atmosphere accounts for more than 70% of the gross emission of harmful substances into the atmosphere. These harmful substances, including carcinogenic ones, create hazardous concentrations that are much more dangerous than industrial and energy pollutants, since they are released in the area of direct human breathing [6].

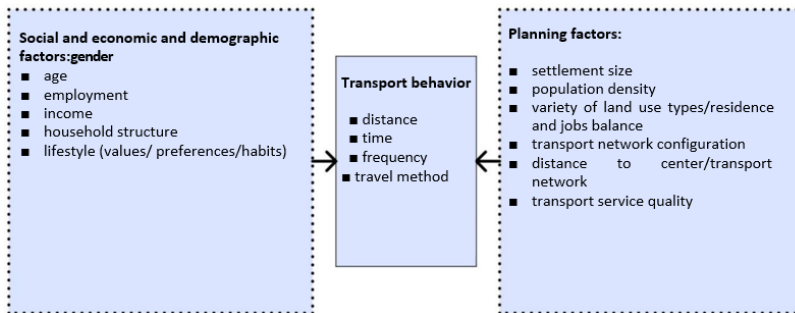
According to WHO experts, road transport will continue to make a significant contribution to air pollution in the next decade. It is estimated that 100 thousand deaths per year in cities of the European Union can potentially be associated with air pollution [6, 9].

## 2 Results and discussion

Today, there are two main tasks of the transport system: the need to transfer the maximum number of people in the most economical and acceptable way and to ensure the safety and stability of all elements of the transport system [4]. Particularly, it should be noted the need to maintain a high quality of life, which requires the creation of comfortable, hygienic and healthy travel conditions for users with different transport behavior.

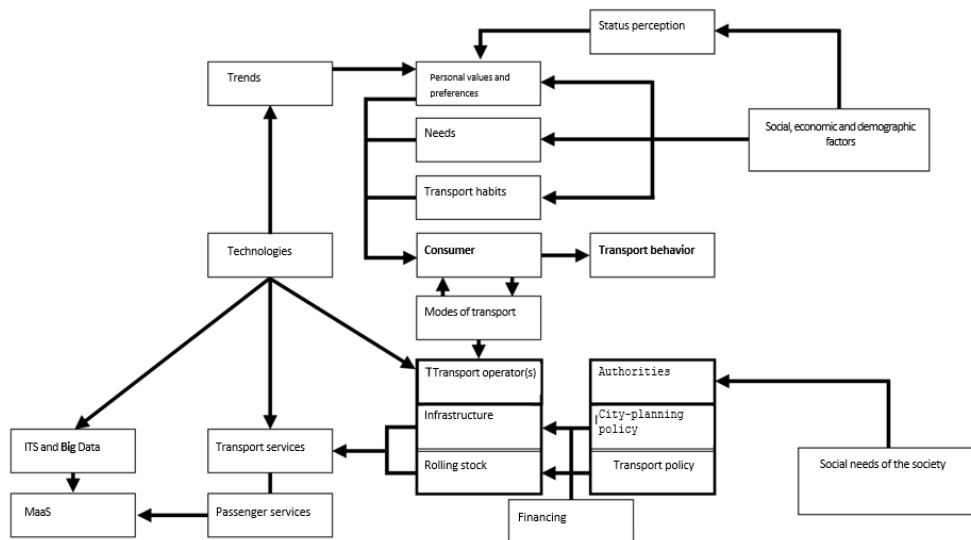
Transport behavior is a set of actions performed by an individual during transport movements [10], as well as a set of mobility scenarios characterized by a mode of movement and quantities that can be quantified: the duration of the trip (correspondence), the distance traveled, and others [7]. However, from the point of view of psychology, behavior is a reaction to internal and external stimuli, which can be irrational, stereotyped and be a consequence of the situation. Thus, in accordance with the author's definition, transport behavior should be understood as a set of reactions and actions of an individual performed during transport movements in various conditions and situations.

The transport behavior of an individual is influenced by many factors. Previously, experts divided these factors into two groups: social and economic factors and demographic factors, and planning factors, as shown in Figure 1 [7].



**Fig. 1. Social and economic factors, demographic factors, and planning factors.**

However, according to the author, the transport behavior of a metropolitan resident is also influenced by other factors that add up to a multifactor model of transport behavior, in the center of which is the consumer of transport services. This model is shown in Figure 2.



**Fig. 2. Multifactor model of transport behavior.**

When moving around the city, a consumer, first of all, interacts with various types of transport, choosing between the available alternatives presented in the city: a personal car, short-term rental (car sharing, bike sharing), public transport (metro and various types of land transport), taxi, means of individual mobility (scooters, bicycles, etc.) and active movements (on foot).

The basic need of users in this model is the need to move from point A to point B in the most optimal way for them, which they choose based on the physical, legal and financial availability of certain modes of transport, as well as their own preferences, which are formed on the basis of the available current information, the previous experience and perception of the quality of movement on various types of transport.

The process of choosing a vehicle depends on the combined influence of external and internal factors.

Speaking about internal factors, first of all, it is necessary to highlight social and economic and demographic factors, such as gender and age, as well as employment and income level, which shape the needs, personal values and transportation habits of an individual user [7].

Speaking about the influence of gender, it should be noted that according to studies, among residents of the largest cities, 45% of men named a private car as the main means of transportation, while this percentage is only 10% among women [7].

Age also affects the use of transport. It is believed that users of working age are more likely to use private cars, which is primarily due to the presence of a car and driver's license, as well as to income and employment. However, the trend is gradually changing. Thus, according to the State Traffic Safety Inspectorate, the popularity of obtaining a driver's license has been steadily declining since 2014. By 2017, the total number of people who received the driver's license in Russia decreased by one third compared to the previous year and reached a minimum of 1.33 million people [12]. The decline in popularity among young people is especially noticeable. The total number of issued driver's licenses to people under the age of 25 decreased by 14%. Moreover, the greatest drop in popularity is observed in the age group of 16-19 years: the share of people who have received driver's license for the first time in this age group has decreased by 32%. The declining popularity of driving is a worldwide trend. Even in the United States, where the level of motorization

is the highest among large countries, over the past 40 years the share of adolescents with driver's license has halved [16].

Employment is also a significant factor, since the working population commits more and longer trips through regular movement between work and residence, while households with higher incomes generate more trips in general, and by car in particular.

Furthermore, the need to move is associated not only with work. Movements can be either regular (to places of work, study and various social facilities, including clinics, schools, kindergartens), or irregular: to places of leisure, large shopping centers, sports centers and other city locations. The purpose of the trip has a significant impact on traffic behavior. Thus, when traveling on a regular route, a user tends to choose the most financially affordable and fastest route, which saves on the cost of travel and travel time, but in some cases, most attention is paid to other indicators: comfort, safety, convenience for low-mobility users, etc.

Personal values and preferences, which are formed based on the perception of the status associated with a certain mode of transport and current trends, have a significant impact on the user's choice. Thus, during the years of active economic growth in the twentieth century, a personal car became more affordable in most European countries and the United States, which made this type of transport a very popular way to increase individual mobility. Initially, this did not cause significant transport and social problems, since the number of cars in some cities was far from critical, and did not lead to congestion, high gas pollution of the environment and significant time delays. A private car was seen as a comfortable way to get around the city quickly, since the public transport system was not sufficiently developed to provide a high quality ride, which is especially typical for remote areas and suburbs. A private car was perceived as an indicator of well-being. However, over time, the car has caused environmental, health and social problems. Today, more and more attention is being drawn to the issues of environmental protection, irrational consumption, sedentary lifestyle and related diseases. Modern trends for a healthy lifestyle, shared consumption and care for the environment are forming new values and more rational transport habits.

In accordance with the author's definition, a transport habit is an established complex of individual preferences, which in certain situations influences the choice of a vehicle for moving around the city. The formation of transport habits is influenced by the subjective perception of a particular type of urban transport, previous experience of use, as well as the actual availability of various types of transport. Transportation habits are easy to follow when there are several similar routes from point A to point B. Based on personal ideas, users will choose the most attractive and understandable option for themselves, and the choice will not always be rational and independent.

However, of greater interest is the relationship between transport behavior and external factors, since it is they that offer levers of influence on the transport behavior of urban residents [7].

The work of the modes of transport presented in a particular city is carried out by transport operators of certain infrastructure and using a certain fleet of vehicles, rolling stock, which, accordingly, reflect the urban planning and transport policy of the city authorities, implemented taking into account the social needs of society.

Urban planning policy has significant historical prerequisites. Thus, by the type of infrastructure and appearance, cities are distinguished with a high priority of the car and a balanced transport system. Cities with a high priority car (Los Angeles, Dubai, Riyadh) are more adapted to travel by private car, rather than public transport, on foot or by individual mobility. Such cities are characterized by a low population density, significant distances between buildings and their remoteness from places of residence of citizens. In cities with a balanced transport system (London, Paris and many other European cities), active

movement and use of public transport is easier and more efficient than a private car, since high building density is a natural barrier to widespread car use.

As mentioned earlier, the rapid economic development and development of the automotive industry led to a rapid increase in the total number of cars in general and a sharp popularization of the car as a comfortable means of transportation, which, in turn, caused global transport, environmental and social problems in most of the largest cities in the world. Today, the transport policy of the city authorities is aimed at establishing a balance between different modes of transport, creating comfortable and safe conditions for movement, as well as reducing the carbon footprint of transport. This is done by replacing the obsolete rolling stock with modern, environmentally-friendly vehicles and financing green transport initiatives [17]. Thus, in many countries (Norway, Sweden, France, China) there are tax incentives for the purchase and maintenance of electric vehicles. Moreover, many cities and entire states declare their intention to abandon the use of transport on internal combustion engines in the very near future. Thus, the authorities of Paris, Madrid, Athens, Mexico City and the Norwegian authorities declare that they will abandon the use of transport with gasoline engines by 2025, and the rest of the cities of France and the United Kingdom will follow suit in 2040 and 2050, respectively [13, 17]. The implementation of the plans will require significant investments from both the authorities and private investors in the modernization of infrastructure, communications, rolling stock and adaptation of the necessary technological solutions.

Modern technologies and innovations in the field of transport development have a direct impact on trends, becoming the subject of discussion both among experts and among ordinary users, and shaping the news agenda. Also, the development of technologies affects the work of transport operators, simplifying many operational processes and allowing to improve not only infrastructure and transport fleets, but also transport services and passenger services.

According to GOST 51006-96, a transport service is the result of the activity of a transport service provider (transport operator) to meet the needs of a passenger <...> in transportation in accordance with established norms and requirements [1]. In accordance with the author's definition, passenger services should be understood as additional services of the transport operator to users, accompanying the main transport service for transportation. The implementation of passenger services is inextricably linked directly to the transport service and complements it to improve the quality of this service. The quality of transport services for passengers is understood as the totality of properties of the transportation process and the system of passenger transportation, which determine their compliance with regulatory requirements [3]. However, regulatory requirements often do not take into account the degree of satisfaction of passengers with the quality of transport services in public transport, which leads to a gap in the quality assurance system between the delivered and perceived quality of services [3].

The given multifactor model of the user's transport behavior demonstrates the system of relationships between the elements of this model and allows us to identify the levers of influence on the transport behavior of residents in megalopolises.

The formation of transport behavior is possible through direct and/or indirect influence on both external and internal factors of the model.

Influence on internal factors is long-term and multi-stage and requires a deep understanding of the motives of certain behavior and ways of modifying them to achieve the desired effect. Thus, effectively built PR practices allow to form new current trends and influence the value system in society, which, in turn, will entail changes in the implementation of the needs and transport habits of users. However, the implementation of such practices can take years, and the results can be evident only after generations of users,

as happened in the case of the highest popularity of the personal car and the reluctance of users to switch to using public transport.

Therefore, such practices should be supported by the influence on external factors, which, on the one hand, make it possible to make a qualitative breakthrough in a relatively short time period, and on the other hand, to support the emerging trends and value systems of users with physical “evidence”. In this case, the management in the model is carried out through the implementation of an effective urban planning and transport policy, as well as sufficient funding for development projects, which will smooth out the consequences of historical prerequisites and balance the operation of the transport system.

However, the development of infrastructure and the renewal of the rolling stock of public transport, which are the actual manifestations of the implemented policy, are often insufficient for the widespread transition of the population to the use of public transport. Along with direct coercive measures (restrictive, prohibitive and economic measures), in order to effectively manage the transport behavior of residents and change the transport habits of the population in favor of more sustainable ones, it is necessary to create conditions under which the quality of transport services in public transport will be sufficient to meet the needs of passengers. Usually, economic, restrictive and prohibitive measures in the management of the transport behavior of residents of megalopolises are most often used systematically and in conjunction with the management of the quality of transport services, stimulating the demand for urban public transport services and reducing the dependence of city residents on private cars.

Assessment of the quality of transport services and passenger satisfaction is usually carried out according to three main criteria: convenience, safety and speed [14]. In the countries of the European Union, where public transport is becoming more widespread, the assessment of passenger satisfaction is carried out according to a large number of indicators [3]:

- Transportation safety;
- Regular traffic;
- Carrier image;
- Attention to consumers;
- Informational content of the transport service;
- Fares for travel;
- Stopping points and terminals;
- Comfort level;
- Seamless path;
- Passenger service.

To improve the image of public transport in the eyes of passengers, modern transport operators pay great attention not only to updating rolling stock and elements of transport infrastructure, creating a financially attractive tariff system, expanding the route network, but also directly to transport services and communication with passengers.

Management of the quality of transport services consists in comparing the quality of transportation with the expectations of passengers and the ability of the transport service to meet the needs of the passenger for mobility [14]. By making public transport better, the authorities are able to achieve changes in the transport behavior of residents of a metropolis both in the short and long term.

Transport in megalopolises is perceived as a single system, the effective management of which is possible only if the efforts of all players in the transport sector are consolidated: state and municipal authorities, transport operators, transport experts, ecologists, doctors and urbanists, technology companies and passengers themselves. Today, modern information technologies are the basis for building effective processes for managing transport systems and transport behavior of passengers. Their use makes it possible to

monitor, analyze and correct the operation of urban transport and the state of infrastructure in a complex real-time mode, on an ongoing basis to assess and improve the quality of transport services, to clarify the wishes of passengers, to receive feedback and to optimize the use of resources.

One of the options for the development of intelligent urban mobility, that is, the ability to effectively move around the city, is the concept of "Mobility as a Service", which has received the greatest development within the ecosystem of "smart city" standards [4]. MaaS is a modern urban transport management concept that offers passengers access to different types of vehicles and travel on different routes within a complex urban transport system.

MaaS describes the transition from personal transportation and the physical maintenance of one's own vehicle to the mobility provided by a transport operator as a service. This is achieved by combining transport services from transport operators into a single channel. The core of the MaaS concept is to offer mobility solutions based on the travel needs of different passengers.

The essence of MaaS is to place the passenger at the center of the transport service and offer him an individual way of travel, taking into account his individual needs and preferences, providing information for making rational choices. The MaaS integrates all types of urban transport into a single service that is available on request via a mobile application. The idea is to provide services through a single personal account with a fixed regular payment and receive a comprehensive transport service [8].

The MaaS relies on seamless mobility. Seamlessness means that all components of the transport system involved in creating a "mobility service" must be tightly, sustainably and continuously integrated with each other. This includes integrating a single fare collection system, enabling advance booking, travel planning and payment, and the use of mobile devices and applications for real-time information.

Within the framework of MaaS, users can purchase a package of transport services that will most closely match their transport behavior, as well as their individual needs and preferences.

The proposal will include "subscription" access to a specific set of trips by different modes of transport [8]. A single mobile application will provide real-time access to various options for multimodal travel, public transport timetables, the location of stations and stops, online booking and payment for the use of vehicles and urban parking spaces.

The introduction and development of functions within the MaaS concept, along with maintaining the correct operation of infrastructure and rolling stock, will allow mega-cities to continue to improve passenger services and create an offer taking into account new global challenges. Moreover, by viewing mobility as a service, transport operators have the opportunity to add value to public transport services by personalizing passenger offerings, increasing the attractiveness of public transport and sustainable ways of moving around the city, and therefore driving the transport behavior patterns of residents in metropolitan areas.

### **3 Conclusion**

The development of infrastructure and renewal of the rolling stock of public transport, which are a real manifestation of the current policy, are often not enough for the mass transition of the population to the use of public transport. Along with direct coercive measures (restrictive, prohibitive and economic measures), in order to effectively manage the transport behavior of residents and change the transport habits of the population in favor of more sustainable ones, it is necessary to create conditions under which the quality of transport services in public transport will be sufficient to meet the needs of passengers. Economic, restrictive and prohibitive measures in managing the transport behavior of residents of megalopolises are most often used systematically and in combination with



quality management of transport services, stimulating the demand for urban public transport services and reducing the dependence of city residents on private cars. By improving public transport, authorities can bring about changes in the transport behavior of metropolitan residents in both the short and long term.

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