

# Concept of a system for monitoring the dynamics of transport infrastructure development in a megalopolis

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**Abstract.** Sustainable development of a metropolis and its transport system is an urgent task of the modern world. The measures taken to develop mobility in a large city require regular measurement of citizens' perceptions of the changes introduced and the use of the data obtained to monitor and manage programs for the development of urban public transport, bicycle and pedestrian infrastructure, public spaces and other areas of improving the comfort of life in a megalopolis. The paper discusses the basic principles and approaches to the formation of a monitoring system of the transport system, presents the results of testing the methodology, and proposes a conceptual model of a monitoring system for the transport infrastructure development to support management decisions.

## 1. Introduction

Megacities around the world are faced with the consequences of the effects of car-centric urban planning. Traffic jams, air pollution, noise, low physical activity of inhabitants, CO<sub>2</sub> emissions, limitations, and unattractiveness of public spaces are trademarks of a considerable number of large cities. Moscow is doing a lot of work to eliminate these negative phenomena, which allowed it entering the top ten world megacities in terms of convenience and efficiency of the transport system according to a global study by McKinsey consulting company [7] in 2018. At the same time, many unsolved problems hinder the transformation in the city. One of them is the lack of a monitoring system to assess the dynamics of the transport system development processes and to monitor the attitude of citizens to the on-going changes.

The development of Moscow transport infrastructure is carried out within the framework of several state programs for the city development [5,4,3]. However, due to the lack of a coherent system of indicators and a single information space, it is difficult to make operational management decisions when implementing these programs. The low coordination of authorities and executors, the lack of awareness of the population and business structures hinder the development of the city's infrastructure. In this regard, the formation of the concept of a monitoring system applicable to various elements of the transport system and allowing an integrated approach to monitor the transport infrastructure development is an urgent task.

## 2. Concept of assessment of the transport infrastructure development of a megalopolis

The concept of assessment of transport infrastructure development is based on the solutions obtained by the author and researchers of Plekhanov Russian University of Economics [1,11,13,14], as well as

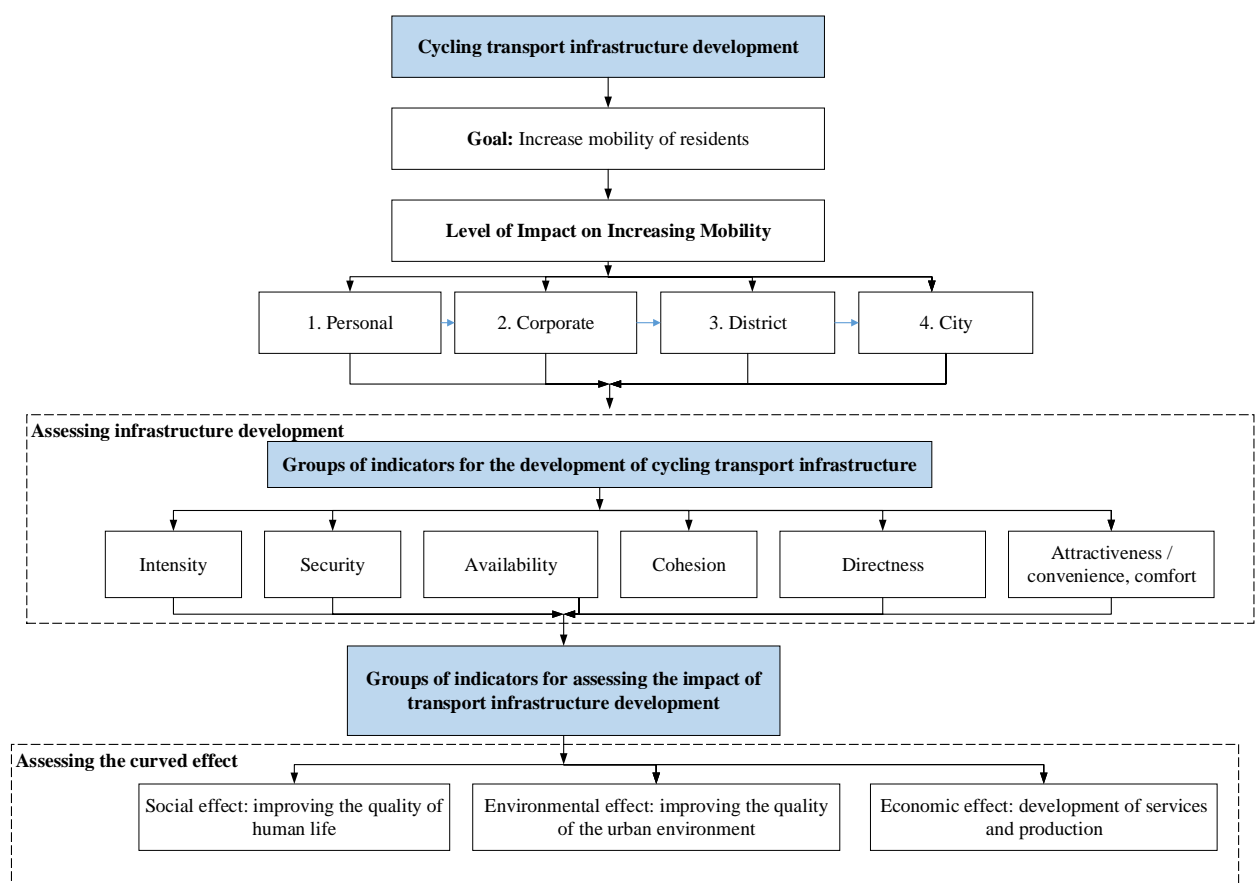


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in-depth interviews with experts on the management of transport infrastructure development, on the basis of which strategic and tactical management goals of the management system were identified.

The strategic goal (goal of the 1st level) is defined in the program documents and is aimed at increasing the mobility of citizens taking into account their needs, preferences, and mobility level in the current architectural restrictions of the metropolis. The main tactical goal is to manage the transport infrastructure development of the city without harming the health of its residents. At the same time, the development should have a positive impact on the modal share transformation processes and decrease in private vehicle usage, as well as positively influence the economic, ecological and social spheres of the city. As a result, the objectives of the 2nd level include: (1) Transport infrastructure development; (2) improving the health of residents of the metropolis; (3) Change in the transport behavior of citizens; (4) planning for the transport infrastructure development; (5) Increasing the effect of the transport infrastructure development.

The assessment of achievements concerning each of the goals of the 2nd level is carried out based on hard and soft indicators. Hard indicators reflect the technical characteristics of the transport system and their compliance with regulatory requirements. Soft indicators make it possible to assess the satisfaction of residents with the transport infrastructure of the city in various aspects (e.g., safety, continuity, convenience). A holistic concept for assessing the transport infrastructure development of a megalopolis is presented in Figure 1.



**Figure 1.** Concept of a system for monitoring the cycling transport development dynamics in a megalopolis

The proposed concept is based on:

- compliance with the principles of sustainable development of metropolises, taking into account the control of social, economic and environmental effects;
- reflection of continuous improvement of the transport infrastructure based on objective and subjective indicators, taking into account the technical characteristics of the object under observation and changes in the preferences of citizens;
- hierarchical principle of assessing the transport infrastructure development “from the bottom up,” from the personal level to the level of a megalopolis

The monitoring system involves personal, micro-district, district and city levels of monitoring, i.e., the inclusion of system monitoring centers at various levels of monitoring objects in the general monitoring system. The integration of information resources of multiple levels is carried out centrally using modern telecommunication systems. Access to information resources should be as open as possible and based on accurate user identification to ensure the decentralized use of monitoring system resources. The monitoring system should have the possibility of structural and functional development, which allows expanding the range of monitoring objects and providing information support to various categories of users. The groups of indicators and monitoring indicators were determined based on the preliminary studies and are supposed to remain unchanged for a long-term period (at least 5-10 years). The groups of indicators for assessing the impact of transport infrastructure represent an independent unit in the monitoring system, which includes a set of mathematical models based on state (municipal) statistics.

### 3. Testing results for a monitoring system using an example of assessing the level of development of bicycle transport infrastructure

According to the results of international and domestic experience in evaluating the level of development of the bicycle transport system **Ошибка! Источник ссылки не найден.Ошибка! Источник ссылки не найден.Ошибка! Источник ссылки не найден.Ошибка! Источник ссылки не найден.Ошибка! Источник ссылки не найден.Ошибка! Источник ссылки не найден.**, the following groups of indicators were identified in the study: (1) traffic intensity, (2) safety, (3) cohesion, (4) directness, (5) attractiveness, (6) comfort. The structure of the hierarchical indicator system is presented in Table 1.

**Table 1.** The structure of indicators for assessing the development level of bicycle transport infrastructure

Intensity	1.1. Traffic intensity on a bicycle path, bicycle and pedestrian path, bicycle lane
Safety	2.1. Accident rate involving cyclists 2.2. Cycling transport infrastructure Safety
Cohesion	3.1. Sufficiency of bike lanes and bike paths in the city for free cycling 3.2. The bicycle infrastructure cohesion with the "points of attraction" of the city 3.3. Perceived level of cohesion of the bicycle transport infrastructure with the “points of attraction” of the city 3.4. Perceived cohesion of cycling transport infrastructure with public transport
Directness	4.1. Cycle riding time characteristic 4.2. Directness to cycling transport infrastructure
Attractiveness	5.1. Personal safety 5.2. Property Security 5.3. Information support
Comfort	6.1. Comfort when riding a bike 6.2 Comfort at the start of the trip 6.3. Comfort at the end of the trip (at the place of work/study) 6.4. Comfort of transporting a bicycle in public transport

Information resources are formed on the basis of open data for the city of Moscow (Open data portal URL: <https://data.mos.ru/>) and surveys of city residents. To assess the perceived level of infrastructure development, it is crucial that the sample matches the real structure of residents using bicycles to move around the city, and therefore the sample was biased towards a younger population. When testing indicators by a telephone survey of 500 residents of Moscow, who use bicycles to move around the city for various purposes, the following results were obtained:

1. As to the Safety category, respondents who gave an assessment equal to or higher than 6 points make up 58%; in the “Cohesion” category - 47%; in the category “Directness” - 53%, in the category “Attractiveness” - 57%, in the category of assessment criteria “Comfort” - 53%. Thus, the perceived level of bicycle transport infrastructure development is assessed as Average.

2. As to the Safety category, movement in the general traffic flow along a highway is perceived as the most dangerous (19% of the respondents rated it as safe), and in the bus-lanes (40% of the respondents rated it as safe), along the separated in-roadway bike-lanes (45% rated it as safe). In this regard, bicycle development programs should be adjusted towards the creation of isolated bike-lanes, regarded as the safest type of bicycle infrastructure (68% rated it as safe).

3. As to the Cohesion category, respondents noted the lowest Cohesion level of bicycle infrastructure with suburban trains (about 70% of respondents rated this indicator by less than 6 points). To solve this problem, it is necessary to implement a program to create bike paths from places of residence to public transport stops, as well as provide a sufficient number of parking spaces near stations/stops of the city’s transport system.

4. When assessing Directness, the lowest value of the indicator was recorded in the indicators Sufficiency of bike lanes and bike paths (42% of respondents rated it 6 or more points) and the lack of parking spaces: at Moscow Central Rail Circle (MCRC) stations - 48%, near metro stations - 47%, and near land transportation stations - 43%.

5. As to Attractiveness category, the most problematic area is the security of personal property - bicycles (only 30% of respondents are satisfied with the security of property at the beginning and at the end of the trip). The creation of secure, but aesthetic places for storing bicycles in the residential area and at the places where the route ends (near places of work and study), can significantly intensify cycling transport not only for leisure but also for work.

6. As to Comfort category, the lowest perceived level of bicycle transport infrastructure development was noted by respondents at the ends of the trips. The presence of conditions to tidy up after riding a bicycle was noted as sufficient by only 30% of respondents. Creating hygiene rooms is a common practice in Europe and in Israel. The experience of these countries can be adapted to create a comfortable working environment.

#### **4. Conclusion**

The activities aimed at improving life comfort in the cities cover various fields, are implemented by multiple organizations, and are controlled by several departments of city administrations. The direction of development associated with the improvement of the urban mobility system requires coordinated integrated solutions and approaches, including the development of public transport, the creation of a practical bicycle and pedestrian infrastructure. Facilities and parts of the infrastructure put into operation and providing urban mobility are perceived, evaluated and mastered by the city residents, gradually changing their mobility models. Effective management decisions of the city authorities require reliable and relevant information not only about the technical characteristics of the created infrastructure elements, but also about their perception by the townspeople, and changes in their behaviour. Such data are collected from the results of research projects implemented by various performers but should use a single system of indicators that allow comparison of results and a comprehensive assessment of the changes introduced. The conceptual approach proposed in the paper to monitoring the transport infrastructure of the city ensures the use of both technical standards and indicators of perception of infrastructure elements and systems by users and residents of the city, and

can serve as a basis for collecting, analysing and visualizing information for making effective management decisions.

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