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SPEED OF URBAN PUBLIC TRANSPORT AS A CRITERION FOR ITS PRIORITIZATION

Summary. *Prioritization of urban public transport is an urgent task in the urban transport system, which is congested with traffic in most cities. The constant growth in traffic volumes and the need for movement of urban residents poses many challenges for local governments, which are quite difficult to solve, especially in cities with formed built-up areas. Travel time constantly increases while the road network's capacity remains unchanged. In these circumstances, it is necessary to resort to various prioritization methods because it is impossible to satisfy all the needs of residents for travel by private car to any transport area of the city. Over the past decade, the share of people using micromobility vehicles (bicycles, electric scooters, etc.) has been increasing. Still, this method of transportation is not widespread and cannot provide large volumes of movement in cities, especially those with large sizes. For this reason, more and more attention is being paid to prioritizing urban public transport, which is capable of moving large numbers of people around the city and surrounding areas. Given that it is difficult to find additional capacity reserves, space and time have to be taken away from those users of the transport network who use private automobile transport to ensure priority for urban public transport. The traffic volumes, traffic flow composition, and average speed of urban public transport on sections of the road network were determined by research results. It became the initial data for simulation modeling of the state of traffic flow under different methods of prioritization of urban public transport. Simulation modeling has identified sections of the road network that differ in delay in the movement of urban public transport and general traffic flow depending on the application of spatial and/or time-based prioritization. As a result, using the example of the road network of Lviv city, where urban public transport routes are designed, six types of segments were identified, which differ in the peculiarities of traffic flow and planning characteristics. The study results make it possible to justify implementing various organizational and regulatory measures to manage the general traffic flow and urban public transport without changing the geometric parameters of the road network within the existing "red lines" defined by the General Development Plan. Unlike the existing regulatory requirements, in practice, it is possible to identify sections of the road network that require different types of prioritization of urban public transport, depending on its volumes, regularity of movement, volume of passenger flow, etc. Notably, these studies recommended measures that could reduce travel time based not on the number of vehicles but on the number of people inside them.*

Key words: *traffic flow, traffic volume, urban public transport, spatial prioritization, time-based prioritization, speed of movement.*

1. INTRODUCTION

Modern approaches to the design of sustainable urban mobility have seen a transformation in conceptual thinking, with a shift from car-centered models of transport planning to human-centered ones. This means that the planning of street space is not only prioritizing the movement of private cars

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throughout the city but also providing better conditions for people's movement in a differentiated manner, depending on the specifics of a particular transport district. For example, the central parts of cities should provide better infrastructure for walking, using means of micro-mobility and urban public transport, the area between the city center and periphery – for means of micro-mobility, public transport, and private cars, and the peripheral areas – for private vehicles and public transport. In addition, depending on the specifics of the formation and location of its functional zones and transport districts, each city has its matrix of correspondence, which is unique to it. Therefore, the main task is to ensure fast and safe connections between different transport districts and points of attraction for residents. It can best be provided by urban public transportation, which can move many residents and visitors.

This article studies the problem of fast and high-quality urban public transportation using the example of Lviv. It is characterized by the following features of functional zoning, configuration of the road network, and specifics of the formation of traffic and pedestrian flows:

– the absence of large industrial zones with a significant population attraction;
– uniform, dense distribution of residents throughout the city;
– radial-ring configuration of the road network with the attraction of traffic flows to the central part;
– the central part is a large business, administrative, and cultural center where significant pedestrian and passenger flows are generated;
– lack of arterial streets of considerable length throughout the city;
– chordal connections between radial streets are underdeveloped.

The above features significantly impact the formation of the urban public transport route network, directly affecting its rolling stock's operating modes and performance.

Currently, in world science, which studies the efficiency and sustainability of urban transport systems, research on methods and techniques related to the prioritization of urban public transport is relevant. Although the principles of applying spatial and time-based priorities have been formed over the past 20–30 years, the novelty of improvements is that new developments in automated traffic management systems are constantly emerging. They are related to the improvement of geographic information technologies and artificial intelligence systems and the fact that each city or its agglomeration is characterized by individual features of the formation of the transport system and indicators of road users in it.

All studies and their scientific and practical results are conditionally divided into those that study the advantages and disadvantages of spatial prioritization (allocation of dedicated traffic lanes) and algorithms for time-based prioritization (control of signals at traffic lights). At the same time, when these two methods are combined on roadways with different planning characteristics and indicators of road users, there is a challenge.

2. RESEARCH STATEMENT

Solving the problem of traffic delays when residents use urban public transport requires identifying problematic locations on the road network where such delays are the most extensive and persistent. The time spent on transportation determines city residents' choice of transportation mode. Problem areas can be identified through field surveys, but conducting them simultaneously on all sections of the road network is expensive and requires many surveyors. Conducting such studies in individual areas will provide only some information about the state of the problem in the urban public transport system. Local studies in transportation systems are relevant only for solving problems in specific areas, most often intersections, certain sections of routes, stopping points, etc. When studying the entire urban public transportation system, it is necessary to have information on all routes simultaneously. Therefore, data from specialized information systems are needed to monitor its operation. Such data may include information on the number of passengers on the network if the e-ticketing system is in place, information on the duration of rolling stock movement on sections of the route network if the GPS monitoring system is in place, information on the state of congestion on the road network if the centralized traffic control system is in place, etc.

One of the main factors or indicators determining the change in the time spent traveling along sections of the road network is the speed of movement, which can be obtained simultaneously on all routes using a GPS monitoring system.

Trends in spatial traffic speed allow us to assess the impact of traffic volumes on the mode of urban public transport movement, locations where there are constant or variable (for different periods of the working day) traffic delays and performance of rolling stock; choose a rational way to prioritize urban public transport, etc.

3. RELEVANCE OF THE STUDY

Reducing the share of residents who use private cars to get around the city is an essential task in sustainable urban mobility projects, as it can significantly solve problems related to traffic jams, environmental pollution, and the efficiency of urban public transport. This result, which ensures convenient and mass transportation, can only be achieved through measures that increase the attractiveness of urban public transport. Therefore, organizing its efficient operation is a scientific and practical task, the first stages of which are research, modeling, and forecasting the state and prospects of the city's transport system. The experience of developed European countries, which were the first to address such problems in cities caused by overpopulation and high levels of motorization, shows that comfortable, fast, and safe transportation by urban public transport is one of the main factors in the fight against congestion. It is only possible to convince city residents or people outside the city to stop using private cars when traveling if the alternative (urban public transportation) saves time.

Based on this, connection speed, as one of the target functions of road traffic, is an essential factor influencing the redistribution of the share of travel modes and is an indicator of identifying bottlenecks in the road network.

4. AIM AND TASK OF THE STUDY

The purpose of this study is to differentiate the sections of the road network with urban public transport routes by the speed of the rolling stock of this type of transport and to justify the implementation of its prioritization for different transport districts in terms of planning features and indicators of road users.

The following tasks have been formulated to achieve this goal:

- to determine traffic flow volumes and composition on sections of the road network with urban public transport routes using the method of field research;
- to form samples of the speed of urban public transport between stopping points obtained from GPS trackers;
- to determine the patterns of changes in bus speed in the samples of values generated for each transport district and bus routes;
- to analyze bottlenecks (in terms of compliance with the established speed limit) and justify ways to prioritize urban public transport.

Field research, documentary study, and traffic simulation were used in the study.

5. ANALYSIS OF RECENT RESEARCH AND PUBLICATIONS

According to the results of the study of the distribution of movements by mode of transportation conducted by the Municipal Institution “City Institute” as part of the development of the Sustainable Urban Mobility Plan for Lviv until 2030 [1], a characteristic feature is a significant share (about 18 %) of walking. It is almost equal to movements using private cars (about 23 %). It is typical for densely populated cities with relatively small areas and a long building and road network development history. Due to the poorly developed infrastructure for micromobility vehicles, the share of travel by this type of transport is about 5 %. The largest share (more than 50 %) of travel is by public transport, and the smallest (about 1 %) is by taxi.

Even though the largest share of trips is made by urban public transport, the average travel time by this mode is the longest (31.6 minutes), making it less attractive to residents and those who use the road network daily. Therefore, it is necessary to take some measures to increase the share of urban public transport use while reducing the average travel duration. The average travel time by private transport is 29.3 minutes, by micromobility vehicles – 25.3 minutes, and by taxi – 23.0 minutes. The fastest travel time is on foot – 15.4 minutes.

The speed, regularity, and comfort of transportation primarily determine the attractiveness of urban public transport. In this paper, the focus is shifted to studying travel speed. Achieving its higher average values on sections of the road network can be ensured by applying spatial and time-based priorities.

Many studies in the world and Ukraine have been conducted in different cities, which substantiate the feasibility of introducing such priorities depending on the configuration of the road network, the specifics of the route network, passenger flows, etc. Authors [2-4] analyze the feasibility of applying spatial and time-based priorities. The spatial priority for urban public transport is the arrangement of dedicated traffic lanes, and it has many advantages: the rolling stock is practically unaffected by the general traffic flow; it allows for control by specific directions at signalized intersections; delays are reduced. At the same time, authors [2] note that the effectiveness of dedicated lanes is most significant when they are available along the entire route and at high volumes of urban public transport. In another case, small sections of the road network with dedicated lanes allow for faster bus and/or trolleybus traffic. Still, in areas with no such lanes, this type of transport may continue to be stuck in traffic jams, and the overall effect on passenger transportation is not achieved. The situation is the same at signalized intersections. Similar recommendations are given in [4–7], which emphasize that the effectiveness of spatial priority is a planning decision, and it is often unpopular among road users who use private cars since dedicated lanes are usually arranged at the expense of lanes previously intended for general traffic. The article [4] focuses on new methodological approaches to transport planning, which are mainly relevant for new transport districts or those being designed but are challenging to implement in “old” transport districts. Similar research results are found in [5], which notes that modern transport planning based on sustainable development and sustainable urban mobility requires an integrated approach to provide rational solutions for all groups of road users. The best planning solutions generally provide for dividing lines into separate roadways on the route network, as noted in studies [6,7]. However, they require significant capital investment and are effective in cities or their agglomerations with a large area. Thus, concerning the analysis of the advantages and disadvantages of spatial priority, it can be noted that the problem may be not only the financial costs of implementation but also the simple lack of free space in cities.

Despite the cost of an automated traffic control system, implementing time-based prioritization also has some features. Such prioritization is based on the detection of rolling stock of route vehicles in traffic lanes using detectors or other GPS equipment and, based on its location (in the vehicle interior, on the roadway), changes in the programs of traffic light objects. Such control can have different algorithms. In particular, the provision of transit through intersections, as described in [8], when the priority of urban public transport can only regulate signal timing in a limited range and is unsuitable for all signal timing projects. Then, providing sufficient priority for bus rapid transit is impossible. This study proposes a signal priority strategy before detecting a bus on bus rapid transit routes with coordination between primary and secondary intersections. Here, time-based prioritization should be combined with spatial prioritization since, by pre-detecting the arrival of a bus at the primary intersection, both the primary and secondary intersection signals are synchronized and, together with the shifts, are adjusted simultaneously based on the total duration of the green signal and the ratio of phase coefficients in each control cycle. Other algorithms are based on determining the vehicle's location on the route and ensuring its priority depending on traffic schedules [9]. The level of available capabilities of such algorithms largely depends on the architecture of the bus priority system, including the location of the detector that determines the degree of priority and its implementation, as well as the method of requesting priority for the traffic signal. These aspects are essential regarding rolling stock performance, communication requirements, and system cost.

There are also several studies that justify the implementation of time-based priority only before signalized intersections. In particular, authors [10, 11] note that providing priority to urban public transport only before signalized intersections and not along the entire length of the road network allows for reducing delays of buses and/or trolleybuses in bottlenecks, such as intersections. It also reduces delays in the general traffic flow by reducing the queue length on the sections between intersections.

A review study [12] notes that theories on the best ways to allocate existing road space for cars and buses in city centers and suburban corridors to improve transport efficiency are highly relevant in urban transport systems. In addition, they are one of the most common strategies for prioritizing public transport, generally recognized as effective in reducing congestion and bus travel time. Of course, evaluating such research is a time-consuming process. Such studies are concluded with proposals comparing all priority options regarding the minimum requirements for justifying prioritization schemes and the advantages and disadvantages of time-based and spatial priorities.

An essential prerequisite for formulating theoretical and practical conclusions analyzed in the above studies is to conduct massive field studies to study the indicators of urban public transport, general traffic flow, passengers, and pedestrians [13]. Otherwise, it is challenging to establish indicators of prioritization efficiency [14], and the results obtained may provide inadequate models with a significant difference between theoretical and practical values.

6. PRESENTATION OF THE MAIN MATERIAL

The documentary study of the materials with the results of measuring the speed of buses on the route network of Lviv was as follows:

1. The results of GPS monitoring of the duration of movement of urban public transport buses between stopping points during January – August 2024 were selected. These results identified routes where spatial priority was implemented in specific areas by allocating dedicated lanes.
2. Based on the methodological recommendations for researching city bus lines, the measurement results for July and August were not considered because they are regarded as periods of decreased volumes due to a decrease in business activity caused by the holiday season and school vacations.
3. The sections of the route network are divided into three conditional zones: central, downtown, and peripheral areas, taking into account the radial-ring configuration of the road and similar arterial route networks.
4. For each conditional zone, two sections were selected with and without dedicated lanes for urban public transport. These areas are adjacent, as one of the study's objectives is to compare the connection speed at approximately the same volumes of urban public transport and general traffic flow.
5. The experimental (selected for detailed analysis) sections have approximately the same distance between stopping points, as downtime is considered in the travel time. Accordingly, runs with different lengths would give characteristically different speeds.
6. From the measurement protocols generated in the MicroGIS software environment (Table 1), vehicle number, date and time of the route start, departure number, planned and actual time of arrival of the bus at the stopping point (with its number following the citywide numbering of stopping points) were determined.
7. The measurement protocol classified the sections into three groups (sections where the GPS tracker failed to record the actual arrival time are shown with a white background):
   - the first group – 4 minutes or more ahead of the planned schedule relative to the actual schedule – blue background;
   - the second group – adherence to traffic schedules (the difference between the planned and actual arrival time was up to 3 minutes) – green background;
   - third group – delay in movement (the difference between the planned and actual arrival time was 3 minutes or more) – red background.

8. Based on the known distance between stopping points (route passports) and the actual time of arrival at them, the connection speed was determined, taking into account the duration of downtime at the stopping point, as well as the delay caused by traffic control (unsignalized pedestrian crosswalks, traffic lights, etc.).
9. The obtained values of traffic speed for the period of the most intense traffic on weekdays (Tuesday, Wednesday, and Thursday) of each experimental site were formed into a sample (summary table), which was processed by mathematical statistics to determine the mathematical expectation of this random variable.

Table 1

A fragment of the protocol of compliance with the traffic schedule for the section of bus route 3A in Lviv, generated in the MicroGIS software environment

Vehicle: BC-0213-OC Schedule: 10 – 2 Start: 2024/01/16 07:44	Route No. A03 (TC King Cross – Rizni Sq.) 2024/01/16 07:10 End: 2024/01/16 08:00		
Geozone	Planned arrival time	Actual arrival time	Notes
TC King Cross (320)	2024/01/16 08:15	2024/01/16 07:44	
Ipodrom (434)	2024/01/16 08:17	2024/01/16 08:05	
Sokilnytska (435)	2024/01/16 08:19	2024/01/16 08:07	
Avtovokzal (433)	2024/01/16 08:22	2024/01/16 08:10	
Maksymovycha (432)	2024/01/16 08:25	2024/01/16 08:15	
Hasheka (431)	2024/01/16 08:27	2024/01/16 08:19	
Skoryny (430)	2024/01/16 08:29	2024/01/16 08:22	
Stryiska-Naukova (436)	2024/01/16 08:32	2024/01/16 08:30	
Avtobusnui zavod (429)	2024/01/16 08:35	2024/01/16 08:33	
Podatkova (428)	2024/01/16 08:38	2024/01/16 08:35	
Dytiacha zaliznytsia (75)	2024/01/16 08:40	2024/01/16 08:38	
Akademiia sukhoputnykh vijsk (76)	2024/01/16 08:42	2024/01/16 08:41	
Stryiskyi rynok (81)	2024/01/16 08:45	2024/01/16 08:52	
Shota Rustaveli (292)	2024/01/16 08:48	2024/01/16 08:54	
Shukhevycha (29)	2024/01/16 08:51	2024/01/16 08:56	
Pidvalna (57)	2024/01/16 08:54	---	
Teatralna (40)	2024/01/16 08:57	2024/01/16 09:06	
Rizni Square (62)	2024/01/16 09:15	2024/01/16 09:07	
Teatr opery ta baletu (68)	2024/01/16 09:18	2024/01/16 09:10	
Svobody Avenu (67)	2024/01/16 09:20	2024/01/16 09:12	
Kniaza Romana (39)	2024/01/16 09:23	2024/01/16 09:16	
Shota Rustaveli (291)	2024/01/16 09:26	2024/01/16 09:18	
Stryiskyi rynok (80)	2024/01/16 09:29	2024/01/16 09:21	

The following experimental street sections have been identified for the three conditional zones:

– central part – Viacheslava Chornovola Avenue (from the intersection with Lypynskoho Street to the intersection with Horodotska Street), dedicated lane (*section C1*); Lychakivska Street (from Mytna Square to the intersection with Chernihivska Street), without dedicated lane (*section C2*);
– downtown – Viacheslava Chornovola Avenue (from the intersection with Varshavska Street to the intersection with Lypynskoho Street) dedicated lane (*section D1*); Lypynskoho Street (from the intersection with Bohdana Khmelnytskoho Street to the intersection with Viacheslava Chornovola Avenue), without dedicated lane (*section D2*);
– peripheral areas – Bohdana Khmelnytskoho Street (from traffic junction "Halytske perekhrestia" to the intersection with Lypynskoho Street), dedicated lane (*section P1*); Stryiska Street (from the intersection with Naukova Street to the intersection with Sokilnytska Street), without dedicated lane (*section P2*).

The experimental sections in the central and downtown areas have two lanes in each direction, and the experimental sections in the peripheral areas have three lanes.

The required sample size to ensure the representativeness of the data was determined using the methodology described in [15]:

$$n = \frac{Z^2 \cdot p \cdot (1 - p)}{E^2}, \quad (1)$$

where Z – value for the selected significance level (we take 1.96 for 95 %); p – the expected proportion (0.5 is assumed if there is no previous measurement data); E – the permissible error (we take 0.05).

Based on the results of the calculations, we will obtain the required minimum number of buses, the average speed of which must be measured for each experimental section to ensure sample representativeness:

$$n = \frac{1{,}96^2 \cdot 0{,}5 \cdot (1 - 0{,}5)}{0{,}05^2} = 384{,}16 \approx 385 \; \textit{buses}.$$

Given the availability of data from GPS trackers in the MicroGIS software environment from January to June (included), the mathematical expectation of the connection speed for each section during the period of the most intensive traffic from the sample size of 576 buses was determined. The results are as follows: the mathematical expectation for section C1 is 18.4 km/h, for section C2 – 15.7 km/h, for section D1 – 23.6 km/h, for section D2 – 18.0 km/h, for section P1 – 26.3 km/h, for section P2 – 18.6 km/h.

Based on the analysis of the above data, the following conclusions can be drawn:

– in dedicated lanes for urban public transport, bus connection speeds are less similar within the same section, as can be seen from the results for sections C1, D1, and P1, in contrast to sections C2, D2, and P2, where buses move as part of the general traffic flow, whose performance affects them. Based on this, the range of bus speeds on the specified sections is larger, given their relatively low traffic volumes and different values of passenger flow on each route. In addition, since the connection speed was determined by comparing the distance between stopping points to the duration of the movement on the section, this duration also includes downtime at controlled intersections and/or pedestrian crosswalks. Accordingly, buses arrived at the stop lines at different times of the prohibition signal;
– the average speeds of buses in dedicated lanes are obviously higher than when they move in the general traffic flow. Still, this difference is different for each of the experimental transport zones. Thus, the difference is 17 % for the central zone, 31 % for the downtown, and 41% for the peripheral areas. Two main factors of influence can explain these trends in dedicated lanes, besides the impact of general traffic flow on the rolling stock of urban public transport in adjacent lanes. The first factor is an increase in the number of buses approaching the center, based on the road network configuration. The second one is an increase in the density of this network in the central part and, therefore, the number of stop–lines at controlled intersections and/or pedestrian crosswalks within one section.

7. CONCLUSIONS AND FUTURE RESEARCH PERSPECTIVES

Based on the results of the study, the following conclusions can be drawn:

– the efficiency of dedicated lanes for urban public transport, based on the criterion of increasing the connection speed, varies throughout the city, even for streets with the same number of lanes, and significantly depends on several factors. They are the density of the road network, general traffic flow volumes when urban public transport is moving in it and dedicated lanes on the volumes of route buses, and the mode of traffic light control at intersections and pedestrian crosswalks.
– the implementation of spatial priority (dedicated lanes) does not give the desired effect of increasing the connection speed on the sections without ensuring time-based (time prioritization of urban public transport) priority at traffic lights.

– since public transport stops (following the established regulatory restrictions) are located before intersections, it is challenging to ensure non-stop bus (trolleybus) traffic using adaptive traffic control algorithms. This is because the detector detects the approach of a vehicle to the intersection and gives it priority for passage. Still, the delay at the stopping point can be so long that it does not satisfy the limitations of the maximum duration of the permissive signal in the current phase of the adaptive control algorithm. If spatial and time-based priority are implemented simultaneously, it is necessary to change the regulations when stopping points are located after intersections on such arterial sections of routes. Such location increases the efficiency of the detectors.
– the implementation of dedicated lanes without taking into account the effect of the simultaneous application of time-based priority during peak traffic periods makes it possible to increase the average speed of traffic by 17–41 % with the increase in distance from the center in cities with a radial-ring configuration of the road network.

Further research will focus on the effectiveness of implementing coordinated traffic management on sections of city arterial streets with dedicated lanes for urban public transport. Along with studies of the passenger flow, this will make it possible to increase the productivity of this type of transport and the attractiveness of this mode of transportation in cities with congested road networks.

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ШВИДКІСТЬ РУХУ МІСЬКОГО ГРОМАДСЬКОГО ТРАНСПОРТУ ЯК КРИТЕРІЙ ЙОГО ПРІОРИТЕЗАЦІЇ

Анотація: *Пріоритезація міського громадського транспорту є актуальним завданням в міській транспортній системі, яка у більшості міст перевантажена рухом. Постійне зростання інтенсивності руху та потреб у пересуванні міських мешканців ставить перед органами місцевого самоврядування низку завдань, які доволі складно розв'язати, особливо у містах зі сформованою забудовою. Часові витрати на пересування постійно зростають, тоді як пропускна здатність вулично-дорожньої мережі фактично не змінюється. За таких умов доводиться вдаватись до різноманітних способів пріоритезації, зважаючи на те, що задовольнити всі потреби мешканців у пересуванні приватними автомобілями у будь-який транспортний район міста неможливо. В останнє десятиліття зростає частка осіб, які для пересування використовують засоби мікро-мобільності (велосипеди, електросамокати тощо), проте такий спосіб переміщення не є масовим і не здатний забезпечити великі обсяги пересування в містах, особливо великих. Тому все частіше звертають увагу на пріоритезацію міського громадського транспорту, який здатний перемістити територією міста та прилеглими районами велику кількість людей. Оскільки додаткові резерви пропускної здатності знайти складно, то для забезпечення пріоритезації простір і час доводиться забирати у тих користувачів транспортної мережі, які для пересування використовують приватний автомобільний транспорт. За результатами досліджень визначено інтенсивність руху, склад транспортного потоку та середню швидкість міського громадського транспорту на ділянках вулично-дорожньої мережі, які стали початковими даними для імітаційного моделювання стану цього потоку за різних способів його пріоритезації. Імітаційним моделюванням визначено ділянки вулично-дорожньої мережі, які відрізняються за затримками в русі міського громадського транспорту та загального транспортного потоку залежно від застосування просторової та (або) часової пріоритезації. У кінцевому результаті, на прикладі вулично-дорожньої мережі міста Львова, якою прокладено маршрути міського громадського транспорту, визначено шість типів відрізків, які вирізняються особливостями руху транспортних потоків та планувальними характеристиками. Результати дослідження дають змогу обґрунтувати введення різноманітних організаційних та регуляторних заходів з управління рухом загального транспортного потоку та міського громадського транспорту без змін геометричних параметрів вулично-дорожньої мережі в межах наявних "червоних ліній", визначених Генеральним планом забудови. На відміну від чинних нормативних вимог, на практиці можна встановити ділянки вулично-дорожньої мережі, які потребують різної пріоритезації міського громадського транспорту, залежно від його інтенсивності, регулярності руху, обсягу пасажирського потоку тощо. Важливо, що результатом цих досліджень є рекомендування заходів, які здатні зменшити тривалість пересувань, і ґрунтуються не на чисельності транспортних засобів, а на чисельності людей, які в них перебувають.*

Ключові слова: *транспортний потік, інтенсивність руху, міський громадський транспорт, просторова пріоритезація, часова пріоритезація, швидкість руху.*