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STUDY OF TIME INDICATORS OF PUBLIC TRANSPORT OPERATION DEPENDING ON THE SEASON OF THE YEAR

Summary. *Mobility problems in large cities of Ukraine and Eastern Europe are complicated by the fact that the increase of private transport volume significantly exceeds street and road network`s capacity. This is most noticeable during peak periods in terms of daylight hours and throughout the year. From the point of sustainable mobility view, this negative phenomenon significantly affects urban public transport, which does not have separate dedicated traffic lines. This article analyzes the issue regarding the deterioration of the transport situation in large cities. The reason for this is the increase in traffic on main streets during the day peaks, as well as the presence of seasonal traffic factors. If the issue of the occurrence and traffic jams duration and the increase in the correspondence time of private transport is sufficiently studied, then the problems of changing the schedules of public transport and taking into account the increase in the trip duration depending on the time of year need to be clarified. The routes of public transport, which do not have a separate infrastructure and move in the general flow together with private cars, were chosen for the study. According to the results of remote monitoring of public transport, a change in the trip duration and time lost due to the boarding and disembarking of passengers on similar trolleybus routes in different seasons was established. Based on the obtained data, a matrix of trip duration unevenness coefficients for public transport routes was formed, and a measure of the seasonality effect on these indicators was established. The obtained results make it possible to quantitatively determine the influence of the season and time of the day on the change in the trip duration, which can be applied in further studies using simulation tools and for practical use in drawing up seasonal traffic schedules. The results of the research complement the currently relevant scientific works, which concern the problems of seasonal mobility, as well as the influence of the social infrastructure objects functioning (schools, kindergartens, and other educational institutions) of cities on the peak load of the street and road network, which extends the duration of traffic not only for private but also public transport.*

Key words: *traffic volume, public transport, trip duration, coefficient of unevenness, seasonality of traffic, speed of connection.*

1. INTRODUCTION

Uneven traffic volume is a common phenomenon for most cities with more than 200,000 inhabitants. In such conditions, the area of an average settlement begins to develop unstably, which provokes an increase in the number of not only labor correspondence but also educational and cultural correspondence. It is easily explained by the increase in the average travel distance when walking takes too much time, and there is a need to increase the speed of connection. In this case, correspondence begins to be distributed by movement modes, and the share of each one is unique for each settlement. It is formed, taking into account the general living standard of the population (the ability to purchase and maintain a car), the state of public transport development, and the spatial structure of the city. Correspondences of the studied city (by type of movement) are as follows: walking – 18 %, public transport – 54 %, private car – 43 %, and bicycle – 6 % [1].

It is also worth mentioning a phenomenon of pendulum migration since it is a factor that partially affects the distribution of correspondence within the agglomeration, which in our conditions consists of movements by private car – 52 %, instead of public transport – 42 % [2]. Therefore, the correspondence structure, if taken in general, is divided in half between the use of private cars and public transport. Such a high level of car use inevitably leads to complications in road traffic, even with an insignificant level of motorization (about 250 cars per 1,000 inhabitants) in the considered settlement [3]. In addition, such conditions are sufficient for the fact that the street and road network, as well as the transport system of the city as a whole, experienced fluctuations in correspondence not only during peak periods but also at different times of the year.

2. RESEARCH STATEMENT

There is no doubt about the relevance of the public transport time indicators issue. That is why a study of transport service quality is of great importance in the era of urban mobility. Knowledge of urban transport problems can help with the construction of further strategies for the city's transport systems development, and they are classically formed according to three scenarios, which are shown in Fig. 1 [4].

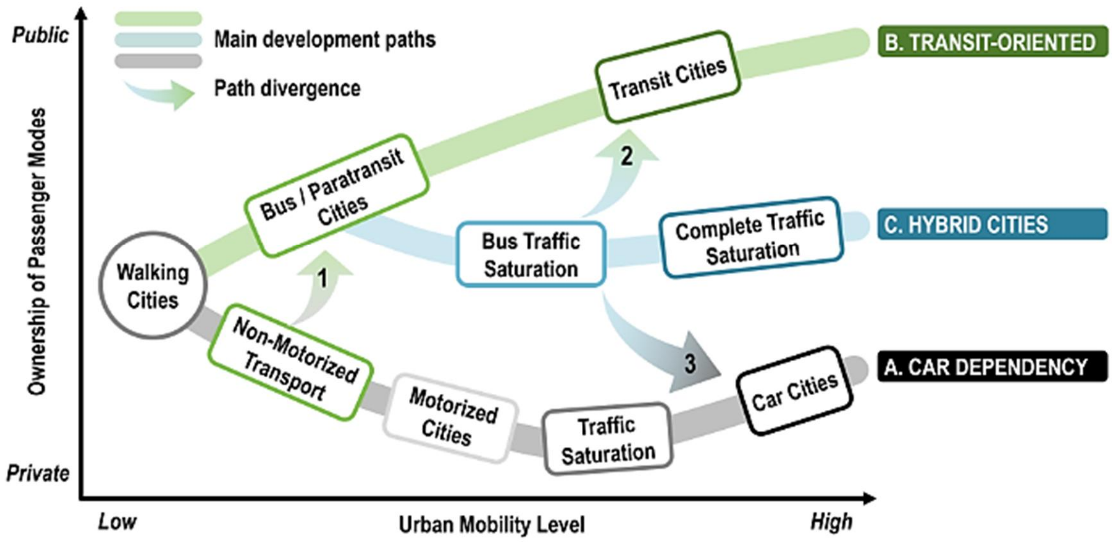

Fig. 1. Levels of urban mobility depending on the scenarios of the development of transport systems [4]

This diagram clearly shows the evolution of typical transport systems of Eastern European cities when settlements of type "C", at the moment of slowing down of bus lines, either transform a transit-oriented system or become car-dependent. This point is critical at the stage of transport system development. Therefore, the issue of traffic forecasting, as well as assessment of the public transport lines` time characteristics, requires constant study and monitoring.

Currently, a significant amount of research is focused on traffic forecasting in large cities and at the regional level. The majority of scientists working on this issue, for the most part, start from the fact that it is necessary to study the correspondence of the urban population constantly to predict the movement,. Thus, it is proposed in the paper [5–6] to study the factors of seasonal fluctuation of traffic volume with the help of mathematical modeling and artificial intelligence models. The authors of the papers [7] considered the method of estimating fluctuations in the volume of movement based on typological analysis and fuzzy logic. In this paper, traffic volume forecasting on various streets and roads in the area of Venice was carried out, and the objects of the street and road network were proposed to be divided into several groups. The results of modeling the average annual daytime traffic volume indicated that during the holiday season, traffic in the city increases by more than 50 %. In addition, authors [8] described passenger flow unevenness and relocation of bus use under COVID-19.

The assessment of seasonal decomposition in road traffic was carried out in the paper [9], where, based on personal cars` movement open data in the city of New York, regularities in traffic changes in different seasons of the year were assessed. It was also established that for different objects of the street and road network, the seasonal decomposition is significantly differentand sometimes even absent, which indicates an individual approach to the study of this issue since the configuration of the transport network of cities is an individual characteristic.

In papers [10–11], a topological analysis of the change in the average speed of traffic based on big data was carried out. Also, the seasonal change in speed modes was studied in the article [12]. The authors of this publication used a Kalman filter depth graph and neural networks to detect atypical changes in traffic. Similar studies were carried out by scientists in the paper [13], where a forecast of changes in average traffic speeds on main streets of large cities in the USA was made.

The considered sources give an understanding of the fact that a large number of studies are devoted to seasonal changes in road traffic, and the purpose of these works was to forecast the volume of correspondence and identify atypical modes of movement. Extending the duration of public transport routes was mentioned to a lesser extent in the reviewed sources. In such conditions, it is worth supplementing the already available research results with temporal measurements of changes in road traffic (and especially in the operation of public transport), taking into account seasonality. Since the problems of changing the time indicators of public transport work need to be studied by a real-time method for their further forecasting, the research presented in this article is relevant.

Based on the literature analysis, the purpose of the study is to determine the patterns of changes in the movement time of urban public transport units during the peak periods of the working day at different times of the year. The object of the research is urban public transport routes, and the scope of research is the regularities of trip time change, considering seasonality.

It is necessary to solve the following tasks to achieve the goal of the research:

- to carry out a sampling of public transport with a similar configuration;
- to calculate duration of trips and the boarding and disembarking of passengers in different periods of the day using the method of remote monitoring;
- to compare research results for different seasons and to express quantitatively the degree of extension of public transport trips` duration during the working day in different seasons of the year.

The expected results of the conducted research and their analysis are the basis, in the form of the trip duration unevenness coefficients, for further study of the loading level impact regularities for the street and road network on the stability of the public transport system. It is also worth noting that, at this time, there is no possibility to obtain time indicators of public transport operation using an automated method. However, using remote traffic monitoring systems, data on the departure and arrival of moving units is sufficient, which can be aggregated into a data set for its further analysis.

3. CHARACTERISTICS OF RESEARCH OBJECTS AND METHODS OF THEIR CONDUCT

The investigated objects are two trolleybus routes which are similar in their configurations, because they:

- are radial;
- have a share of chord mileage;
- pass through the arterial streets.

Diagrams of the studied trolleybus routes are shown in Fig. 2.

Route №1 (R1) **Route №2 (R2)**

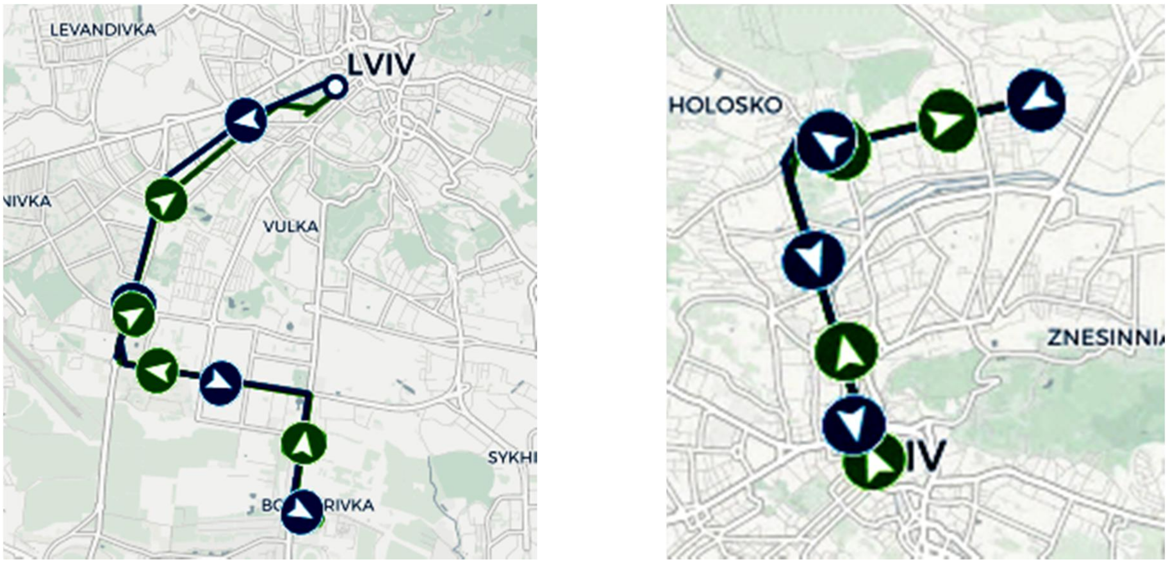

Fig. 2. Schemes of trolleybus routes [14]

The considered trolleybus routes are typical for large cities with a population of more than 200,000 inhabitants as they serve peripheral residential areas of the city, educational institutions, and other social infrastructure facilities, and the configuration of the street and road network in the areas of the route is similar. It is also worth noting that route No. 1 has a length of 10.5 km, 21 traffic lights along the way, and it stops for boarding and disembarking passengers 22 times. At the same time, route No. 2 passes 13 traffic lights and has 13 stops along the way; the length of the route is 6.2 km. Another indication that these routes are similar is that the number of stopping points and traffic lights is proportional to the length of the route. Based on this, in the process of traffic monitoring, relevant data will be obtained from routes of different lengths but with a similar configuration.

Traffic monitoring was carried out using a geoinformation system UA-GISTrek [15], which allows tracking the transport, as well as obtaining indicators of its operation for past periods. In our case, we received data on the duration of trips and stops while boarding and disembarking passengers.

A sampling of the trolleybus operation time characteristics was carried out by hour of the day and at different times of the year to achieve the aim of the study. For better differentiation of results, it was decided to form the seasons as follows:

– summer (June-August);
– autumn-spring (September-November and March-May);
– winter (December-February).

The autumn and spring seasons are combined since the main activities of the city's residents are similar at these times. The decision to investigate changes in the duration of trips and stops by season was made in order to compare the greater and lesser social activity periods by season. In this way, it is possible to determine the impact on the general condition of the street and road network and, in particular, the route network during the holiday season (summer and winter) with indicators of periods of active population activity (autumn and spring).

4. MAIN PART

The first research stage is the data collection on the time indicators of the trolleybus operation in the summer period. With the help of the UA-GISTrek service, reports were created for the summer months. The summarized information is shown in Table 1 and Fig. 3.

Table 1

Change of time indicators of transport operation in the summer period

Time	Route No. 1		Route No. 2	
	Avg. trip duration, min	Avg. stop duration, min	Avg. trip duration, min	Avg. stop duration, min
7	39	0.9	24	0.7
8	46	1.2	26	1.3
9	47	1.4	25	1.2
10	42	1	25	1.3
11	42	0.8	20	1.1
12	41	0.7	23	0.7
13	44	1	22	0.9
14	44	1	25	0.65
15	43	0.7	23	0.55
16	45	1	25	0.6
17	46	1.2	23	0.9
18	43	1.4	26	1.2
19	42	1.3	26	0.9
20	44	1	26	0.6
21	40	0.6	24	0.4
22	40	0.5	23	0.4
Weighted result	**43.00**	**0.98**	**24.13**	**0.84**

The graphically obtained results look like this:

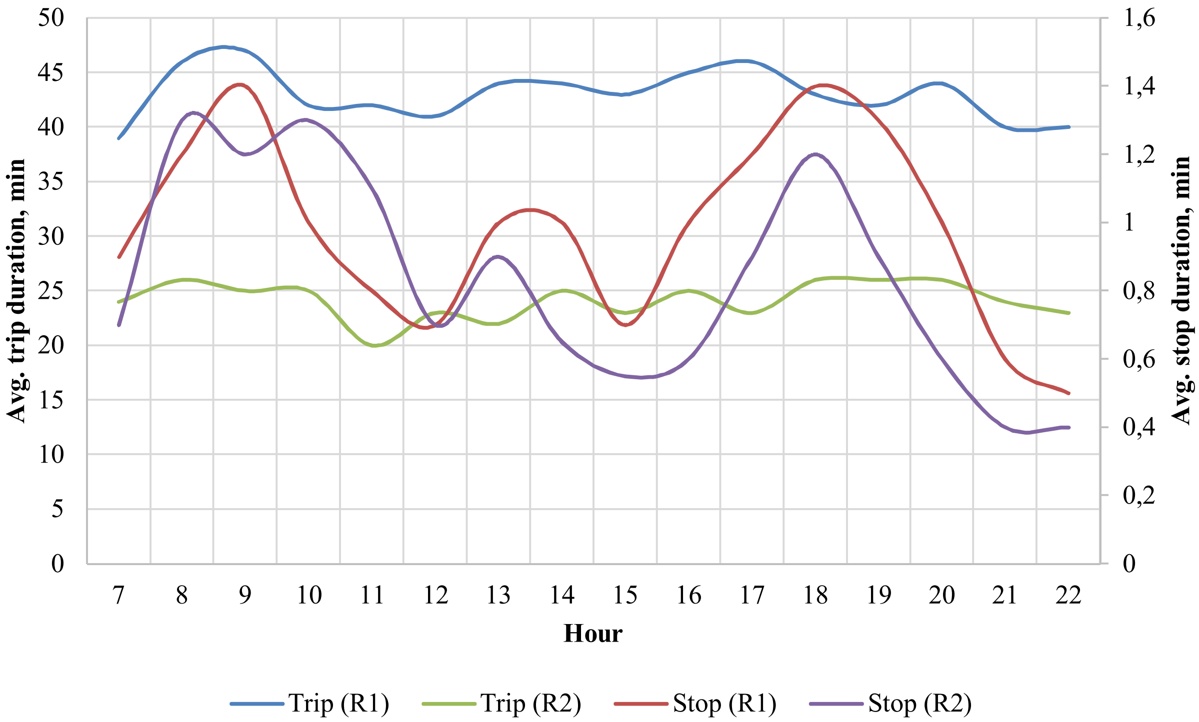

Fig. 3. Change in the average trip and stops duration on trolleybus routes in the summer season

As can be seen from the graph, the longest trip duration for route No. 1 is observed at 9:00 a.m., and the shortest trip duration is from 9:00 p.m. to 10:00 p.m. respectively, the average duration of stops increases and decreases. For trolleybus route No. 2, such sharp fluctuations in the time indicators of its operation have not been observed: the longest trip duration is at 8 a.m. morning peak time and 6–8 p.m.

evening peak time, and the shortest trip duration is at 11 o'clock. The longest average duration of the stop is observed at 8 and 10 a.m. and the smallest at 9–10 p.m. By analogy, the results for the winter period are given in Table 2 and Fig. 4.

Table 2

Change of time indicators of transport operation in the winter period

Time	Route No. 1		Route No. 2	
	Avg. trip duration, min	Avg. stop duration, min	Avg. trip duration, min	Avg. stop duration, min
7	45	0.9	28	0.8
8	52	1.4	32	1
9	50	1.3	35	0.7
10	50	1	29	0.5
11	47	0.8	25	0.6
12	47	0.7	30	0.7
13	49	1	28	0.9
14	53	1.1	25	0.65
15	45	0.7	28	0.75
16	45	0.7	32	1.1
17	46	0.9	28	1.3
18	53	1.4	36	1.2
19	49	1.3	37	1.3
20	50	1	27	0.8
21	44	0.6	25	0.6
22	43	0.5	24	0.6
Weighted result	**48.00**	**0.96**	**29.31**	**0.84**

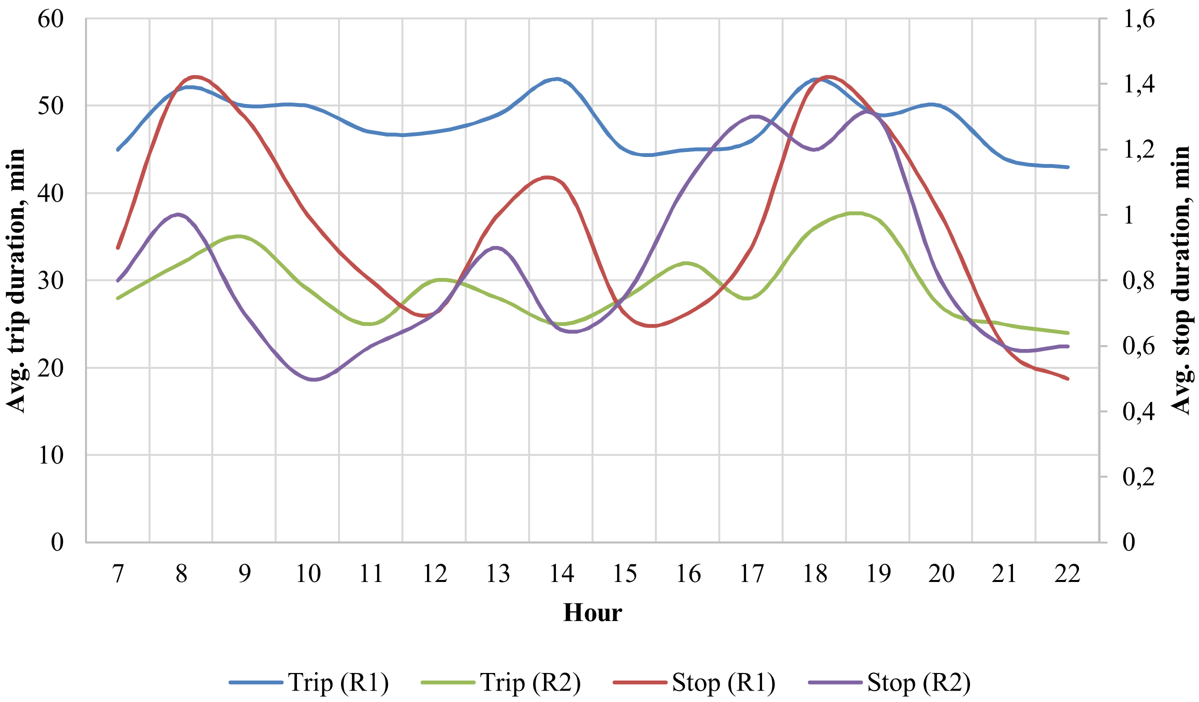

Fig. 4. Change in the average trip and stops durationon trolleybus routes in the winter season

For the trolleybus route No. 1, it was established that the average duration of the trip ranges from 43 to 53 minutes. The weighted average value of this indicator is 48 minutes. The average stop duration ranges from 0.5 to 1.4 minutes. The weighted average value of the stop duration is 0.96 min. The data of route No. 2 indicate that the average trip duration ranges from 24 to 35 minutes. The weighted average value of the trip duration is 29.31 minutes. The average stop duration is from 0.5 to 1.3 minutes. The weighted average value of the stop duration is 0.84 min. The research results for the autumn-spring period are shown in Fig. 5 and Table. 3.

Table 3

Change of time indicators of transport operation in the autumn-spring period

Time	Route No. 1		Route No. 2	
	Avg. trip duration, min	Avg. stop duration, min	Avg. trip duration, min	Avg. stop duration, min
7	47	0.9	28	0.7
8	52	1.2	32	1.3
9	54	1.4	35	1.4
10	46	1	29	1.3
11	43	0.8	25	1.1
12	40	0.7	30	0.7
13	44	1	28	0.9
14	44	1	25	0.65
15	43	0.7	28	0.55
16	45	1	32	0.6
17	47	1.2	28	0.9
18	53	1.4	36	1.4
19	54	1.3	36	1.5
20	44	1	27	0.6
21	40	0.6	25	0.4
22	40	0.5	24	0.4
Weighted result	**46.00**	**0.98**	**29.25**	**0.90**

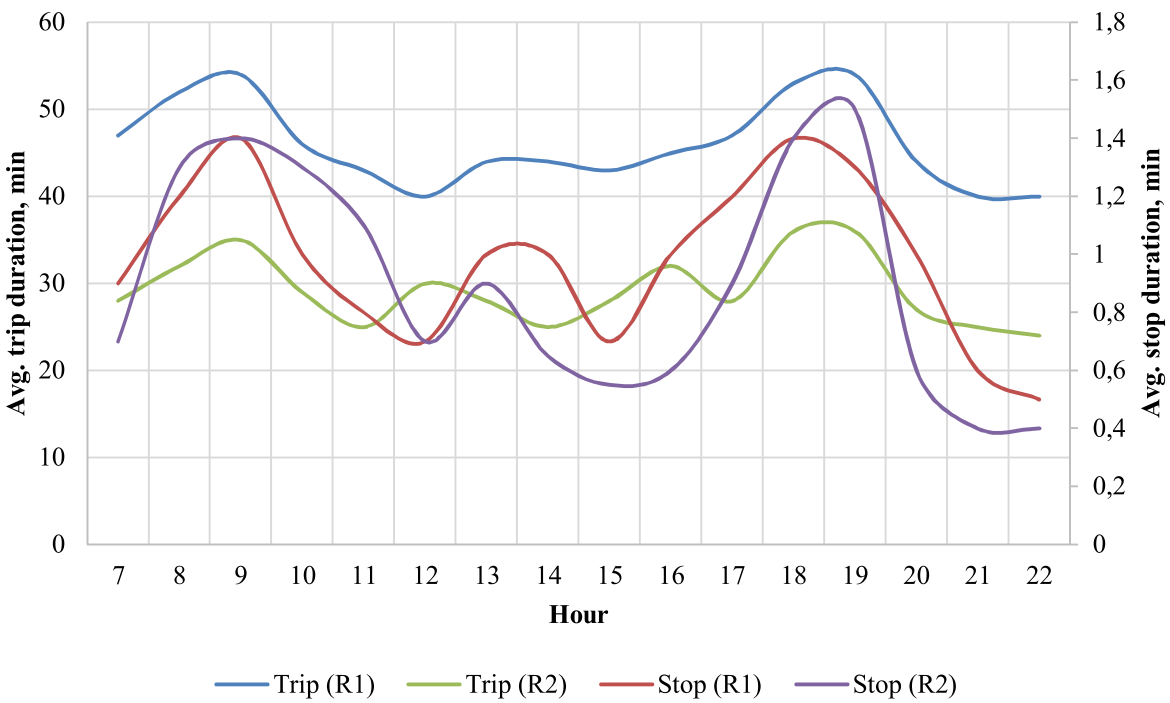

Fig. 5. Change in the average trip and stops duration on trolleybus routes in the autumn-spring season

The average duration of a trip in the autumn-spring period on route No. 1 ranges from 40 to 54 minutes, and the weighted average for this indicator is 46 minutes. The average duration of the stop ranges from 0.5 to 1.4 minutes. The weighted average stop duration is 0.98 min. For route No. 2, it was established that the average duration of the trip varies from 24 to 36 minutes, and the weighted average value of the trip duration is 29.25 minutes. The stop duration changes from 0.4 to 1.4 min; the weighted value is 0.90 min.

As can be seen from the charts, the longest trip duration for route No. is observed at 9 a.m. peak time and 7 p.m., and the shortest trip duration is at 12:00 p.m. and 9–10 p.m. respectively, the average duration of stops increases and decreases. For the trolleybus route No. 2, the longest trip duration is observed at 9 a.m. peak time and 6–7 p.m. in the evening, and the shortest trip duration is at 11:14 a.m. and 9–10 p.m. The longest average stop duration is observed at 6–7 p.m. and the shortest at 9–10 p.m.

Research results indicate that the amplitude of fluctuations in the duration of trips for different seasons differs significantly: in the summer period, during the peak periods of the day, trip duration on both routes increases by 11–12 %; in the winter, this difference is 20 %, and in the autumn-spring period this value reaches 32–35 %. It indicates a noticeable impact of seasonality in road traffic on the congestion of the street and road network, which, in turn, has a negative impact on the regularity of public transport, in particular trolleybuses.

In general, delays in public transport can be separated into two categories – those related to traffic and those resulting from visits to stops for boarding and disembarking passengers. Fig. 6 shows the diagram of the trip distribution time in different seasons.

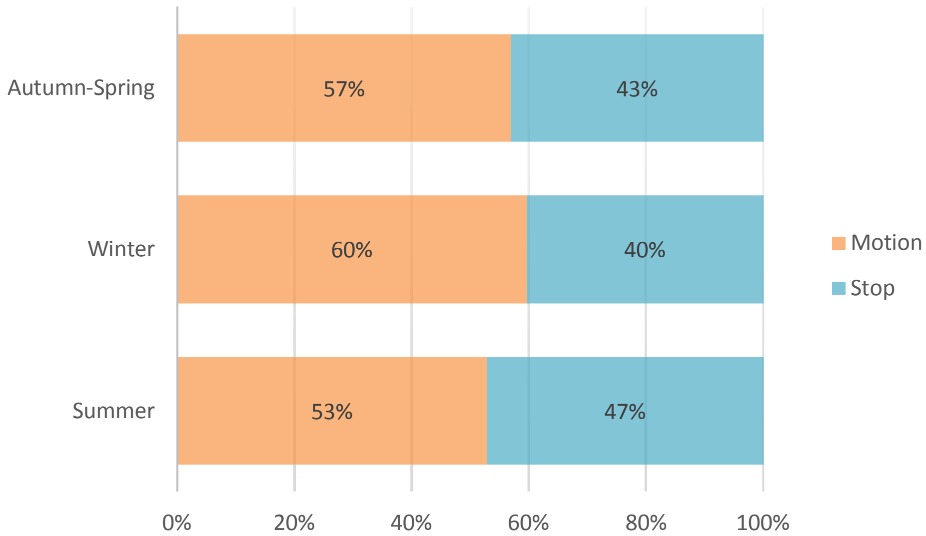

Fig. 6. Trip time distribution of the studied trolleybus routes in different seasons

The calculation results show a difference between the duration of operations on trolleybus routes within 3–7 %. It means there is no influence of the season on the duration of stopping and parking since the share of time for these operations does not exceed 47 %. It is typical for trolleybus routes in large cities. It is worth noting that the share of time spent while boarding and disembarking passengers is the largest in the summer, which is explained by the decrease in time spent on movement during this period. Since Tables 1–3 show that the average time per stop does not change critically during the year.

Based on the results of field studies, it is possible to calculate a quantitative indicator that evaluates the extension of trips duration for trolleybus routes. This indicator can be the coefficient of unevenness of trip duration, calculated as the ratio of the actual trip duration at a certain hour of the day of a separate season to the average hourly trip duration in the summer period. The summer period was chosen as the reference value, as it corresponds to the optimal loading of the street and road network. It is confirmed by the low values of fluctuations in the trip duration in peak and off-peak hours of the day. The results of the calculations are listed in Table 4.

Table 4

Coefficients of unevenness of trips duration on trolleybus routes in different seasons

Time	Summer	Autumn-Spring	Winter
7	0.94	1.12	1.09
8	1.07	1.25	1.25
9	1.07	1.33	1.27
10	1.00	1.12	1.18
11	0.92	1.01	1.07
12	0.95	1.04	1.15
13	0.98	1.07	1.15
14	1.03	1.03	1.16
15	0.98	1.06	1.09
16	1.04	1.15	1.15
17	1.03	1.12	1.10
18	1.03	1.33	1.33
19	1.01	1.34	1.28
20	1.04	1.06	1.15
21	0.95	0.97	1.03
22	0.94	0.95	1.00

The obtained coefficients should be used to evaluate research results in general and to use the forecasting of the trolleybus movement in terms of work on the line at different times of the year. As the results show, the total duration of trips in the winter period is increased compared to the reference time. However, the biggest difference in the studied indicator is still in the autumn-spring period since it is clearly visible in the peak periods. It is also worth noting that the seasonal unevenness of traffic in the winter period is clearly distinguished, the number of city residents gives greater preference to moving by private car (if available). That is evidenced by the general rating of the coefficients of the unevenness of the trips` duration in this period.

As was previously proven, the share of time loss associated with the boarding and disembarking passengers at the stop is almost unchanged. This table also clearly illustrates the state of loading of street and road network traffic both at different times of the day and by season. Regarding the application of the results in the field of public transport management, it is worth noting that in the period of significant extension of the trip duration, one of the measures to maintain the permissible traffic interval may be the release of an additional unit, which will encourage carriers to increase the coefficients of the technical readiness of the fleet.

5. CONCLUSIONS AND RESEARCH PERSPECTIVES

The basis of this paper was the study of the traffic unevenness characteristics in large cities through the prism of public transport indicators. Scientific papers on this topic are aimed at forecasting the volume and speed of traffic on the street and road networks of cities at different times of the year. However, papers related to the unstable public transport operationhave recently been poorly presented.

Two trolleybus routes, different in length but similar in configuration, were chosen for the research, serving both social infrastructure and locations of employment and residential neighborhoods, and the lerger part of the line passes through arterial streets. Time indicators of public transport operation, such as trip duration and the average stop duration for boarding and disembarking passengers were chosen for evaluation. Observation of public transport traffic and data acquisition was carried out using the UA-GISTrek geoinformation system which is a convenient tool for research of this kind. The data are collected in terms of the operation of trolleybuses on the line (hourly) for different seasons, considering that autumn and spring are combined into one season due to the similar nature of population movement.

The research results indicated significant differences in the trip duration change during the day at different times of the year. Thus, in the summer months, during peak hours, the maximum duration of the trip did not exceed the minimum by more than 12 %, but in the autumn-spring period, this difference reached 35 %. It was also found that the time of year is not a factor that changes the time spent while boarding and disembarking passengers.

According to the research results, the coefficients of the trip duration unevenness relative to the reference time were determined. According to these calculations, the maximum value of this coefficient is 1.35 for the autumn-spring period in the evening peak, and the minimum value is reached in the off-peak periods in summer and is 0.92–0.94.

The obtained results make it possible to evaluate further the loading of the street and road network using public transport traffic monitoring, and to use coefficients of trip duration unevenness for drawing up prospective traffic schedules.

References

1. Sustainable Urban Mobility Plan (SUMP) of Lviv. Retrieved from: https://mobility-lviv.com/en/creating-sump/. (in English).

2. Sociological research "Views and opinions of Lviv Agglomeration residents". Retrieved from: https://decentralization.gov.ua/uploads/library/file/859/Report_LvivAgglomeration_March2023_eng_fin.pdf/. (in English).

3. Fornalchyk, Y., & Hilevych, V. (2020). To determination of traffic delay at controlled intersection. *Transport Technologies*, 1(1), 65–72. doi: 10.23939/tt2020.01.065 (in English).

4. The Geography of Transport Systems. Retrieved from https://transportgeography.org/. (in English).

5. Spławińska, M. (2017). Factors determining seasonal variations in traffic volumes. *Archives of Civil Engineering*, *63*(4), 35–50. doi: 10.1515/ace-2017-0039 (in English).

6. Qiang, S., & Huang, Q. (2023). Impacts of bus holding strategies on the performance of mixed traffic system. *Physica A: Statistical Mechanics and its Applications*, *611*, 128455. doi: 10.1016/j.physa.2023.128455 (in English).

7. Gastaldi, M., Rossi, R., Gecchele, G., & Della Lucia, L. (2013). Annual average daily traffic estimation from seasonal traffic counts. *Procedia-Social and Behavioral Sciences*, *87*, 279–291. doi: 10.1016/j.sbspro. 2013.10.610 (in English).

8. Bhin, M., & Son, S. (2021). Reduction and reallocation of bus use under COVID-19: an analysis of bus card data of Gyeonggi Province, South Korea. *International Journal of Urban Sciences*, *25*(3), 416–436. doi: 10.1080/12265934.2021.1936137 (in English).

9. Karve, V., Yager, D., Abolhelm, M., Work, D. B., & Sowers, R. B. (2021). Seasonal disorder in urban traffic patterns: a low rank analysis. *Journal of big data analytics in transportation*, *3*, 43–60. doi: 10.1007/s42421-021-00033-4 (in English).

10. Sun, Y., Lu, Y. C., Fu, K., Chen, F., & Lu, C. T. (2022). Detecting anomalous traffic behaviors with seasonal deep Kalman filter graph convolutional neural networks. *Journal of King Saud University-Computer and Information Sciences*, *34*(8), 4729–4742. doi: 10.1016/j.jksuci.2022.05.017 (in English).

11. Hamedmoghadam, H., Zheng, N., Li, D., & Vu, H. L. (2022). Percolation-based dynamic perimeter control for mitigating congestion propagation in urban road networks. *Transportation research part C: emerging technologies*, *145*, 103922. doi: 10.1016/j.trc.2022.103922 (in English).

12. Carmody, D. R., & Sowers, R. B. (2021). Topological analysis of traffic pace via persistent homology. *Journal of Physics: Complexity*, *2*(2), 025007. doi: 10.1088/2632-072X/abc96a (in English).

13. Ge, L., Li, S., Wang, Y., Chang, F., & Wu, K. (2020). Global spatial-temporal graph convolutional network for urban traffic speed prediction. *Applied Sciences*, *10*(4), 1509. doi: 10.3390/app10041509 (in English).

14. Public transport routes in Lviv. Retrieved from https://lad.lviv.ua. (in English).

15. UA-GISTrek software. Retrieved from http://track.ua-gis.com/ (in Ukrainian).

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ДОСЛІДЖЕННЯ ЧАСОВИХ ПОКАЗНИКІВ РОБОТИ ГРОМАДСЬКОГО ТРАНСПОРТУ ЗАЛЕЖНО ВІД ПОРИ РОКУ

Анотація. *Проблеми мобільності у великих містах України та Східної Європи ускладнюються тим, що збільшення інтенсивності приватного транспорту значно перевищує пропускну здатність вулично-дорожньої мережі, а найбільше це відчутно у пікові періоди не лише світлового дня, але і року. З погляду стійкої мобільності це негативне явище істотно впливає на міський громадський транспорт, який не має окремих виділених ліній руху. В статті проаналізовано питання щодо погіршення транспортної ситуації у великих містах, спричиненого підвищенням інтенсивності руху на магістральних вулицях в пікові періоди доби, а також наявністю сезонних чинників руху. Якщо питання виникнення та тривалості заторів та збільшення часу кореспонденцій приватного транспорту є досить вивченим, то проблеми зміни графіків руху громадського транспорту та врахування збільшення тривалості рейсів залежно від пори року потребують уточнення. Для дослідження вибрано маршрути руху громадського транспорту, який не має окремої інфраструктури і здійснює рух в загальному потоці разом із приватними автомобілями. За результатами дистанційного спостереження за громадським транспортом встановлено зміну тривалості рейсів та втрат часу за рахунок посадки-висадки пасажирів на подібних тролейбусних маршрутах в різні сезони. На основі отриманих даних сформовано матрицю коефіцієнтів нерівномірності тривалості рейсів для маршрутів громадського транспорту та встановлено ступінь впливу сезонності на ці показники. Отримані результати надають можливість кількісно визначити вплив пори року та часу доби на зміну тривалості рейсів, що може бути застосованим як у подальших дослідженнях з використанням засобів імітаційного моделювання, так і у практиці під час складання сезонних розкладів руху. Результати досліджень доповнюють актуальні на цей час наукові праці, які стосуються проблем сезонної мобільності, а також впливу функціонування об’єктів соціальної інфраструктури (школи, дитячі садочки та інші заклади освіти) міст на пікове навантаження вулично-дорожньої мережі, що подовжує тривалість руху не лише приватного, але і громадського транспорту.*

Ключові слова: *інтенсивність руху; громадський транспорт; тривалість рейсу; коефіцієнт нерівномірності; сезонність руху; швидкість сполучення.*