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СОДЕРЖАНИЕ

THE IMPACT OF TRAFFIC FLOW ON BUS MOVEMENT IN URBAN MAIN ROAD NETWORKS

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Annotation: This article addresses the challenges faced by public transportation systems in urban areas and provides recommendations for improvement based on studies conducted in developed countries. The study analyzes the impact of traffic flow, vehicle composition, and speed on the efficiency of bus services in Tashkent's main streets. It highlights the necessity of dedicated bus lanes to enhance safety, reduce delays, and improve travel speed. Data from observations on key roads in Tashkent from 2023–2024 are presented, emphasizing the importance of effective lane management. The study concludes with recommendations for organizing safe and efficient bus movements, supporting urban economic development and social well-being.

Key Words: safe movement, bus stop, mainline network, bus lane, speed, traffic volume, lane.

ВЛИЯНИЕ ТРАНСПОРТНОГО ПОТОКА НА ДВИЖЕНИЕ АВТОБУСОВ В ГОРОДСКИХ МАГИСТРАЛЬНЫХ ДОРОЖНЫХ СЕТЯХ

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Аннотация: В статье рассматриваются проблемы общественного транспорта в городских районах и предлагаются рекомендации по их решению на основе исследований, проведенных в развитых странах. Анализируется влияние интенсивности движения, состава транспортного потока и скорости на эффективность автобусного сообщения на магистралях Ташкента. Особое внимание уделено необходимости выделенных автобусных полос для повышения безопасности, сокращения задержек и увеличения скорости передвижения. Представлены данные наблюдений на ключевых дорогах Ташкента за 2023–2024 годы, подчеркивается значимость эффективного управления полосами движения. Завершается работа рекомендациями по организации безопасного и эффективного движения автобусов, способствующими экономическому развитию городов и благополучию населения.

Ключевые слова: безопасное движение, автобусная остановка, магистральная сеть, автобусная полоса, скорость, интенсивность движения, полоса.

Introduction. Worldwide, public transportation is considered one of the main solutions to traffic congestion problems in urban highway networks [1-2]. The majority of the population prefers to use private vehicles rather than route buses [3-4]. The United Nations aims to make "Safe, Convenient, and Sustainable Transport" accessible to all people on Earth by 2030 [5]. According to the widely accepted view of the transport research community, urban bus systems are inherently more sustainable than private transport systems due to their social, economic, and environmental characteristics. For the efficient and safe operation of urban transport systems, it is necessary to ensure the coordinated operation of route buses, taking into account the limitations of urban transport infrastructure. One of the key issues in eliminating traffic congestion in cities is

making it convenient for people to use route buses. To achieve this, we need to ensure that traveling by public transport is more convenient and faster than using personal vehicles. For the efficient and safe operation of urban transport systems, it is necessary to ensure the coordinated operation of route buses, taking into account the limitations of urban transport infrastructure. One of the main issues in eliminating traffic jams in cities is creating convenience for the population to use buses. To do this, we need to ensure that public transportation is more convenient and faster than personal transportation.

Taking these factors into account, it is necessary to develop requirements for bus stops to be installed before intersections on city main streets. This should be done by studying the current state of route bus traffic organization on the city's main street and road networks, analyzing the impact of traffic flow indicators on the movement of route buses, and examining the left-turn movements of route buses in single-level intersection zones.

A number of scientific researchers have conducted studies on the standardization of these indicators.

In his research, K.R. Kutlimuratov studied route parameters that affect the reliability of transportation services when planning and organizing urban public transport. He focused on the movement of buses during morning and evening rush hours, taking into account intermediate stops [6]. Based on research conducted by A. Nazarov, Doctor of Technical Sciences, for the city of Tashkent, criteria have been developed that consider 10 indicators determining the quality level of passenger transportation services in Tashkent [7]. In the research conducted by K.N. Muslimanov under the guidance of Prof. K.Kh. Azizov, it was observed that the composition of traffic has a significant impact on the speed of the traffic flow. The speed of the traffic flow decreases due to reduced dynamic characteristics with an increase in the proportion of heavy trucks and buses, as well as deteriorating visibility conditions [8]. A.A. Khomidov's research examined changes in the speed of route buses under different weather conditions. He provided recommendations to improve the efficiency of transport services in various weather conditions [9]. In Le Dik Long's scientific research under the guidance of Prof. P.I. Pospelov, the impact of pedestrians on vehicle delays on Vietnamese highways was studied. He proposed a method for determining the distance required for cars to change lanes and turn right at pedestrian-regulated and unregulated intersections when there is a dedicated lane for street-level route buses [10]. In his candidate work under the supervision of Prof. V.I. Sarbayev, M.N. Khamidulin analyzed route characteristics affecting the traffic safety level of route buses. He formulated a classification of these characteristics in comparison to city buses serving regular routes in large cities [11].

Separate lanes have been established for public transport on certain streets of Tashkent. However, the conditions for passenger boarding and alighting, equipment, and turning at intersections for buses currently operating in these lanes are not fully developed. Typically, buses arrive late at their destinations, and there are instances where they obstruct the flow of traffic in the general lane when making left turns. Therefore, developing and scientifically substantiating recommendations for the proper organization and improvement of bus traffic on dedicated lanes within the city's main street and road networks is considered one of the urgent tasks.

Methods. The reliability of the passenger transportation process depends on several factors, primarily: the reliability of the bus design; the complete and timely dispatch of buses on routes; the non-return of buses to the auto enterprise due to technical malfunctions and other reasons; the qualifications of drivers; and most importantly, the condition of road infrastructure, etc. The time spent by passengers during their journey includes: the time taken for passengers to reach public transport stops; waiting time for the bus; travel time; time to reach the destination; and time for transferring to another bus [12].

In order to enhance the appeal of bus routes in Tashkent city and establish consistent and steady bus movements, dedicated bus lanes totaling 50.6 km were created on 17 streets of the city in 2023.

Separate lanes are primarily established to ensure the free, fast, and convenient movement of route buses on the city's main street and road networks. The main indicators influencing the

movement of route buses are the traffic intensity of motor vehicles, traffic composition, traffic flow speed, and traffic density.

The change in traffic composition on city streets is as follows: passenger cars 85-92%; buses 3-6%; trolleybuses 0.5-2%; trucks 3-8% [13].

The traffic volume is a variable indicator with respect to years, months, hours of the day, days of the week, as well as sections of the road. The traffic volume on city streets varies depending on the importance of the streets and the economic development of the surrounding districts.

In visual accounting of traffic intensity, according to paragraph 2.5 of MQN 45-2007 [14], the average daily traffic intensity is determined using the transition coefficient "K_t," which is calculated for 1, 2, 3, ... 11-hour (N-hour) traffic intensity measured under field conditions using the following formula:

$$N_{day} = N_{hour} * K_t$$

where: K_t - the coefficient for converting hourly traffic intensity to average daily traffic intensity (Appendix F of MKN 45-2007).

To develop the aforementioned requirements, the main streets of Tashkent city were selected as research objects. To study the impact of traffic volume, speed, and composition on the movement of route buses, research was conducted on the following streets (Table 1):

Table 1

№	Street name	Existence of a dedicated lane for route buses	Number of tapes
1	Nukus	Available	4x2
2	Amir Temur	Available	
3	Fargona yuli	Available	
4	Mirzo Ulugbek	Available	
5	Yuzrabod	Available	
6	Shota Rustaveli	Not available	5x2
7	Amir Temur	Available	
8	Mukimiy	Not available	
9	Kichik halka yuli	Not available	

Results. Today, the state and quality of urban transport systems largely depend on the efficiency and safety of city buses, which serve as the most crucial system ensuring the economic development of cities and the social well-being of the population [15].

Dhaka, the capital of Bangladesh, is one of the most densely populated cities in the world. Approximately 14 million people reside in an area of around 2000 square kilometers [16]. The existing public transport system in Dhaka's street network is primarily characterized by large buses, minibuses, and rickshaws. The 2004 Dhaka Strategic Transport Plan categorizes buses into several types: minibuses (41%), microbuses (30%), large buses (13%), rickshaws (12%), and staff and school buses (4%). The private sector accounts for 95% of passenger transportation in Dhaka [17].

China plans to reduce the number of cars in the future by approximately 75%, which amounts to 196.1 million vehicles. If a bus can accommodate 40 people, then 4.9 million buses would need to be added. This will decrease traffic congestion on roads and contribute to the sustainable development of cities. On average, a passenger car travels 10,000 km per year and consumes 1,000 liters of gasoline, with annual carbon emissions of about 2.7 tons per vehicle. By reducing the number of cars by 196.1 million, it could potentially decrease carbon emissions by 529.5 million tons [18].

In our research work, we conducted observations to determine the volume and composition of traffic on the Small Ring Road, Muqimiy, Nukus, Shota Rustaveli, Amir Temur, Fergana Road,

Mirzo Ulugbek, and Yuzrabod streets of Tashkent from 2023 to 2024. Our observations were carried out on motor vehicles from 8:00 a.m. to 8:00 p.m.

The traffic volume is a variable indicator at different hours of the day. Research conducted over the years shows that it reaches high levels in the morning and evening, while being somewhat lower during the daytime.

The results of the research conducted on 8 main street and road networks in Tashkent city have been summarized and are presented in Table 2 and Figure 1.

Changes in traffic volume (N) by hour on the city's main street and road networks

Table 2

Street names	Days of the week							total
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	
Kichik halka yuli	68426	65463	64585	66624	66646	61083	45208	438035
Mukimiy	55264	56184	54969	57604	57274	47489	31443	360227
Nukus	53922	48254	54452	51897	50251	44002	27630	330408
Shota Rustaveli	58923	59068	57549	57800	57672	55959	35453	382424
Amir Temur	69534	68925	67390	68103	68302	59826	39720	441800
Fargona yuli	60167	60070	59401	59504	59486	49263	36367	384258
Mirzo Ulugbek	68685	68203	63614	64094	63947	57456	38922	424921
Yuzrabod	43489	43281	42048	40620	40617	35178	29527	274760

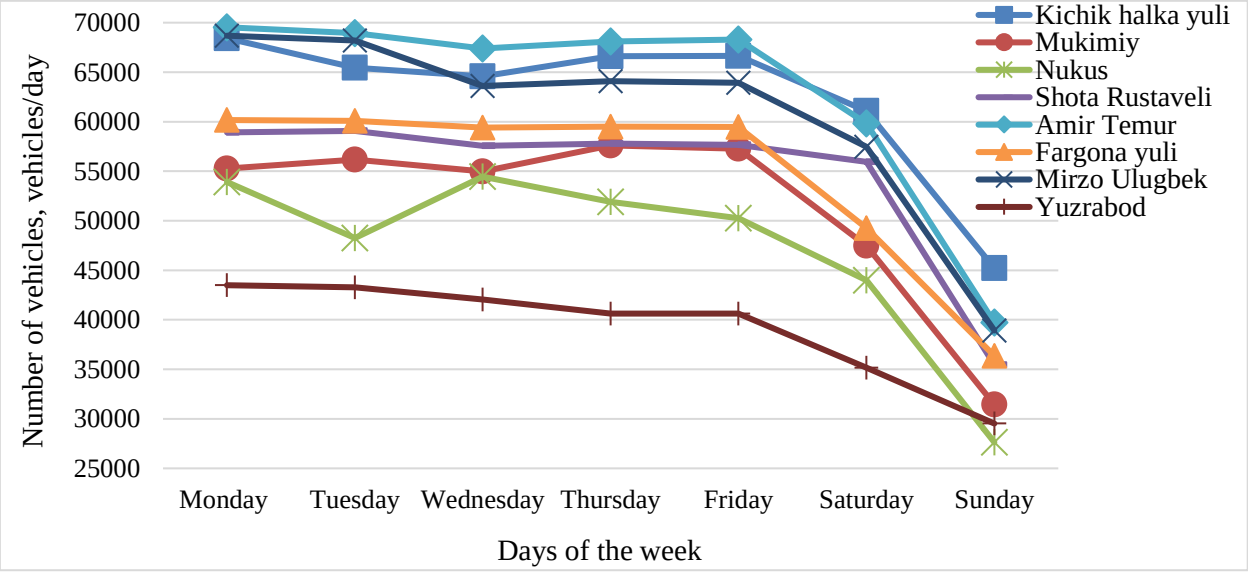

Figure 1. Graph showing the change in traffic volume of motor vehicles on the main streets of Tashkent.

As evident from the graph in Figure 1, the traffic volume on the Small Ring Road, Amir Temur Street, and Mirzo Ulugbek Street is higher compared to other streets. Yuzrabad Street shows a significantly lower traffic intensity than other streets. We can observe that the traffic intensity on the remaining 4 streets falls within the average range among the 8 streets.

The composition of traffic flow significantly influences the speed of the traffic. As the proportion of heavy trucks and buses in the flow increases, the speed of the traffic flow decreases due to reduced dynamic characteristics and deteriorating visibility conditions.

The results of the traffic composition study conducted on the streets of Tashkent city are presented in Table 3 below.

Table 3

Vehicle composition over a week on the main streets of Tashkent						
Street names	Types of transport					
	Passenger car	Truck	Bus	Minibus	Bicycle and motorcycle transport	Total
Kichik halka yuli	399123/ 91,3	25040 / 5,7	6993/ 1,6	4587/ 1,0	1740 / 0,4	438035/ 100
Mukimiy	351820/ 96,6	8272 / 2,3	1544/ 0,4	1587/ 0,4	794 / 0,2	360227/ 100
Nukus	321487/ 97,3	3965 / 1,2	3304/ 1,0	330/ 0,1	1322 / 0,4	330408/ 100
Shota Rustaveli	369899/ 96,7	4543 / 1,2	5053/ 1,3	645/ 0,1	2284 / 0,6	382424/ 100
Amir Temur	416682/ 94,3	15453 / 3,5	3453/ 0,8	4472/ 1,0	1739 / 0,4	441800/ 100
Fargona yuli	349484/ 91,0	22096 / 5,8	8109/ 2,1	2131/ 0,6	2437 / 0,6	384258/ 100
Mirzo Ulugbek	414594/ 97,6	1600 / 0,4	5544/ 1,3	2608/ 0,6	575 / 0,1	424921/ 100
Yuzrabod	261918/ 95,3	5288 / 1,9	5132/ 1,9	607/ 0,2	1815 / 0,7	274760/ 100

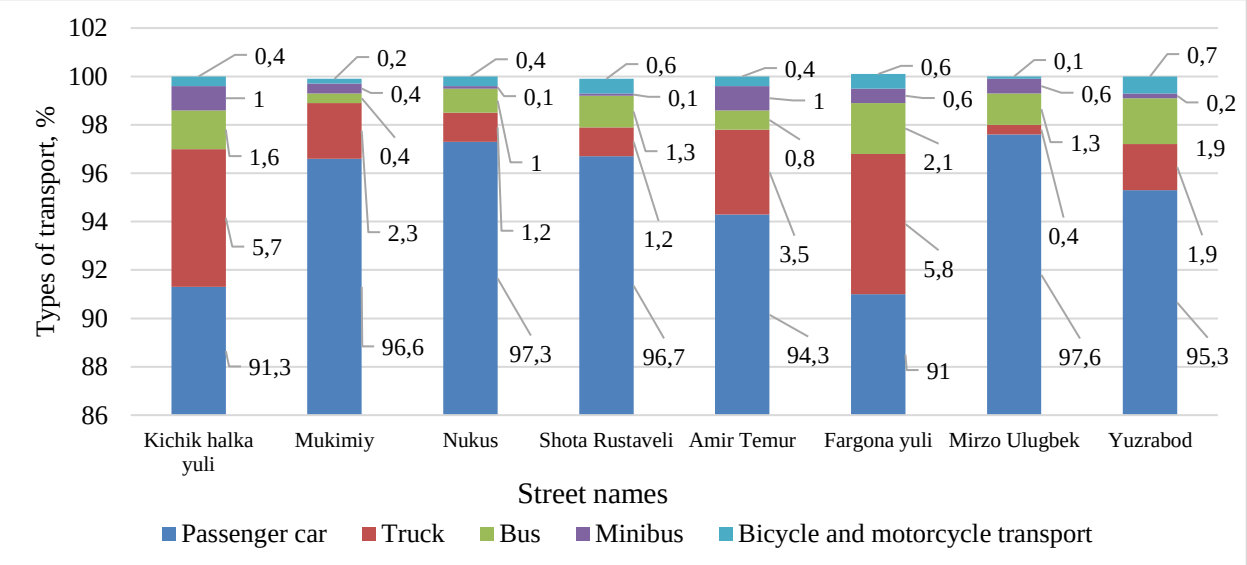

Figure 2. Graph showing the weekly composition of vehicle types on the main streets of Tashkent

As shown in Table 3 and Figure 2, there is less passenger car traffic on the Small Ring Road and Fergana Road streets. Trucks have higher numbers primarily on the Small Ring Road, Amir Temur, and Fergana Road streets. Bus traffic is more prevalent on Fergana Road, Yuzrabad, and Small Ring Road streets. The more active movement of minibuses is mainly observed on Amir Temur and Small Ring Road streets. There is active movement of bicycles and motorcycles on Shota Rustaveli, Fergana Road, and Yuzrabad streets.

The changes in traffic composition on these streets were as follows: passenger cars 91.0-97.6%, trucks 0.4-5.8%, buses 0.4-2.1%, minibuses 0.2-1.0%, and bicycles and motorcycles 0.1-0.7% (Figure 2).

Discussion. Observations show that the main peak hours of vehicle traffic occur during the morning and evening time intervals. This leads to high levels of congestion during morning and evening hours, hindering the scheduled movement of route buses, requiring more time for drivers and passengers to reach their destinations, and causing some drivers of passenger cars and trucks to violate rules by using dedicated bus lanes on streets where special bus sections have been established.

As a solution to the studied problems, we can look at the municipality of Bucharest. They approved a "Sustainable Urban Mobility Plan" for 2016-2030 and began implementing a comprehensive transport policy in the Bucharest-Ilfov region[19]. An important part of the transport policy is to encourage certain types of transportation, which reduces congestion and air pollution. A key element of this strategy is the development of route buses.

The organization of dedicated lanes for route buses can be implemented using the following methods:

- Separating lanes for vehicles and taxis of the Bucharest Public Transport Company in the same direction as existing traffic. These lanes can operate continuously (24 hours a day) or only during specific time periods;

- Streets reserved exclusively for route buses. Depending on local urban conditions and street widths, these are typically located in city centers. For example, they have been introduced near pedestrian-only zones in Birmingham and Leeds in the United Kingdom.

- A lane reserved for route buses in the left lane of one-way streets[19].

It is known that in accordance with the Decree of the President of the Republic of Uzbekistan No. PP-59 "On measures to reform the public transport system" dated February 16, 2023, the creation of 36 dedicated bus lanes with a total length of 475 km for the continuous operation of regular bus routes is planned in the city of Tashkent by 2025[20]. In order to ensure the implementation of the decree, enhance the appeal of Tashkent's city bus routes, and organize their regular and uniform movement, separate bus lanes with a total length of 50.6 km were established on 17 streets of the city in 2023[21]. Data on dedicated bus lanes established for public transit buses on these streets, as of January 1, 2024, is presented in Table 4.

Table 4.

№	Streets where bus lanes have been implemented	Number of streets	Length of bus lane, km
1	“Yangi yunusobod” Street	1	2,4
2	“Amir Temur” Street	1	8
3	“Bobur” ва “Furkat” Streets	2	4,8
4	“Samarkand darvoza” Street	1	0,73
5	“Alisher Navoiy” ва “Beruniy” Streets	2	7,6
6	“Rixsiliy” Street	1	1,5
7	“Farxod” (From the intersection of Lutfiy Street), “KHAY” (Up to Shota Rustaveli Street) Streets	2	4
8	“Yangi sergeli” Street	1	5,3
9	“Istikbol” Street	1	1,3
10	“Mirzo Ulugbek” Street	1	2,78
11	“Feruza” and “Yuzrabad” Streets	2	4
12	“Fargona yuli” Street	1	6,7
13	“Nukus” Street	1	1,5
Total		17	50,6

A study conducted by specialists from the project office of the Ministry of Transport examined the implementation of dedicated bus lanes on main streets between the "Yunusabad Dekhkan Bazaar" and "Alai Bazaar" stations. The comparison of bus speeds before and after the allocation of these separate lanes showed that the average speed increased by 68%, from 14.2 km/h to 23.8 km/h [22]. Figure 3 illustrates the graph of bus speed changes developed as a result of this research.

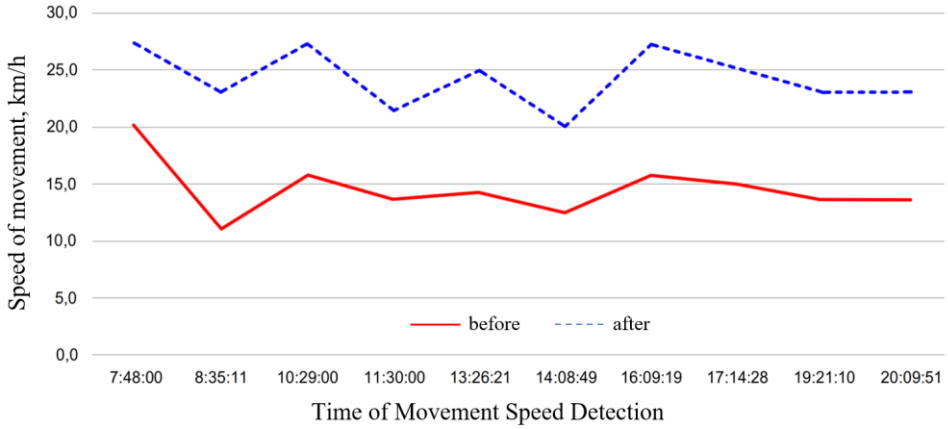

Figure 3. Graph of average travel speed between "Yunusabad Dekhkan Bazaar" and "Aloy Bazaar" stations

By implementing dedicated bus lanes on city streets, we can increase the speed of buses to some extent. However, if traffic in these lanes is not properly organized, the bus speed will not differ significantly from its previous state. The traffic flow in lanes designated for route buses should be safe and convenient.

Bus stops located on separate special bus lanes

If they are positioned in accordance with the requirements of regulatory documents such as SHNK 2.07.06-24 and O'zDst 3196-23, the safe operating speed of buses will increase, and the delay time at stops will be reduced.

Based on the information provided above, to improve the organization of safe movement of city buses on dedicated bus lanes, it is advisable to perform the following tasks:

–Analyze the movement of route buses on separate lanes allocated for public transport vehicles in the streets of developed foreign cities;

–Determine the impact of traffic volume, composition, speed, density, and level of congestion on the movement of route buses in streets with lanes separately allocated for public transport vehicles within the city's main street and road networks;

–Assess the influence of geometric dimensions of streets with separate lanes for public transport vehicles on the movement of route buses within the city's main street and road networks;

–Develop a model for organizing safe traffic on different sections of streets with lanes separately allocated for public transport vehicles;

–Develop recommendations for improving the organization of route bus traffic on the city's main street and road networks and determine their economic efficiency.

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