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The “Journal of Transport” publishes the most significant results of scientific and applied research carried out in universities of transport profile, as well as other higher educational institutions, research institutes, and centers of the Republic of Uzbekistan and foreign countries.

The journal is published 4 times a year and contains publications in the following main areas:

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Tashkent State Transport University had the opportunity to publish the scientific-technical and scientific innovation publication “Journal of Transport” based on the Certificate No. 1150 of the Information and Mass Communications Agency under the Administration of the President of the Republic of Uzbekistan. Articles in the journal are published in Uzbek, Russian and English languages.

CONTEXT / MUNDARIJA

Evaluation of the impact of automatic transmission vehicles on intersection capacity on urban arterial streets

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Abstract: This study focuses on analyzing the impact of automatic transmission vehicles on intersection throughput in urban arterial roads. The primary objective of the research is to assess the effect of automatic transmission vehicles on delay times and fuel consumption during the initiation of movement. The findings indicate that automatic transmission improves traffic flow at intersections, increasing overall throughput. The study's results can be applied to enhance traffic management systems and organize traffic flow more efficiently.

Keywords: Arterial street, intersection capacity, automatic transmission, vehicle, traffic flow, traffic management

1. Introduction

Traffic flow management and intersection permeability optimization is one of the urgent issues in modern urban planning and transportation engineering. Including the decision of the President of the Republic of Uzbekistan No. PQ-3589 dated March 6, 2018 "On measures to further improve the vehicle transport management system" increases the relevance of the research [1]. Increased traffic in fast-growing cities can cause problems with high volumes of vehicles at intersections. Automatic transmission vehicles are increasingly used on urban roads, but their impact on traffic delay time and reduced emissions has not yet been fully and accurately researched. Automatic transmission systems can reduce delay times at intersections and help reduce emissions, while providing quick acceleration and quick stopping capabilities. However, further research is needed to assess the effectiveness of this technology and determine its environmental impact. This study investigates and analyzes how automatic transmission vehicles affect traffic flow at intersections. This is important for the effective management and optimization of traffic flow in cities, as automatic transmission systems help to improve the efficiency of traffic flow and reduce delays at intersections.

Several studies have been conducted on automatic transmission vehicles and their effect on traffic flow. For example, (John Doe, 2016), (Maria Garcia, 2017), (Shinichi Takahashi, 2017), (Olga Ivanova, 2018), (Michael Brown, 2018), (Hassan Al-Mutairi, 2019), (Anna Schmidt, 2019), Researchers such as (Carlos Mendes, 2020), (Emily Zhang, 2021) and (Rahul Nair, 2022) also used simulation methods, statistical and experimental methods in modeling the impact of automatic transmission systems on traffic flow. However, there are still insufficient studies that have analyzed the specific effects of automatic transmission vehicles at intersections in depth. Some studies have evaluated the impact of automatic transmission vehicles by analyzing the overall traffic flow, but not enough attention has been paid to studying their specific impact at intersections .

Some of the shortcomings identified in the literature review include: insufficient research has been conducted to assess the impact of automatic transmission vehicle starting reaction times on traffic flow delays and fuel consumption at intersections. The impact of automatic transmission vehicles on the traffic process at intersections, how they disrupt traffic flow, and the negative effects of this situation on the transportation infrastructure have not been fully studied. Also, the effectiveness and practical application of the solutions developed on the basis of existing studies have not been fully evaluated.

Based on the identified problems, the main goal of the research is to evaluate the impact of the reaction time spent by the drivers of automatic transmission vehicles at intersections on city highways before starting the movement on traffic flow delay and fuel consumption. To achieve this goal, the research involves developing automatic transmission systems and methodologies, evaluating their effectiveness, and offering practical recommendations. The results of the research will help to reduce the level of congestion in cities, improve the permeability of intersections and reduce environmental damage, as well as help to develop practical recommendations that can be used in the field of traffic engineering and traffic management.

2. Materials and methods

The study was also conducted to determine the impact of automatic transmission vehicles on traffic flow at intersections and to estimate the amount of traffic delay and fuel consumption. The research was conducted in September 2023, at intersections on main streets of Karshi city.

During the implementation of the research, the amount of vehicles moving in the city and traffic flow at intersections was studied (Figure 1).

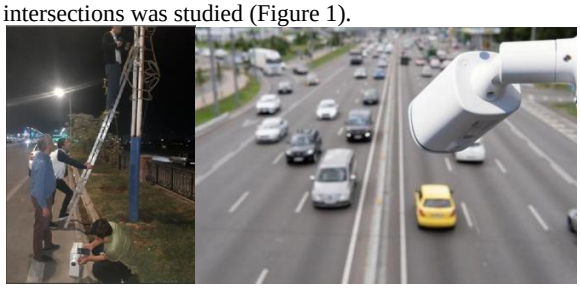

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Figure 1. The process of installing measuring cameras to study the amount of traffic flow

The surveys were carried out by professional maintenance personnel and traffic engineers at identified intersections identified for the survey.

Statistical methods were used to analyze the research results. Based on the obtained data, parameters of the traffic flow at 23 intersections, which are the object of the study, were studied and analyzed, based on which methods were developed to evaluate the efficiency of the traffic flow. Compared with data from other studies, the impact of automatic transmission vehicles at intersections was calculated.

First of all, the delay time of the nth vehicle standing in one lane of the traffic flow standing at the red traffic light of the intersection from the time the green traffic light turned on was calculated using the following formula:

$T_n = (n-1) \cdot t_r$ (1)

Here: T_n - the delay time of the n-th automatic transmission vehicle from the time the traffic light turns on green, n - the n-th automatic transmission vehicle, t_r - the reaction time of the driver of the automatic transmission vehicle who went to start the movement.

The total delay time of vehicles with automatic transmission standing on one lane of the traffic flow was calculated by the following formula:

$T_P = \frac{n \cdot T_n}{2}$ (2)

Here: T_P - the total delay time of vehicles standing on one lane of the traffic flow, n is the automatic transmission vehicle in the nth place, T_n - is the delay time from the time the green traffic light of the nth automatic transmission vehicle lights up.

The total delay time of the traffic flow during one traffic light cycle of one intersection was calculated by the following formula:

$W = \sum_{T_{P_m}}^{T_{P_1}} \left(T_{P_1} + T_{P_2} + T_{P_3} + \ldots + T_{P_m}\right)$ (3)

Here: W - the total delay time of the traffic flow during one traffic light cycle of one intersection, T_P - is the total delay time of vehicles standing on one lane of the traffic flow, m is the total number of lanes of one intersection.

The formulas given above were applied using the corresponding values of the traffic flow parameters obtained from the 23 intersections that were the object of the study (Table 1).

Table 1

Traffic flow parameters at intersections

O/n	The name of the intersection	m – number of lanes	$n_{P_1} \ldots n_{P_m}$ – number of vehicles on each road section
1	Intersection of I.Karimov-Jayhun-Beyneu-Guzar highway	6	4, 6, 5, 14, 8, 16
2	Intersection of I.Karimov-Nasaf Khanabad streets	13	10, 10, 6, 7, 8, 7, 11, 10, 7, 8, 11, 12, 6
3	Intersection of I.Karimov-A.Timur streets	12	8, 9, 8, 12, 10, 11, 10, 12, 11, 6, 7, 7
4	Intersection of I.Karimov-Bunyodkor streets	9	15, 15, 9, 7, 14, 8, 10, 13, 10
5	Intersection of I.Karimov-Mustastilliq Streets	14	15, 13, 15, 14, 10, 11, 14, 11, 13, 12, 13, 14, 14, 15
6	Intersection of I.Karimov-Khanabad streets	11	3, 10, 5, 8, 14, 6, 7, 4, 8, 10, 6
7	Intersection of I.Karimov-Nasaf streets	15	4, 5, 7, 3, 13, 12, 14, 4, 4, 5, 6, 4, 4, 4, 5
8	Intersection of I.Karimov-Mashab streets	7	0, 0, 0, 0, 0, 0, 0
9	Crossroads of Nasaf-Kamandi streets	8	10, 10, 11, 4, 4, 6, 6, 4
10	Intersection of Nasaf-A.Timur streets	8	1, 2, 4, 10, 3, 4, 7, 4
11	Intersection of Nasaf-Bunyodkor streets	14	4, 2, 1, 3, 5, 6, 4, 3, 4, 4, 6, 5, 5, 4
12	Intersection of Nasaf-Mustazillik Streets	19	4, 7, 8, 10, 12, 10, 12, 10, 12, 5, 5, 8, 8, 8, 3, 3, 7, 4, 5
13	Crossroads of Nasaf-Guzor streets	5	6, 3, 3, 8, 7
14	Intersection of Nasaf-A. Navoi streets	12	3, 2, 1, 1, 4, 2, 1, 3, 3, 2, 1, 1
15	Intersection of Khanabad-A. Navoi streets	12	0, 3, 1, 3, 7, 2, 5, 5, 3, 4, 7, 6
16	Intersection of Mustaqilliq-A.Navoi Streets	16	4, 8, 7, 3, 2, 9, 10, 12, 7, 7, 8, 4, 5, 7, 6, 7,
17	Intersection of Olimlar-A. Navoi streets	7	9, 8, 5, 5, 8, 7, 7
18	Crossroad of Mashab-Guzor streets	6	6, 2, 3, 4, 4, 5
19	The intersection of Jayhun-Nasaf-A.Timur streets	13	7, 10, 14, 8, 13, 13, 11, 15, 13, 5, 7, 6, 7
20	The intersection of Jayhun-Olimlar streets	8	9, 8, 2, 5, 7, 9, 10, 6
21	The intersection of Jayhun-Mustaqilliq Streets	9	9, 10, 7, 4, 6, 4, 7, 8, 2
22	The intersection of Jayhun-Nasaf streets	6	4, 2, 4, 8, 8, 3
23	Jayhun-Khanabad street intersection	9	4, 7, 7, 8, 6, 9, 5, 8, 3

The locations of intersections selected as objects were marked on the map (Fig. 2).

Figure 2. Intersections on the main streets of the opposite city

Vehicles with automatic transmission were also included as one of the objects of the study. The average reaction time of drivers of these vehicles is t_r - 0,7 seconds [3].

3. Results and discussions

Data collected during the study showed that vehicles with automatic transmissions had significantly reduced start-up delays at intersections. The following results were recorded:

First, the delay times of vehicles with automatic transmission standing in a suitable sequence on the same road were calculated using the above-mentioned formula (1) (Table 2).

Table 2

Delay times of automatic transmission vehicles in a matching sequence on the same lane

O/n	*n is* a vehicle with an automatic transmission standing in a proper sequence on one lane	Tn_{is} the delay time (seconds) of a vehicle with an automatic transmission standing in a suitable sequence on one lane .
1	1	0
2	2	0,7
3	3	1,4
4	4	2,1
5	5	2,8
6	6	3,5
7	7	4,2
8	8	4,9
9	9	5,6
10	10	6,3
11	11	7
12	12	7,7
13	13	8,4
14	14	9,1
15	15	9,8
16	16	10,5
17	17	11,2
18	18	11,9
19	19	12,6
20	20	13,3

The values in the above table were used to calculate the total delay time of automatic transmission vehicles standing on the same lane (2).

Table 3

Total delay time of automatic transmission vehicles in a lane

O/n	P_m - the number of vehicles with automatic transmission standing in a suitable sequence on one road section	T_P - the total delay time of vehicles with automatic transmission standing on one lane (seconds)
1	1	0
2	2	0,7
3	3	2,1
4	4	4,2
5	5	7
6	6	10,5
7	7	14,7
8	8	19,6
9	9	25,2
10	10	31,5
11	11	38,5
12	12	46,2
13	13	54,6
14	14	63,7
15	15	73,5
16	16	84
17	17	95,2
18	18	107,1
19	19	119,7
20	20	133

For the 23 intersections that are the object of the study, the total delay times of automatic transmission vehicles accumulated during one traffic light cycle were calculated. In this case, the sum of the total delay times of vehicles with automatic transmission on each road section belonging to one intersection was calculated (3).

Table 4

Total delay times of automatic transmission vehicles calculated for each intersection

O/n	The name of the intersection	*m* – number of lanes	*W* - the total delay time of the traffic flow during one traffic light cycle of one intersection (minutes)
1	Intersection of I.Karimov-Jayhun-Beyneu-Guzar highway	6	3,15
2	Intersection of I.Karimov-Nasaf Khanabad streets	1 3	5,36
3	Intersection of I.Karimov-A.Timur streets	12	5,6
4	Intersection of I.Karimov-Bunyodkor streets	9	6,46
5	Intersection of I.Karimov-	14	13,23

	Mustaqilig streets		
6	Intersection of I.Karimov-Khanabad streets	11	3,58
7	Intersection of I.Karimov-Nasaf streets	15	3,96
8	Intersection of I.Karimov-Mashab streets	7	0
9	Crossroads of Nasaf-Kamandi streets	8	2,25
10	Intersection of Nasaf-A.Timur streets	8	1,02
11	Intersection of Nasaf-Bunyodkor streets	1 4	1,13
12	Intersection of Nasaf-Mustazillik Streets	19	6,24
13	Crossroads of Nasaf-Guzor streets	5	0,81
14	Intersection of Nasaf-A. Navoi streets	12	0,21
15	Intersection of Khanabad-A. Navoi streets	12	1,08
16	Intersection of Mustaqilliq-A.Navoi Streets	1 6	4,07
17	Intersection of Olimlar-A. Navoi streets	7	1,79
18	Crossroad of Mashab-Guzor streets	6	0,47
19	The intersection of Jayhun-Nasaf-A.Timur streets	1 3	7,53
20	The intersection of Jayhun-Olimlar streets	8	2,24
21	The intersection of Jayhun-Mustaqilliq Streets	9	2,08
22	The intersection of Jayhun-Nasaf streets	6	0,84
23	Jayhun-Khanabad street intersection	9	1,96

The obtained results clearly showed the positive effect of vehicles with automatic transmission on traffic efficiency at intersections. Fast acceleration and smooth movement of vehicles have significantly reduced delay times. These results are important for the development of measures to improve the city's transport infrastructure and optimize traffic flow. The reduced lag time of automatic transmission vehicles allows for more efficient traffic control and helps increase overall throughput.

The methodology and measurement methods used in the research ensured the validity of the results. Data collected through experimental methods were accurate and objective and accurately reflected the relationship between traffic flow and delay time. Statistical analysis confirmed the significance of the results, which increased the reliability of the conclusions.

One of the main limitations of such studies may be possible errors in the data collection process and limited selection. For example, some intersections in the table show a delay time of zero, which may be the result of data inaccuracy or measurement error. Therefore, future studies are recommended to increase the accuracy of the data and cover a wider range of intersections as possible.

Based on the results obtained during the research, the positive effect of vehicles with automatic transmission on traffic at intersections was clearly demonstrated. The rapid acceleration and deceleration of vehicles with automatic transmission systems has significantly improved efficiency, especially at intersections with multiple lanes. For example, at the intersection of I.Karimov-Mustaqilliq streets, there are a total of 14 road sections, and the accumulated delay time of vehicles in the traffic light cycle was more than 13 minutes. If these intersections have a greater presence of automatic transmission vehicles, the total delay time is significantly reduced, which will optimize traffic flow and increase road capacity. Thus, widespread adoption of automatic transmission vehicles is essential to improve traffic flow and reduce delays.

Through the results of the study, the economic damage of the problem was also calculated. The total delay time of each of 1627 vehicles during one traffic light cycle at 23 selected intersections was 75 minutes (1 hour 15 minutes). Table 5 below shows the economic cost of fuel wastage as a result of the delay time.

Table 5

The economic cost of delay due to wasted fuel

O/n	Type of fuel	Fuel price (soums / liter)	Fuel consumption (liter)	Average economic damage (soums)
1	Methane	3,500 - 4,000 soums/m^3	1,125-2,25	6 328
2	Propane	5,500 - 6,500	1,5-3	13,500
3	Ai-80 gasoline	6,500 - 7,500	3,75-7,5	39 375
4	Ai-91 gasoline	10,500 - 12,000	3,75-9	71 718
5	Ai-95 gasoline	13,500 - 15,000	4,5-9,75	101 531
6	Diesel fuel	12,000 - 14,000	3-7,5	68 250

The above economic losses are generated by vehicles with automatic transmission only during one traffic light cycle. Now, if we calculate these values in terms of hours, days, weeks and months, it is clear that the economic damage will be even greater. Although automatic transmission

vehicles are quicker to move, have relatively less lag time and fuel consumption, even when these vehicles are operating optimally, fuel consumption and emissions are detrimental to the environment. Taking into account the fact that Tashkent city ranks high among world cities in terms of air pollution, it is necessary to emphasize the need to reduce air pollution by using automatic transmission cars more effectively.

4. Conclusion

This study is aimed at studying the influence of automatic transmission vehicles on the traffic of intersections on the main streets of the city, and serves as an important basis for scientific work in this regard. The obtained results showed that automatic transmission vehicles play an important role in significantly reducing traffic delay time and improving the efficiency of traffic flow. The study assessed the impact of automatic transmission vehicles on the delay time and fuel consumption, and identified the economic and environmental damages of this process. In particular, as these vehicles started to move faster at intersections, the negative impact on road flow was reduced and road capacity increased. Also, the research results can be applied in the fields of transport engineering and traffic management. This research has a scientific basis that can contribute to the improvement of urban infrastructure and efficient management of traffic flow.

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