The influence of the corona virus pandemic on the characteristics of vehicle flow on the e-661 highway

Vladimir Gatarić
Assistant, Master of Science in Traffic Engineering, Pan-European University APEIRON, College of Traffic Engineering, Banja Luka, Republic of Srpska, vladimir.j.gataric@apeiron-edu

Tanja Marjanac
Assistant, Bachelor of Science in Architecture, Pan-European University APEIRON, College of Traffic Engineering, Banja Luka, Republic of Srpska, tanja.l.skoric@apeiron-edu.eu

Vuk Bogdanović
Professor, APEIRON, College of Traffic Engineering, Banja Luka, Republic of Srpska, vukbogdanovic1966@gmail.com

Abstract: In this work, the characteristics of the traffic flow on the section of the Gradiška- Banja Luka highway, which is part of the European road route E-661, were analyzed in the period from 2019 to 2022. Data on the size of flow requests were taken from the database of the toll station "Jakupovci" on the Gradiška- Banja Luka highway. When defining the size of the flow request, the structure of the traffic flow was also taken into account, in accordance with the categories according to which the toll is collected. The period in which the analysis of flow characteristics was performed also includes the period in which the coronavirus pandemic reigned, when certain travel rules and prohibitions were in force. In accordance with that, the work will specifically analyze the impact of the COVID 19 pandemic on the characteristics of the traffic flow on the Gradiška- Banja Luka highway section. Given that the „Jakupovci" toll station is the busiest toll station on the Gradiška- Banja Luka highway, the results of the analysis can be applied to other sections of highways in the Republic of Srpska.

Keywords: Traffic flow characteristics, vehicle flow, COVID 19 pandemic, Gradiška- Banja Luka highway

INTRODUCTION

Traffic is affected by numerous factors, such as traffic accidents, works, weather conditions, natural disasters, etc. Given that, predicting the flow of traffic is an extremely complex and complex job. The accuracy of predictions depends on the credibility and precision of the data we use in research. When we collect and process data, it is very important to organize them into one common set, so that we can more easily predict the traffic flow based on them.

Determining the characteristics of the traffic flow on the national road network and monitoring trends is an integral part of the road manager's activities in order to manage the development and management of the road network and to determine the real needs for improving the existing network or its individual parts in the dynamics of time.

Changes in the flow request sizes are influenced by various factors, changes in the degree of motorization, land use, i.e. the construction of new attractions and travel generators, weather events...

Until 2021, the world did not face an occurrence similar to the Corona virus pandemic and the way of organizing the way of life that also affected the change in the characteristics of the traffic flow. The subject of this paper is the analysis of the impact of the Corona virus pandemic on the characteristics of vehicle flow on the E-661 Highway. The analysis includes the flow of vehicles at the "Jakupovci" toll station, through which the largest number of vehicles pass during the year. The goal of the analysis is to determine whether the Corona virus pandemic, and to what extent, had an impact on the characteristics of the flow of vehicles on the observed section of the highway.

MATERIAL AND METHODS

Bearing in mind that the goal of the work is to determine and compare the flow of vehicles before and after the Corona pandemic, the first task was to choose the location from which the data will be collected. In this regard, the toll station "Jakupovci" (Figure 1) was selected, which is the busiest station on the E-661 highway (Figure 2).

This station is located north-east of Banja Luka, at the entrance to Highway E-661, going from the direction of Banja Luka towards Gradiška. The station was con-

TTTP (2024)**9**(1):16-21

Vladimir Gatarić, et al.
The influence of the corona virus pandemic on the characteristics of vehicle flow on the e-661 highway

ceived as one of the stations in the closed toll collection system on the highways of the Republic of Srpska. It has six traffic toll lanes, of which one on the far right in each direction is intended exclusively for electronic tolling, the two middle lanes are exclusively used for manual tolling, while the remaining two are combined, and can be used for both electronic and manual payment. The two central lanes are reversible, and can be used for tolling in both directions if necessary, while the remaining lanes, two in each direction, are intended exclusively for vehicle movement and tolling in one direction.

Figure 1: *"Jakupovci" toll station, direction Banja Luka-Gradiška (True, 2018)*

Figure 2: *Highway E-661 (Freelance artist, 2013)*

The conducted research included the counting of traffic during four years, after the transition to a closed charging system on the entire network of highways in the Republic of Srpska. The research was conducted in the period from the beginning of November 2019 to the end of December 2022. The data were collected from the Public Company " Republic of Srpska Motorways", from the Center where all traffic data on highways managed by the mentioned company are stored. After data collection, a database was created in the "Microsoft Office Excel" program, in which data analysis was performed. General data analysis was performed for each month individually, as well as for each year separately.

RESEARCH RESULTS

Data for the subject research were obtained from the System for management and supervision of toll collection of the Public Company " Republic of Srpska Motorways", made by the "Mihajlo Pupin" Institute.

Table 1: The flow request sizes during 2019

Year			
2019			
Month			
	Input	Output	Total:
January			0
February			0
March			0
April			0
Maj			0
June			0
July			0
August			0
September			0
October			0
November	105827	104484	210311
December			0
In total:	105827	104484	210311

Table 2: The flow request sizes during 2021

Year			
2020			
Month			
	Input	Output	Total:
January	19847	16680	36527
February	59403	61983	121386
March	67295	69997	137292
April	33680	35391	69071
Maj	61097	66572	127669
June	104392	111530	215922
July	102893	113553	216446
August	115228	120610	235838
September	105938	111693	217631
October	111854	118822	230676
November	96824	100758	197582
December	119599	131732	251331
In total:	998050	1059321	2057371

Vladimir Gatarić, et al.
The influence of the corona virus pandemic on the characteristics of vehicle flow on the e-661 highway

TTTP (2024)9(1)16-21

Table 3: The flow request sizes during 2021

Year			
2021			
Month			
	Input	Output	Total:
January	111619	111341	222960
February	119057	124986	244043
March	121906	129672	251578
April	110373	117987	228360
Maj	136113	142276	278389
June	140413	149261	289674
July	158334	179889	338223
August	191143	191427	382570
September	147031	152310	299341
October	149964	160392	310356
November	137120	138483	275603
December	142631	162865	305496
In total:	1665704	1760889	3426593

Table 4: The flow request sizes during 2022

Year			
2022			
Month			
	Input	Output	Total:
January	134179	126940	261119
February	123165	128350	251515
March	128807	137238	266045
April	144783	157261	302044
Maj	158573	161824	320397
June	153637	161762	315399
July	170814	188251	359065
August	201153	194767	395920
September	164377	165995	330372
October	194027	202894	396921
November	164824	161078	325902
December	161115	177160	338275
In total:	1899454	1963520	3862974

The research includes data on the total number of vehicles that pass through the Jakupovci toll station in both directions. On that occasion, November 2019 and all months in 2020, 2021 and 2022 were taken into account. During the research period, a total of 9557249 vehicles passed through this toll station. In November 2019, 210311 vehicles passed through the station, while during the whole of 2020, 2021 and 2022, 2057371, 3426593 and 3862974 passed through the station, respectively. A detailed presentation of the data is given in Tables 1, 2, 3 and 4.

The system categorizes vehicles into 5 categories. Category I consists of motorcycles, while category I, II, III and IV are determined based on the height of the vehicle above the front axle and the number of axles, so that category I consists of vehicles that have a height above the front axle less than or equal to 1.3m and less of 3 axles, category II vehicles that have a height above the front axle less than or equal to 1.3m and 3 or more axles, category III vehicles that have a height above the front axle greater than 1.3m and less than 4 axles and category IV vehicles that above the front axle have a height greater than 1.3m and 4 or more axles.

The counting of vehicles is done automatically when passing through the toll lanes of the Jakupovci station, in which there are counters in the form of electromagnetic loops, as well as "OCR" cameras, so that the possibility of error during counting is reduced to a minimum.

For the year 2019, there was data on the flow only for the month of November, and in order to assume the flows for the other months, as well as for the whole year, it was calculated what share the month of November has in the total annual flow. For this, the flows in November 2021 and 2022 were used, whereby it was obtained that November 2021 participates with 8.04%, while November 2022 with 8.44% in the total annual flow. In the further calculation for the year 2019, the mean value of the received participation in November was used, i.e. 8.24%.

After assuming that November 2019 participates with 8.24% in the total annual flow, it was calculated that in 2019 a total of 2552377 vehicles passed through the Jakupoveci toll station. The flows for the other months of 2019 were calculated according to the average value of the participation of individual months of 2021 and 2022 in the total annual flow. The obtained percentages were multiplied by the total annual flow in 2019 and the obtained results were presented in a table (Table 5).

Table 5: The flow request sizes by month and in total during the relevant four years of research

	2019.	2020.	2021.	2022.
January	169303	36527	222960	261119
February	173982	121386	244043	251515
March	181589	137292	251578	266045
April	184834	69071	228360	302044
Maj	209530	127669	278389	320397
June	212082	215922	289674	315399
July	244589	216446	338223	359065
August	273281	235838	382570	395920
September	220629	217631	299341	330372
October	246716	230676	310356	396921
November	210311	197582	275603	325902
December	225532	251331	305496	338275
In total:	2552377	2057371	3426593	3862974

TTTP (2024)9(1):16-21

Vladimir Gatarić, et al.
The influence of the corona virus pandemic on the characteristics of vehicle flow on the e-661 highway

DISCUSSIONS

The analysis of the obtained results was performed according to the total flow of vehicles (input + output) per month and according to the total annual flow of vehicles.
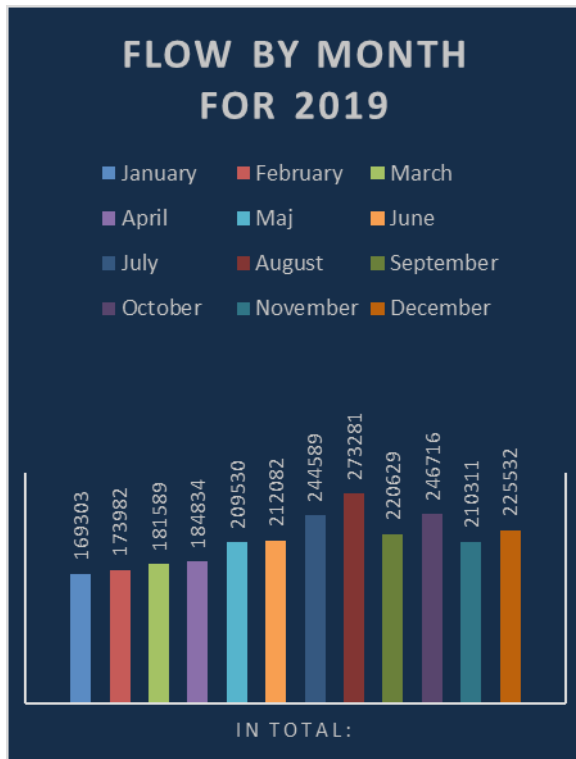

Figure 3: Chart of flow request sizes during 2019

Figure 4: Chart of flow request sizes during 2020

Figure 5: Chart of flow request sizes during 2021

Figure 6: Chart of flow request sizes during 2022

Vladimir Gatarić, et al.
The influence of the corona virus pandemic on the characteristics of vehicle flow on the e-661 highway

TTTP (2024)**9**(1)16-21

Display of flow request sizes in 2019

Figure 3 shows the assumed flow per month for 2019 in the form of a diagram. The highest flow was recorded during August, which is expected, considering the annual holidays and increased traffic on all roads during that period. The month of January had the lowest flow.

Display of flow request sizes in 2020

The flow by month for 2020 is shown in Figure 4. Unlike 2019, when the highest flow was in August, the highest flow in 2020 was recorded in December. The reason for this is that the Corona virus pandemic reached its peak during April and May of that year, as well as numerous movement restrictions in European and surrounding countries, so it is assumed that a smaller number of people could travel on vacation during the summer.

Display of flow request sizes in 2021

What characterizes the flow by month for the year 2021 is that August is again the month with the highest flow during the year, which we can see in Figure 5. The reason for this is the liberalization of movement after the weakening of the Corona virus pandemic, so that people are provided with a greater opportunity for movement during vacations. The month of January is again the month with the lowest flow, as it was during 2019.

Display of flow request sizes in 2022

When we look at the year 2022, it can be noticed that the flow experienced its maximum during the month of October, which is shown to us in Figure 6.

In addition, we can see that August still retained the status of one of the months with the highest flow during the year, while this year February had the lowest flow.

Growth trends in the flow request sizes during the four years of the study in question

If we look at the total flow of vehicles during the

Table 6: The flow request sizes by month and in total during the relevant four years of research

	2019.	2020.	2021.	2022.
January	169303	36527	222960	261119
February	173982	121386	244043	251515
March	181589	137292	251578	266045
April	184834	69071	228360	302044
Maj	209530	127669	278389	320397
June	212082	215922	289674	315399
July	244589	216446	338223	359065
August	273281	235838	382570	395920
September	220629	217631	299341	330372
October	246716	230676	310356	396921
November	210311	197582	275603	325902
December	225532	251331	305496	338275
In total:	2552377	2057371	3426593	3862974

relevant four years of the study, it can be concluded that the corona virus pandemic had a significant impact on the flow of traffic. This can be seen from Table 6, which represents the total flow of vehicles through the toll station "Jakupovci" during the observed four years.

In 2020, the total flow dropped from 2552377 to 2077371 vehicles, and in 2021 and 2022 it reached the value of 3426593 and 3862974 vehicles.

A graphic representation of this is presented in Figure 7, i.e. a diagram of flow request sizes during the relevant four years of research.

From this diagram, it can be concluded that the flow of vehicles in 2022 was 436381 higher than in 2021. When the flow from 2022 is compared with the flow from 2019, it can be seen that its value is higher by 1310597. From all this, it can be seen that the flow has an average annual increase of about 438000 vehicles, so we can conclude that the flow of vehicles during 2021 and 2022 reached the expected value, and that the flow in 2022 maintained the expected growth trend compared to 2021.
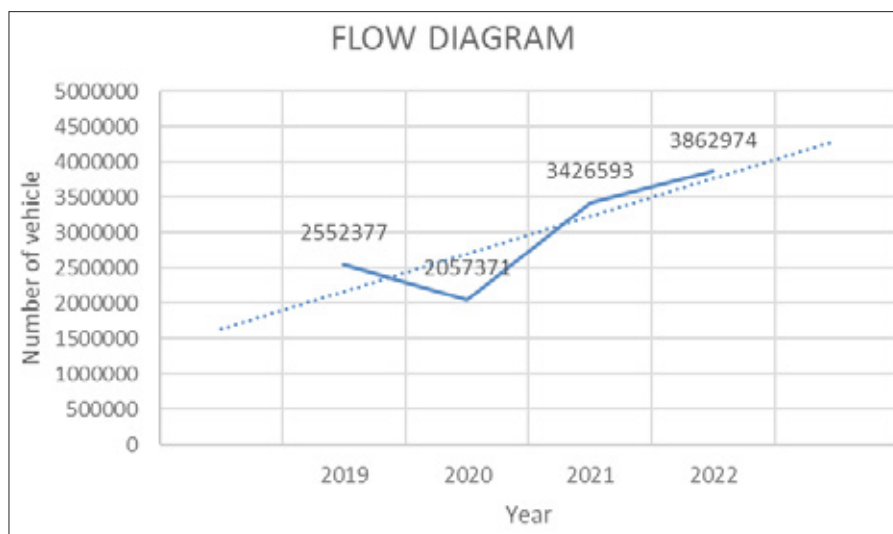
Figure 7: Diagram of flow request sizes during the relevant four years of research

Vladimir Gatarić, et al.

TTTP (2024)**9**(1):16-21   The influence of the corona virus pandemic on the characteristics of vehicle flow on the e-661 highway

CONCLUSION

As part of this work, an analysis of the flow of vehicles at the "Jakupovci" toll station, which is the busiest toll station on the E-661 highway, was performed. The flows during the last four years (2019, 2020, 2021 and 2022) were analyzed, with special reference to the year 2020, in which the Corona virus pandemic reached its peak.

It was observed that the flow of vehicles during 2020 experienced a significant decrease compared to 2019, which was undoubtedly influenced by the afore-mentioned pandemic. With the weakening of the pandemic, the flow of vehicles began to increase, so it already reached its expected value in 2021. The flow of vehicles in 2022 maintained the expected growth trend compared to the previous year.

From all this, it can be concluded that the Corona virus pandemic, during its duration, had an extremely significant impact on the characteristics of the flow of vehicles at the "Jakupovci" toll station, but that it did not leave a significant mark on the flow of traffic at this toll station after its completion.

REFERENCES

[1] Dadić, I., Kos, G., & Ševrović, M. (2014). TEORIJA PROMETNOG TOKA. Zagreb: Fakultet prometnih znanosti.

[2] Istinito. (2018, Novembar 26). Istinito. Preuzeto Maj 30, 2023 sa https://www.istinito.com/bih/drustvo/22164-poceo-zatvoreni-sistem-naplate-putarine-na-autoputu-9-januar/

[3] Kulović, M., & Bogdanović, V. (2016). TEORIJA SAOBRAĆAJNOG TOKA sa primjerima praktične primjene. Banja Luka: Panevropski univerzitet "Apeiron".

[4] National Research Council. (2000). HIGHWAY CAPACITY MANUAL (HCM). USA: TRANSPORTATION RESEARCH BOARD.

[5] Kuzović, Lj., & Bogdanović, V. (2004). Teorija saobraćajnog toka. Novi Sad: Fakultet tehničkih nauka u Novom Sadu.

[6] Slobodni umjetnik. (2013, Maj 3). Serbian Wikipedia. Preuzeto Maj 30, 2023 sa https://en.wikipedia.org/wiki/European_route_E661#/media/File:Mahovljanska.jpg

Use of video surveillance systems for detecting seat belt usage, mobile device usage, or vehicle registration - penalty or prevention

Siniša Macan
PhD, IT technologies, adviser, Ministry of Interior of Republic of Srpska, BiH - sinisa.macan@mup.vladars.rs

Slaviša Paunović
adviser, Ministry of Interior of Republic of Srpska, BiH – slavisa.paunovic@mup.vladars.rs

Abstract: The concept of smart traffic or smart cities involves the use of a large amount of data collected in real-time and processed using available tools. Data is collected from various sources. One common source for traffic control is video or imagery. In many countries, camera systems are installed to monitor traffic, track speed, or oversee intersections. Data is collected and processed in operational centers, allowing for insights into vehicle registration, vehicle speed, and passengers. At the same time, significant risks in traffic arise from the use of mobile phones or smart devices while driving. Furthermore, research indicates that wearing seat belts significantly reduces the risks of traffic accidents. A common occurrence in traffic is that vehicles are unregistered and uninsured. At the same time, the use of video surveillance systems is associated with the protection of privacy and personal data, necessitating the need to find an optimal balance between the right to privacy and the right to a secure environment, including safe participation in public traffic. The aim of this study is to explore the possibility and analyze the use of video surveillance to analyze the use of video surveillance in detecting mobile phone usage and seat belt compliance while driving. The systems for detecting mobile phone usage or seat belt usage during driving can instantly provide information on a prominently displayed screen near the roadside for preventive action. The paper analyzes the use of such systems for prevention purposes, along with an analysis of the potential application of penalties to reduce identified risks in traffic.

Keywords: Artificial Intelligence, Deep Learning, Machine learning, Smart Systems, Violations, Preventive Action

INTRODUCTION

The use of traffic video surveillance systems has significantly increased in recent years with the development of digital and video technologies. In the Republic of Srpska, systems have been installed to monitor traffic, particularly since this possibility has been legally defined for speed measurement.[1] Vehicle speed measurement systems are developed and widely used. As stated, the law in Bosnia and Herzegovina has defined the possibility of speed measurement, and a complete system for deploying radar or video systems that measure speed has been developed. Furthermore, enforcement systems have been developed to enable the identification, processing, and issuance of traffic violation notices, as well as monitoring of fine payments. An integrated system for issuing traffic violation notices and enforcing violations has been

implemented, linking with vehicle registration systems and other citizen rights.

However, the development of high-resolution cameras equipped with integrated machine learning systems, along with the advancement of telecommunications systems for data transmission and data processing centers, has enabled the collection of large amounts of data about vehicles in traffic. It is now possible to read and automatically process vehicle registration data, as well as driver behavior data within the vehicle itself. Furthermore, systems for monitoring vehicles' compliance with traffic signals have been established.

The surveillance system for seat belt and mobile phone usage during driving, upon detection of an incident, instantly sends a notification to the display near the roadside for preventive action. The vehicle registration detection system identifies violations and sends a traffic violation notice to the vehicle owner. The paper describes these systems and analyzes their impact on law-

---

[1] Article 45, Law on Basics of Traffic Safety on the Roads in BiH (Official Gazette of BiH, 6/06, 75/06, 44/07, 84/09, 48/10, 18/13, 8/17, 89/17, 9/18, 46/23, 88/23)