

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

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**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-

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.

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 |

## RESEARCH RESULTS

Data for the subject research were obtained from the System for management and supervision of toll collection of

**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 Jakupovci 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 |

## 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.

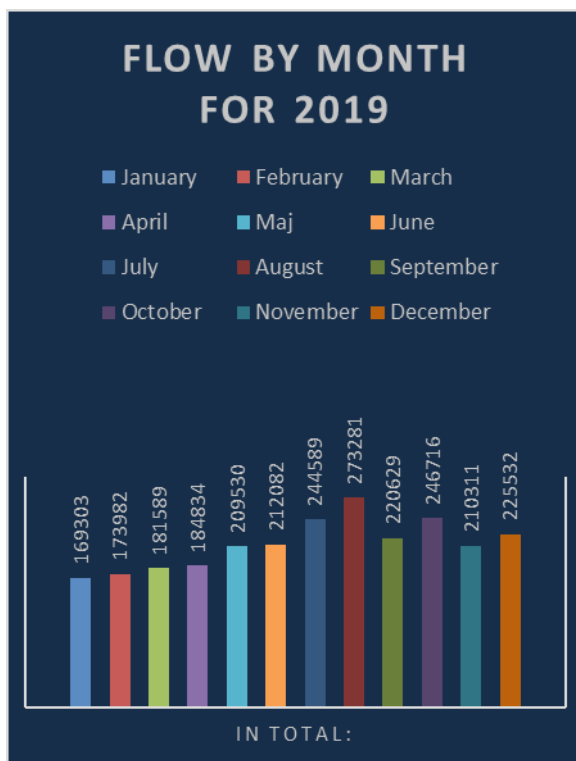


Figure 3: Chart of flow request sizes during 2019



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



### 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

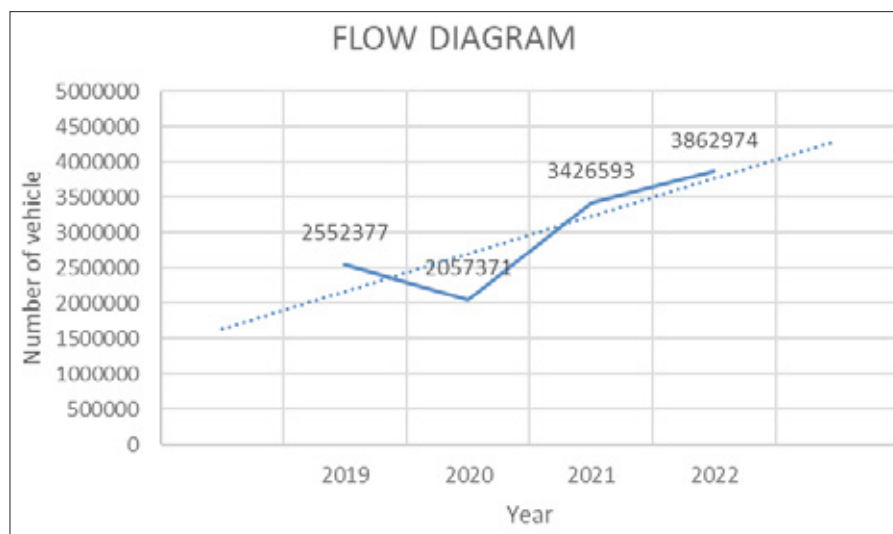
|           | 2019.   | 2020.   | 2021.   | 2022.   |
|-----------|---------|---------|---------|---------|
| January   | 169303  | 36527   | 222960  | 261119  |
| February  | 173982  | 121386  | 244043  | 251515  |
| March     | 181589  | 137292  | 251578  | 266045  |
| April     | 184834  | 69071   | 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

## 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 aforementioned 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.

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