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THE VEHICLES' ARRIVAL TIME IN A POINT ANALYZED FROM THE TRAFFIC FLOWS POINT OF VIEW

Ariadna ILIUȚ, Daniel MATEI, Ioan NEUVIRT

The Transilvania University of Braşov, Mechanical Engineering Faculty, Automotive and Engines Department, 29, Eroilor Street, 500036, Braşov, Romania, andai@unitbv.ro.

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Abstract The subject of this paper concerns the vehicles' arrival time in a certain point of a main street in Braşov from the traffic flows point of view. The real data was collected in the field and afterwards it has been grouped, processed, analyzed and related to tables and diagrams. Since the arrival analysis is based on mathematical functions, which predict the traffic strength, some mathematical relations were used in order to be related to the probability that a certain number of vehicles arrive in the observation point. In the end of the paper, the results of the experimental data are discussed and the proper conclusions are stated.

1. INTRODUCTION

During the last years, since the number of vehicles (automobiles and transport vehicles) increased, in the large cities of our country a lot of traffic problems occurred. Braşov is one of these cities that will be the subject of the present study. The traffic problems that are the most disturbing in our town are the rush hour traffic jams, which are caused by the large number of vehicles that move throughout the town at certain time intervals.

If we take into account the fact that in the whole country the total number of vehicles has an increasing tendency, one can only ask if these problems are only the beginning of traffic problems that we will have within Braşov, too. Another question that occurs is if the street network, already suffocating, is able face the new traffic demand and how.

The aim of this study is to analyze the vehicles arrival times in a certain point within an urban road and to try to explain what happens and why.

The object of our study is Calea Bucureşti Street. It is in fact the entrance from the Bucharest direction, but also it makes the connection between two very important tourist areas. This street is also the entrance for the Săcele town and it makes the connection of Noua neighborhood with the center of the town.

Another road traffic component in the area which also generates problems is the fact that the goods demand grew and it determined the presence of malls. They imply various car dealerships in the area, many vehicles, pedestrians and also gas stations, for which people do not have proper access and exit areas, and no alternative routes.

All these facts determine a very difficult traffic during rush hours; the traffic jams being its result. This is the reason why we have chosen to analyze one of the most important streets in Braşov.

In order to start understanding the complexity of the traffic in the area, one can take five minutes and sit at any intersection along the mentioned segment of road and observe that we have all the vehicle categories, a lot of important places in the immediate vicinity of each intersection, a lot of people traveling by car or by foot. And they have only one thing in common: they all lose their time when they go, or come from work, when they shop or want to get out of the city in that direction.

For a better understanding of the traffic composition and strength in the area, an arrival analysis in some important points was accomplished. One of the points that were analyzed is represented is placed on Calea Bucureşti before the intersection with Zorilor and Uranus Streets, on both directions.

The arrival analysis is based on mathematical functions, which predict the traffic strength. In order to apply these functions it is necessary that the events are totally independent. But in reality because of the traffic control devices the events are influencing one another. The most frequent distribution model that is hoped to be obtained is the Poisson model.

In order to make an arrival analysis we need a set of experimental data. This set of data can be obtained through various methods of data collection. The human observer is preferred because he can give more information than any device. For example a person while counting the cars passing through a point can separate very accurately the light and heavy traffic, can easily observe the public transportation vehicles, and make a lot of other remarks connected to the location that he is gathering traffic information in. Since we own a Mobotix D12i-Sec traffic video surveillance camera, we used it in order to collect data in the field.

The traffic data collection for the arrival analysis was accomplished for a period of 60 minutes. In this time the observer wrote in a special table the number of vehicles that passed through his observation point for every 10 seconds interval.

The traffic observation was repeated several days in order for the annalist to have a better image of the traffic in the area. The collection of traffic information, in order to be relevant, has to be accomplished starting Monday afternoon and ending Thursday afternoon. In this time interval, the traffic data collected can be considered relevant, because outside this interval the traffic is generated by random factors (trips for the weekend, relaxation traveling, and other specific activities which appear only on weekends but not all the weekends).

2. EXPERIMENTAL

The experimental data was collected during three consecutive days, at rush time, the traffic observations being accomplished using a D12i-Sec Mobotix video surveillance camera.

The area that was analyzed is represented by 2 lanes for each direction, the traffic volumes being the ones that passed from the Bucharest direction towards the center of the town.

The traffic data that was collected represents the sampling space, namely the whole results of an experiment, which may be finite or infinite.

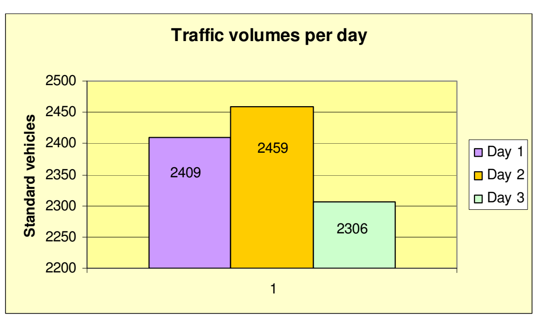

Fig. 1: The traffic volumes per days and the number of counted standard vehicles.

The traffic volumes presented above are structured for every day of counting. We can easily observe that during the second day of measurements, the largest traffic volume was counted. It should be emphasized that these numbers do not represent the actual vehicles, but the standard ones.

Prior to this, the actual vehicles were transformed into standard ones using STAS7348-86, and also the data collected was grouped and processed.
Thus:

Table 1: 10sec time interval data processing table

Pag.	Xj	0	1	2	3	4	
1	N1	21	13	6	5	3	
2	N2	25	16	7	3	3	
3	N3	27	18	4	2	3	
4	N4	25	20	3	4	2	
5	N5	27	13	9	1	4	
6	N6	25	19	6	3	1	
7	N7	17	12	6	6	1	
	Ni	167	111	41	24	17	360

Table 2: 20sec time interval data processing table

Pag.	Xj	0	1	2	3	4	5	
1	N1	5	5	4	5	2	4	
2	N2	7	7	4	5	0	4	
3	N3	6	10	4	3	3	1	
4	N4	7	7	7	3	0	3	
5	N5	6	7	7	2	3	2	
6	N6	6	8	5	5	1	1	
7	N7	5	3	5	4	1	3	
	Ni	42	47	36	27	10	18	180

Table 3: 30sec time interval data processing table

Pag.	Xi	0	1	2	3	4	5	6	
1	N1	1	3	1	3	2	4	2	
2	N2	2	3	2	5	3	1	2	
3	N3	3	6	1	2	3	0	3	
4	N4	3	3	6	1	2	2	1	
5	N5	3	2	4	2	4	1	2	
6	N6	1	7	1	4	2	3	0	
7	N7	1	0	4	2	5	1	1	
	Ni	14	24	19	19	21	12	11	120

In our study we analyzed the vehicles' arrival times for each day and each lane, but for the sake of simplicity, we will present in this paper the results for only one lane and one day of data collecting, namely the first lane and the second day of study.

For the 10 s time interval, there following magnitudes were obtained:

Table 4: The coefficients obtained for the 10 s time interval measurements.

xi	Ni	fi	$f_{\Sigma>}$	$f_{\Sigma<}$	M	D	P(X=x)	Ni'	Ni^2/Ni'
0	167	0,46	0,46	**1,00**	0,00	0,00	0,51	184,41	151,23
1	111	0,31	0,77	0,54	0,31	0,15	0,24	84,88	145,16
2	41	0,11	0,89	0,23	0,23	0,36	0,11	39,06	43,03
3	24	0,07	0,95	0,11	0,20	0,52	0,05	17,98	32,04
4	17	0,05	**1,00**	0,05	0,19	0,69	0,02	8,27	34,92
Σ	**360**	**1,00**	**4,08**	**1,93**	**0,93**	**1,71**	**0,93**	**334,61**	**46,39**
N	**360**								

Table 5: The coefficients obtained for the 20 s time interval measurements.

xi	Ni	fi	$f_{\Sigma>}$	$f_{\Sigma<}$	M	D	P(X=x)	Ni'	Ni^2/Ni'
0	42	0,23	0,23	**1,00**	0,00	0,00	0,32	57,60	30,62
1	47	0,26	0,49	0,77	0,26	0,14	0,19	33,86	65,24
2	36	0,20	0,69	0,51	0,40	0,51	0,11	19,90	65,12
3	27	0,15	0,84	0,31	0,45	0,98	0,06	11,70	62,31
4	10	0,06	0,90	0,16	0,22	0,79	0,04	6,88	14,54
5	18	0,10	**1,00**	0,10	0,50	2,03	0,02	4,04	80,15
Σ	**180**	**1,00**	**4,17**	**2,83**	**1,83**	**4,45**	**0,74**	**133,98**	**137,98**
N	**180**								

Table 6: The coefficients obtained for the 30 s time interval measurements.

xi	Ni	fi	$f_{\Sigma>}$	$f_{\Sigma<}$	M	D	P(X=x)	Ni’	Ni^2/Ni’
0	14	0,12	0,12	**1,00**	0,00	0,00	0,22	26,66	7,35
1	24	0,20	0,32	0,88	0,20	0,13	0,15	17,79	32,38
2	19	0,16	0,48	0,68	0,32	0,45	0,10	11,87	30,42
3	19	0,16	0,63	0,53	0,48	1,01	0,07	7,92	45,58
4	21	0,18	0,81	0,37	0,70	1,91	0,04	5,28	83,46
5	12	0,10	0,91	0,19	0,50	2,03	0,03	3,53	40,84
6	11	0,09	**1,00**	0,09	0,55	2,72	0,02	2,35	51,43
Σ	**120**	**1,00**	**3,26**	**3,74**	**2,74**	**8,24**	**0,63**	**75,40**	**120,03**
N	**120**								

In order to understand the three tables above, the relations used in order to compute their magnitudes have to be explained. These are the following:

$$f_i = \frac{N_i}{\Sigma N_i} \qquad (1)$$

In relation 1, f_i represents the relative frequency, N_i is the total number of intervals and ΣN_i is the sum of the total number of intervals.

$$M = x_i f_i \qquad (2)$$

In the relation above, M represents the average and xi is the number of intervals, while fi is the relative frequency, as stated above.

The dispersion is computed using formula 3, while the probability that x favorable results occur is calculated using relation 4.

$$D^2 = (x_i - M)^2 * f_i \qquad (3)$$

$$P(X = x) = C_{k-1} * p^k * q^x \tag{4}$$

In the following relations, we have denoted by k the probability of occurrence, q is the probability of a failed result and p represents the probability of a favorable result to occur.

$$k = \frac{M^2}{D - M}$$
$$p = \frac{M}{D} \tag{5}$$
$$q = 1 - p$$

The histogram of the relative frequencies results from the tables above. The fact that these histograms correspond to the 10 s, 20 s and 30 s time intervals has to be also emphasized.

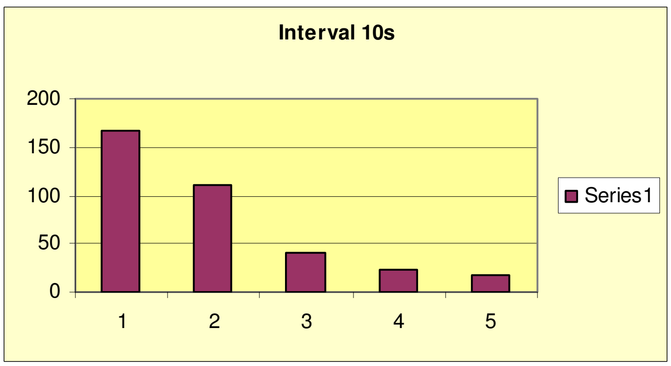

Fig. 2: The relative frequencies histogram for the 10s time interval.

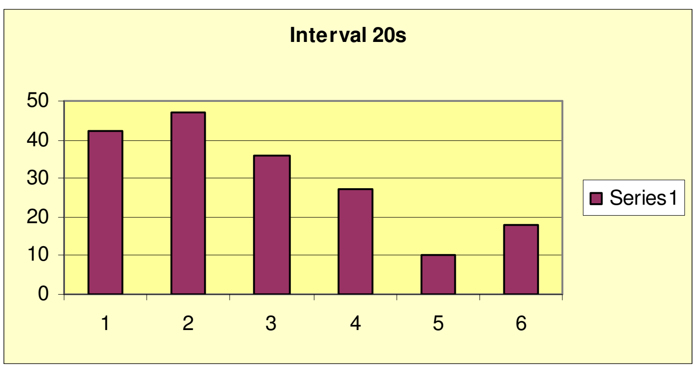

Fig. 3: The relative frequencies histogram for the 20s time interval.

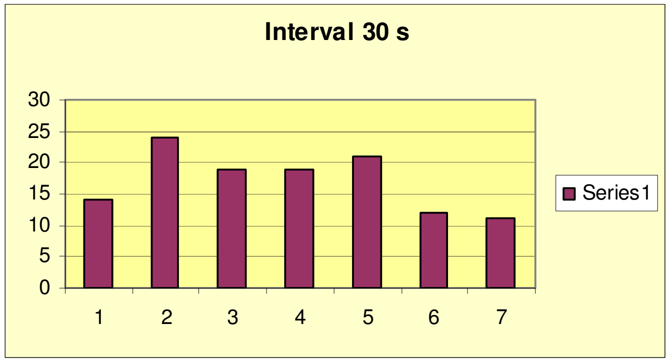

Fig. 4: The relative frequencies histogram for the 30s time interval.

The relative frequency is in fact the frequency that a certain number of vehicles may occur during a fixed time interval of 10s, 20 s and 30 s.

The diagrams of frequencies cumulated in increasing order and decreasing one are also derived for the 10 s, 20 s and 30 s.

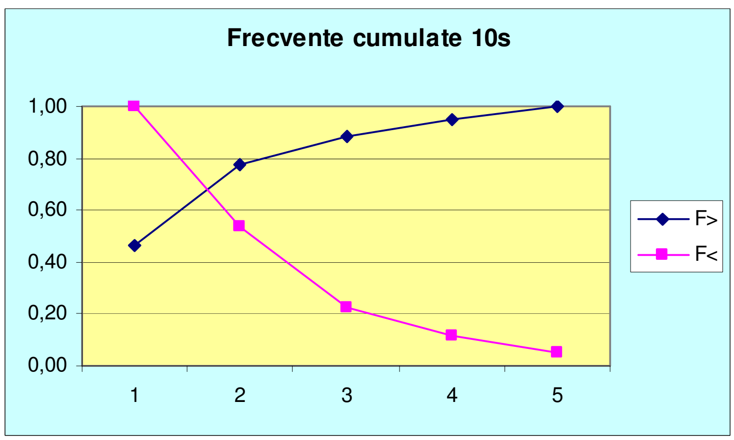

Fig. 5: The diagram of frequencies cumulated in increasing order and decreasing one for 10 s.

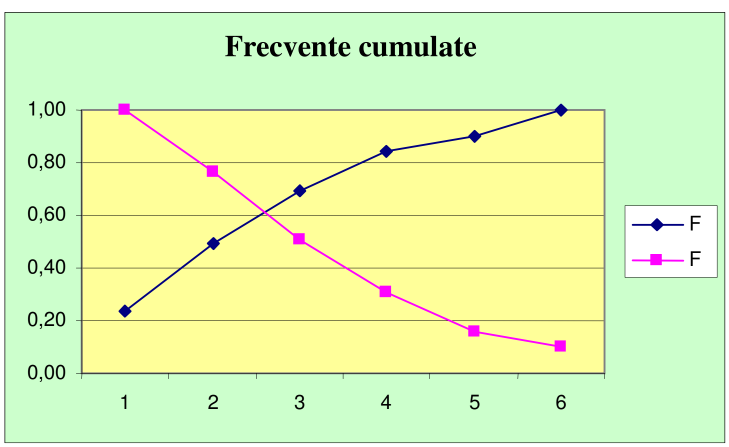

Fig. 6: The diagram of frequencies cumulated in increasing order and decreasing one for 20 s.

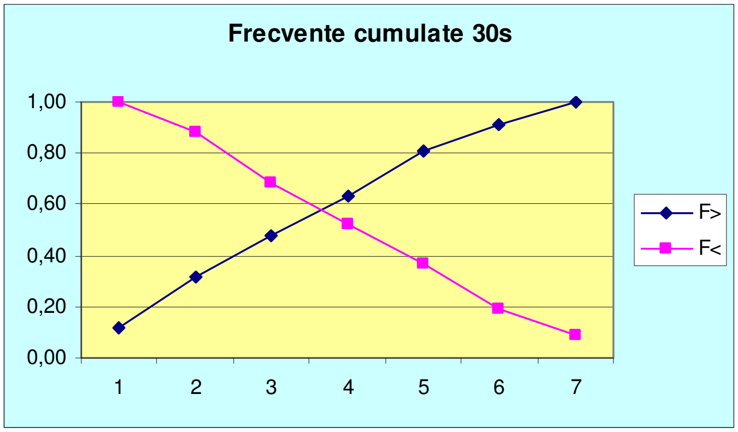

Fig. 7: The diagram of frequencies cumulated in increasing order and decreasing one for 30 s.

3. RESULTS AND DISCUSSIONS

Regarding the above diagrams, namely Fig. 5, 6 and 7, we have to emphasize that the blue line represents the frequency cumulated in an increasing order, while the pink one represents the frequency cumulated in a decreasing order.

Using the curve of frequencies cumulated in a decreasing order, one can evaluate the probability that in a certain time interval more than x vehicles may arrive in that particular point. The other way around is also valid, namely, using the curve of frequencies cumulated in an increasing order, one can evaluate the probability that in a certain time interval less than x vehicles, or even x vehicles may arrive in that point of observation.

For instance, the probability that 2 or less than 2 vehicles may arrive during the 10 s time interval is 70%. The probability that 4 or less than 4 vehicles to arrive is 75%, while the probability that more than 4 vehicles to arrive is 5%.

Another example is represented by the case in which we enlarge the time interval, namely from 10 s up to 30 s. When considering this fact, the probability that in the 30 s time interval may arrive 2 or less than 2 vehicles is 7.5%, while the one that more than 4 vehicles may arrive is 92.5%.

4. CONCLUSIONS

A known fact is that modern roads must satisfy the most demanding needs of all road users that are represented by drivers, pedestrians or cyclists.

In the same time, roads must assure fluency, safety, efficiency, namely reduced traveling times, minimum fuel consumption and reduced pollution.

These requirements imply knowledge (to know) but also ability (to know how) related to road traffic characteristics, roads' geometrical and functional designing elements and regulations.

Traffic engineering resorts to the science of traffic measurements, to the planning, design and operation of traffic systems in order to assure the effective movement of people and goods.

The traffic, especially the urban one, is made up of a "mixture" of pedestrians and various means of transportation that belong to different forms of transportation. Due to the mixture of slow and fast vehicles, the operation characteristics vary a lot and, therefore, the traffic situations are very complex. Their analysis requires elaborated traffic studies.

The traffic studies are carried out in order to determine the traffic characteristics and their main objectives are:
• To obtain information regarding to current traffic volumes and estimation of long-term values;
• To obtain information concerning the current roads and long-term developments;
• To design geometrical characteristics and pavement parameters;
• To obtain information related to the nature and number of road traffic accidents and their causes;
• To obtain information regarding the redesigning road dimensions, radius of curvature, traffic signals;
• To decide upon the priority of extending the traffic network or solely upon the improvement of the current one.

The most important studies carried out in order to fulfill the above mentioned objectives are the studies of traffic volumes.
They focus on the recording of vehicles that pass a point along a roadway per interval (for example 15 minutes) or per unit of time. The unit of time may refer to a second, an hour, a day or a year, according to the type of study.
Therefore, traffic volumes may be expressed in unitary vehicles also called standard vehicle.

Regarding the results of the experimental data that was collected in the field and that was presented in the present paper, we may conclude that the diagrams of cumulated frequencies during various time intervals emphasize the fact that if the time interval is larger, then the probability the vehicles arrive also increases in the case of the frequencies cumulated in a decreasing order and the other way around, namely it decreases when considering frequencies cumulated in an increasing order.

This is an important fact that may help solving the traffic problems that are the most disturbing in our town, namely the rush hour traffic jams, which are caused by the large number of vehicles that move throughout the town at certain time intervals.

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